Research

Healthcare Waste Generation and Management in Public Healthcare Facilities in Adama, Ethiopia

Samuel Fekadu Hayleeyesus,¹ Wondemagegn Cherinete¹

¹ Department of Environmental Health Science and Technology, College of Public Health and Medical Science, Jimma University, Ethiopia

Corresponding Author:
Samuel Fekadu Hayleeyesus
Assistant Professor
Department of Environmental Health Science and Technology, Jimma University, Ethiopia
P.O. Box: 1714 Jimma, Ethiopia
Tel. +251-911-774580
Fax +251-471-11 20 40
samuel.fekadu@ju.edu.et
sami.fekadu@yahoo.com

Introduction

Poor management of healthcare waste (HCW) is a potential health risk to patients, healthcare workers and the general public, as well as to the environment.¹³ A systematic review of 150 articles published since 2000 revealed that at least 50% of the world population is threatened by environmental, occupational and public health risks due to poor healthcare waste management (HCWM).³

The hazardous nature of HCW is mostly due to infectious agents, genotoxic, toxic or hazardous chemicals or pharmaceuticals, radioactive and sharps.⁸ Indiscriminate handling and unsafe disposal practices contribute to the spread of disease and pollution of air, soil and water.⁹ For instance, in 2000, the World Health Organization (WHO) estimated that injections with contaminated syringes caused 21 million hepatitis B virus infections, accounting for 32% of all new infections; 2 million hepatitis C virus infections, comprising 40% of all new infections; and 260,000 human immunodeficiency virus infections, or 5% of all new infections.¹⁰ In particular, safe segregation of HCW leads to a dramatic reduction in the rate of needle-related injuries.¹¹

Healthcare wastes can be categorized into two broad classes: general (non-hazardous) and hazardous waste. Hazardous HCW consists of infectious materials, sharps, pharmaceuticals, hazardous chemicals, substances with

Background. Over the past few years there has been rising production of hazardous byproducts, including dioxins, furans, and mercury from indiscriminate handling and treatment of healthcare waste. This situation is worse in developing countries where there is a serious lack of reliable data on factors such as generation and characteristics of healthcare waste.

Objectives. To investigate healthcare waste generation and current management practices of public healthcare facilities in Adama, Ethiopia.

Methods. All departments and sections in studied healthcare facilities (one referral hospital and four health centers) were examined for the characterization and determination of healthcare waste generation based on World Health Organization (WHO) guidelines. Wastes were collected and measured daily for seven consecutive days. Plastic buckets and bags of different colors were used for different types of wastes. Plastic bags were removed every morning and their weights were measured every day at 8 am using a scale.

Results. The average daily generation of healthcare waste from studied health centers ranged from 0.02 to 0.03 kg/patient/day, and the average daily waste generation of Adama referral hospital was 1.23 kg/bed/day. The healthcare waste generation rate was statistically different across the health service delivery sectors (p < 0.001). The proportion of hazardous healthcare waste generated in Adama referral hospital and health centers was 34.9% and 75%, respectively. There was no segregation of healthcare waste by type at the point of generation or pre-treatment of infectious waste in the studied healthcare facilities. Open pit burning and single chamber incinerators were the most utilized final treatment methods. Furthermore, there was a low level of awareness about safe healthcare waste management.

Conclusions. The overall findings of this study indicate that the proportion of hazardous healthcare waste generated from the studied healthcare facilities was above the threshold set by the WHO. There is a lack of proper waste management systems in all public healthcare facilities in Adama, Ethiopia. Awareness raising activities on proper healthcare waste management should be undertaken targeting all healthcare workers.

Competing Interests. The authors declare no competing financial interests.

Keywords: healthcare waste management; medical waste; infectious waste; healthcare facility; healthcare waste; healthcare worker

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high heavy metal content and genotoxic material. This type of waste accounts for 10-25% of HCW, including chemical or pharmaceutical waste (3%), body part waste (1%), sharps (1%), radioactive and cytotoxic waste, and broken thermometers (less than 1%). General wastes do not pose a risk of injury or infection due to the conditions under which they are generated. They are generally similar to household wastes.

Proper management of HCW in developing countries is far behind the recommended guidelines. The results of a WHO assessment conducted in 22 developing countries showed that the proportion of healthcare facilities that do not use proper waste disposal methods ranges from 18% to 64%. Moreover, there is a serious lack of reliable data on factors such as waste generation and waste characteristics, making it very difficult to identify appropriate and sustainable management solutions.

In addition, many countries lack national legislation and even simple segregation and treatment techniques. Unfortunately, waste generation and resource consumption have greatly increased in healthcare, along with the rising production of hazardous by-products, including dioxins, furans, and mercury.

The WHO has recommended technical guidelines as the basis for a national program of improvement of HCWM, together with a realistic legal framework, including designation of responsible authorities and mechanisms for coordination. In this regard, Ethiopia developed national guidelines in 2008 which can be implemented in all regional states of the country.

Along with the many challenges to sustainable HCWM, especially in low- and middle-income countries, systematic and comprehensive studies on HCWM are lacking. Thus, this study was conducted specifically to investigate HCW generation and its current management practices in public healthcare facilities in Adama, Ethiopia. Moreover, the perception of health professionals and support staff on HCWM was assessed.

**Methods**

**Study Characteristics**

The present study was conducted in the city of Adama, Ethiopia. The city is located about 99 kilometers from Addis Ababa, to the southeast along the main road to Harar. It lies between 80° 33’ to 80° 36’ North and 39° 11’ 57’’ to 39° 21’ 15’’ East. There are five public healthcare facilities that provide services for more than 222,035 people.

The present study focused on an assessment of all the public healthcare facilities in the city of Adama. This includes one referral hospital, Adama referral hospital, and four health centers: Adama health center, Biftu health center, Bokusheen health center and Geda health center. The study was conducted from March to April 2014.

**Data Collection**

All departments and sections in the healthcare facilities were examined for the characterization and determination of HCW generation. The HCW was collected and measured daily for seven consecutive days using a scale (baby scale, capacity range 15 kg and Model 4, capacity range 20 kg), Plastic buckets and bags of different colors were used according to waste type; for instance, blue for general waste, green for pharmaceutical waste and red for infectious and pathological waste. The plastic bags were kept inside in the buckets. The plastic bags were removed every morning and their weights were measured every day at 8 am. An observational checklist was used to assess the management system in terms of segregation, collection, transportation, and treatment of HCW. Moreover, during the data collection days, the outpatient flow and inpatient occupancy in the healthcare facilities were recorded daily.

For the survey on HCWM knowledge and practices of the healthcare facility workers (health professionals and support staff), a questionnaire was developed by referring to WHO documents. For data collection, 10 environmental health professionals and 2 supervisors were assigned after one day of training. All healthcare facility workers were included in the study. They included 225 health professionals and 188 support staff members.

**Statistical Analysis**

The raw data collected from the field were entered and compiled using EPI data version 3.1 and SPSS version 21.0. Data cleaning was performed by running each variable to check for accuracy, inconsistencies, and missing values. The average quantity of HCW in the healthcare facilities under study
main referral hospital has 200 beds and the average daily outpatient flow ranges from 650-700 patients, with an inpatient occupancy ranging from 145-185 patients. The daily average outpatient flow of all health centers was 171 patients per day (range: 160-185). The outpatient flow per day was 185, 160, 170, and 168 for Adama health center, Biftu health center, Bokushenen health center, and Geda health center, respectively.

#### Generation Rate

The total and mean weight of HCW generated in Adama referral hospital was 1600.3 kg/week and 228.6 kg/day, respectively.

As can be seen in Table 1, the highest and lowest weight proportions of the total HCW generated in Adama

| Department                        | General | Infectious | Pharmaceutical | Sharps* | Pathological | Total   | % by weight |
|-----------------------------------|---------|------------|----------------|---------|--------------|---------|-------------|
| Medical                           | 160.00  | 45.20      | 0.00           | 0.00    | 0.00         | 205.20  | 12.80       |
| Surgical                          | 114.40  | 12.60      | 2.80           | 2.10    | 1.10         | 133.00  | 8.30        |
| Pediatrics                        | 108.90  | 10.30      | 1.60           | 1.50    | 3.70         | 126.00  | 7.90        |
| Gynecology                        | 13.40   | 26.20      | 0.00           | 2.00    | 5.40         | 47.00   | 2.90        |
| Outpatient department             | 16.30   | 21.50      | 2.60           | 4.60    | 0.00         | 45.00   | 2.80        |
| Orthopedic                        | 28.10   | 13.70      | 2.40           | 2.30    | 4.00         | 50.50   | 3.10        |
| Emergency                         | 119.90  | 49.80      | 20.60          | 4.60    | 24.10        | 219.00  | 13.70       |
| Antiretroviral therapy            | 58.50   | 1.50       | 10.00          | 1.50    | 0.00         | 71.50   | 4.50        |
| Neonatal                          | 37.50   | 3.60       | 3.40           | 0.50    | 3.00         | 47.50   | 3.30        |
| X-ray & ultrasound                | 27.50   | 28.50      | 0.00           | 1.50    | 0.00         | 56.50   | 3.50        |
| Dental                            | 27.10   | 3.90       | 0.00           | 0.00    | 0.00         | 31.00   | 1.90        |
| Obstetric                         | 131.00  | 69.80      | 12.20          | 1.80    | 81.20        | 296.00  | 18.50       |
| Laboratory                        | 25.10   | 49.90      | 0.00           | 2.00    | 0.00         | 77.00   | 4.80        |
| Pharmacy                          | 10.70   | 1.00       | 20.30          | 0.00    | 0.00         | 32.00   | 1.90        |
| Psychiatry                        | 23.50   | 0.00       | 0.00           | 0.00    | 0.00         | 23.50   | 1.50        |
| Administration                    | 13.00   | 0.00       | 0.00           | 0.00    | 0.00         | 13.00   | 0.80        |
| Library                           | 18.00   | 0.00       | 0.00           | 0.00    | 0.00         | 18.00   | 1.10        |
| Main kitchen                      | 108.60  | 0.00       | 0.00           | 0.00    | 0.00         | 108.60  | 6.70        |
| Total weight (kg/week)            | 1041.50 | 337.50     | 75.90          | 24.40   | 122.50       | 1600.30 | 100.00      |
| Mean kg/day                       | 148.80  | 48.20      | 10.80          | 3.50    | 17.50        | 228.60  |             |
| % by weight                       | 65.10   | 21.10      | 6.86           | 1.48    | 19.42        | 79.36   |             |
| SD                                | 50.27   | 21.70      | 6.86           | 1.48    | 19.42        | 79.36   |             |

**Table 1 — Distribution and Healthcare Waste Generation Rate by Point Source and Type in Adama Referral Hospital**

*Includes needles, blades, lancet needles, syringes, and scalpel blades  
SD—standard deviation

was computed. The likelihood of statistically significant differences in average waste generation rates among the health service delivery sections was computed by the Kruskal-Wallis test.

**Results**

**Healthcare Facility Characteristics**

All public healthcare facilities located in Adama city were investigated. The

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Referral hospital was from obstetric wards (18.5%) and administration (0.8%). The proportion of general, infectious, pharmaceutical, sharps and pathological waste was 65.1%, 21.1%, 4.7%, 1.5% and 7.7% by weight, respectively. Moreover, the largest amount of infectious and pathological waste came from obstetric wards and the largest amount of pharmaceutical and sharps waste came from the emergency unit. The analysis also found that the proportion of hazardous HCW generated from Adama referral hospital was 34.9%.

The average daily generation of HCW from the studied health centers ranged from 0.02 to 0.03 kg/patient/day. As shown in Table 2, the mean HCW generation rate per health center was 4.46 ± 0.45 kg/day, of which (25.3%) 1.12±0.169 kg/day was general or non-hazardous waste and (74.7%) 3.34 ± 0.419 kg/day was hazardous waste. The largest amount of HCW per day was generated at Geda health center (5.02 ± 3.86) and the smallest amount was generated at Adama health center (4.07±3.45). Furthermore, the HCW generation rate was statistically different across health service delivery sections for all studied health centers (p < 0.001). As shown in Table 3, the highest quantity of HCW in all studied health centers was attributed to delivery rooms, which accounted for 39.8% of HCW, and the least amount was recorded at the voluntary counseling and testing department, which accounted for 7.3% of HCW. The proportion of general, infectious, pharmaceutical, sharps and pathological waste was 25.18%, 22.31%, 22.87%, 9.24% and 20.40% by weight, respectively. Moreover, the greatest amount of infectious and pathological HCW was generated in delivery rooms and the greatest amount of pharmaceuticals waste was generated in the pharmacy unit. Finally, the greatest amount of sharps waste was generated from injection and laboratory rooms.

Source Segregation and Handling Practices
In addition to data collection on HCW generation rate, an observational checklist was used to assess HCW management practices. It was observed that in Adama referral hospital and four health centers, HCW was temporarily stored in plastic buckets. The use of a color coding system for HCW containers was not practiced and there was no labeling practice for hazardous waste. Segregation of HCW by type at the point of generation and pre-treatment of infectious waste was also not practiced. Moreover, sharps are required to be disposed of in a safety box, but this was not practiced at the time of observation in many locations.

In all studied healthcare facilities, HCW is collected on a daily basis by cleaning personnel and transported to an on-site handling area. Most of the devices used for on-site transportation of HCW were open or unprotected.

In all healthcare facilities under investigation, HCW was not transported to an off-site area. Incineration was the main waste disposal method employed by healthcare facilities in the present study. Other handling practices observed included open pit burning and disposal (Figures 1 and 2) and placenta pits for bodily waste (Figure 3). The type of incinerator used was a single chamber incinerator built of brick (Figure 4).

Perceptions of Health Professionals and Support Staff of Healthcare Waste Management
In order to assess the knowledge of health professionals and support staff regarding HCWM, all staff at the investigated healthcare facilities were interviewed by 10 environmental health professionals. A total of 255 health professionals and 188

### Table 2 — Healthcare Waste Generation Rate in Health Centers in Adama, Ethiopia

| Health Center          | Total Healthcare Waste per week (kg) | Mean of Healthcare Waste ± SD | Mean of General Waste (%) | Mean of Hazardous Waste (%) |
|------------------------|--------------------------------------|-------------------------------|---------------------------|-----------------------------|
| Adama Health Center    | 28.5                                 | 4.07±3.45                     | 0.98(24.2)                | 3.1(75.8)                   |
| Biftu Health Center    | 32.6                                 | 4.65±4.07                     | 1.37(29.4)                | 3.28(70.6)                  |
| Bokushenen Health Center | 28.9                           | 4.12±3.45                     | 1.08(26.3)                | 3.03(73.7)                  |
| Geda Health Center     | 35.2                                 | 5.02±3.86                     | 1.07(21.1)                | 3.95(78.7)                  |
| Mean kg/day            | 31.3                                 | 4.465                         | 1.125(25.3)               | 3.34(74.7)                  |
| SD                     | 3.188521                             | 0.453615                      | 0.169411                  | 0.419603                    |

SD—standard deviation; HCW—healthcare waste
support staff members completed a questionnaire assessing perception of HCWM.

As shown in Table 4, 75% of health professionals reported knowledge of the different categories of HCW, but only 37% knew the color coding system used for waste containers. Moreover, only 33% of support staff knew the different categories of HCW and only 22% knew the color coding system used for waste containers. Only 28% of health professionals and 4% of support staff knew of the existence of HCWM guidelines. Finally, 69% of health professionals and 97% of support staff had never received training on safe HCWM practices.

### Discussion

The HCW generation rate is the fundamental information used for evaluating and designing a HCW management system. A study performed in various African country hospitals showed that the total waste generation rate in the sub-Saharan region was in the range of 0.3 kg/bed/day–1.5 kg/bed/day.\(^2\) The average daily HCW generation rate of Adama referral hospital was 1.23 kg/bed/day, which is in line with these studies. A study conducted in Sylhet, Bangladesh showed that the average generation rate of medical waste was about 0.934 kg/bed/day and a study in northern Jordan reported a rate of 0.83 kg/bed/day.

| Department                          | General | Infectious | Pharmaceutical | Sharps* | Pathological | Total | % by weight |
|-------------------------------------|---------|------------|----------------|---------|--------------|-------|-------------|
| Outpatient department               | 0.50    | 0.29       | 0.53           | 0.13    | 0.49         | 1.93  | 10.76       |
| Pharmacy                            | 0.26    | 0.19       | 1.31           | 0.06    | 0.00         | 1.81  | 10.12       |
| Injection and dressing room         | 0.53    | 0.34       | 0.43           | 0.51    | 0.07         | 1.89  | 10.52       |
| Mother and child health             | 1.19    | 0.00       | 0.16           | 0.14    | 0.00         | 1.49  | 8.29        |
| Laboratory                          | 0.47    | 0.51       | 0.86           | 0.51    | 0.01         | 2.37  | 13.23       |
| Voluntary counseling and testing    | 0.36    | 0.30       | 0.31           | 0.23    | 0.14         | 1.34  | 7.49        |
| Delivery room                       | 1.21    | 2.37       | 0.50           | 0.07    | 2.94         | 7.10  | 39.60       |
| Total weight (kg/wk)                | 4.51    | 4.00       | 4.10           | 1.66    | 3.66         | 17.93 | 100         |
| Mean kg/day                         | 0.64    | 0.57       | 0.59           | 0.24    | 0.52         | 2.56  | 14.28       |
| % by weight                         | 25.18   | 22.31      | 22.87          | 9.24    | 20.40        | 100   |             |
| SD                                  | 0.39    | 0.81       | 0.39           | 0.20    | 1.08         |       |             |

Table 3 — Distribution and Healthcare Waste Generation Rate by Point Source and Type Across Healthcare Delivery Sections in Adama, Ethiopia

*Includes needles, blades, lancet needles, syringes, and scalpel blades  
SD—standard deviation
However, in some countries, the HCW generation rate was more than twice of the generation rate recorded in the present study. For instance, studies performed in Iran, Nigeria, and Kuwait reported rates of 2.71, 2.78, and 3.65 to 5.4 kg/bed/day, respectively. These differences may be due to differences in the size and type of hospitals investigated, in addition to differences in economic situation. For instance, the use of disposable instruments and packaging materials rather than the use of reusable items in healthcare facilities in developed countries has increased the amount of waste generation.

Each specific type of HCW requires specific proper handling and safe disposal practices. In particular, the hazardous content of HCW requires careful management. As stated in the WHO document on safe disposal of HCW, the usual generation rate of hazardous HCW ranges between 10-25%.

The present study showed that the proportion of hazardous HCW generated from Adama referral hospital was 34.9%. This high level of hazardous waste generation may be due to lack of segregation of waste at the point of generation. In addition, the low economic status of patients may lead to lower production of general waste, and therefore the proportion of hazardous HCW is high in comparison. In addition, the amount of hazardous waste generated

| Interview Questions | Health Professionals (n=255) | Support Staff (n=188) | Health Professionals + Support Staff Responses (n=443) |
|---------------------|-----------------------------|----------------------|-----------------------------------------------------|
| Yes (%)             | No (%)                      | Yes (%)              | No (%)                                              |
| Do you know the categories of HCW? | 190 (75) | 65 (25) | 62 (33) | 126 (67) | 252 (57) | 191 (43) |
| Do you know the specific color coding system used for waste containers? | 95 (37) | 160 (63) | 42 (22) | 146 (78) | 137 (31) | 306 (69) |
| Have you received training on safe HCWM? | 80 (31) | 175 (69) | 5 (3) | 183 (97) | 85 (19) | 358 (81) |
| Do you know about the existence of HCWM guidelines? | 70 (28) | 185 (72) | 7 (4) | 181 (96) | 77 (17) | 366 (83) |
| Do you know about disease transmission by improper HCW disposal? | 255 (100) | 0 (0.0) | 160 (85) | 28 (15) | 415 (94) | 28 (6) |
| Do you know that waste should not be stored for >48 hours? | 65 (26) | 190 (75) | 10 (5) | 178 (95) | 75 (17) | 368 (83) |
| Do you segregate waste at the point of generation? | 56 (22) | 199 (78) | 40 (21) | 148 (79) | 96 (22) | 347 (78) |
| Do you use gloves when handling HCW? | 201 (79) | 54 (21) | 172 (91) | 16 (9) | 373 (84) | 70 (16) |
| Do you treat hazardous HCW differently from general waste? | 199 (78) | 56 (22) | 48 (26) | 140 (74) | 247 (56) | 196 (44) |
in the studied health centers was far higher than the amount of general waste generated. This proportion is the complete opposite of the proportion seen at Adama referral hospital. This might be due to the poor collection system for general waste in the health centers. In addition, patients do not have lengthy stays in the health centers compared to the referral hospital.

In all studied healthcare facilities, the most basic elements of the HCW management system included: waste classification, waste segregation, waste minimization, containerization, color coding, labeling and signage, handling, transport, storage, treatment, and final disposal of waste. Healthcare facilities need to address each component of the waste management system, especially segregation. Waste segregation is the key to efficient HCWM. It entails the separation of different types of waste (infectious, sharps, chemically hazardous, radioactive, non-hazardous) at the point of generation, with specific requirements for handling, treatment and disposal.

In the studied healthcare facilities, the best available final disposal method of HCW was incineration using a single chamber incinerator built of brick. However, this type of incinerator is against the Stockholm Convention, since several problems have been reported with single chamber brick-made incinerators, including emission of toxic substances into the environment that are a risk to public health. Therefore, there is a need for alternative solutions, such as microwave disinfection used in South Korea and autoclaving in Laos. Other authors have also suggested the importance of developing and introducing locally-made autoclaves for low and middle-income countries.

Due to the economic situations in low-income countries like Ethiopia, it may be difficult for each healthcare facility to have non-incinerator technologies for the treatment of the hazardous components of HCW. Therefore, having central treatment facilities at the city or district level might make the required capital and operating costs more feasible. For instance, autoclaves are easy to operate, maintain and monitor. Models are available ranging from desktop units that process a few liters of waste, to machines for central treatment facilities that are capable of processing tons of waste at a time.

In addition to having the physical facilities for proper management of HCW, it is important to raise the awareness of healthcare workers. Various studies have shown that raising awareness plays an essential role in proper HCW handling and management with simple and low-
cost approaches.\textsuperscript{36-38} The present study revealed a low level of awareness of safe HCWM practices by both health professionals and support staff. This low level awareness might be a major contributor to the mismanagement of HCW in the studied healthcare facilities.

**Conclusion**

The overall findings of this study indicate that the proportion of hazardous HCW generated from healthcare facilities in Adama, Ethiopia is above the threshold set by the WHO. There is lack of appropriate waste segregation, storage, transport, treatment and disposal practices in all public healthcare facilities. This can poses a risk to human health and the environment. These inappropriate HCWM practices are mostly due to a lack of awareness of the proper HCWM system. Thus, continual training for both categories of workers is essential to raise their awareness of the proper HCW handling and management practices. Moreover, the presence of HCWM regulation guidelines may be insufficient unless they are well communicated and enforced in all healthcare facilities. Open pit burning and single chamber incineration were the most utilized treatment methods. Other alternatives for waste treatment should be evaluated and implemented in order to avoid emission of toxic substances into the environment that may present a risk to public health.

There is a shortage of research on healthcare waste generation and characteristics in low- and middle-income countries.\textsuperscript{7} These findings may be generalizable to other African and low- and middle-income countries to develop sustainable and cost effective solutions.

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