Healthcare Waste Generation, Composition and management Practice in Dilla University Referral Hospital: A cross-sectional study

Girum Gebremeskel Kanno (girummeskell@gmail.com)
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia https://orcid.org/0000-0001-6689-1983

Belay Negassa Gondol
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Tizalegne Tesfaye Mamo
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Abriham Shiferaw Areba1
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Zemachu Ashuro Lagiso
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Awash Alembo Tsebe
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Miheret Tesfu Legesse
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Daniel Abera Dansa
Ethiopian Public Health Institute

Mulugeta Admasu
Assosa University College of health and Medical Science, School of Public Health, Assosa Ethiopia

Dagmawit Tesfaye
Center for Innovative Drug Development and Therapeutic trials for Africa (CDT-Africa).

Gizaw Sisay
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Negassa Eshete
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Mekonnen Birhanie Aregu
College of Health and medical Science, school of Public health, Dilla University, Dilla Ethiopia

Research Article

Keywords: Healthcare waste composition, Healthcare waste generation rate, health care waste management, Dilla University Referral Hospital, Southern Ethiopia

Posted Date: April 5th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-394127/v1

Version of Record: A version of this preprint was published at Sustainable Environment on October 25th, 2021. See the published version at https://doi.org/10.1080/27658511.2021.1988383.

Abstract

Background: Improper collection, segregation, transportation, treatment and disposal of healthcare wastes waste pose risk to public health and the environment. The aim of this assessment was to determine the healthcare waste generation rate, composition and management practice in Dilla University Referral Hospital.

Methods: An institutional based cross-sectional study was conducted in Dilla University Referral hospital from May to June 2019. The quantitative data was collected for eight consecutive days using direct measurment of healthcare waste. The qualitative data was collected by using questionnaire, observation checklist, and in-depth interview. The qualitative data was collected and transcribed and thematic content analysis was done.

Result: A total of 1212.5 kg of healthcare waste was generated in the study period with an average of 151.56 kg (±73.4). The hazardous fraction of the healthcare waste was 581.9 kg (48 %) while the generation rate was 0.866 kg $bed^{-1}day^{-1}$. From the total healthcare waste, general waste was the highest 630.6 kg (52%) followed by infectious waste which was 299.5 kg (24.7%). There was no segregation of healthcare waste by type at the point of generation and there was no pre-treatment of infectious wastes. Placenta pit was used for pathological wastes and open burning was the main disposal mechanism for the remaining wastes.

Conclusion: The finding indicated that the proportion of hazardous waste generated from the hospital was above the threshold set by the World Health Organization. There was a lack of appropriate waste segregation, storage, transport, treatment and disposal practices in the referal hospital.

Highlights

- The health care waste generation rate for the referal hospital was 866 kg bed^{-1} day^{-1}.
- The hazardous fraction of the healthcare waste was 48 % which was higher than it should be.
- Plastic (30.%) and food waste (1%) were the two major constituents of the health care waste.
- There was a lack of appropriate waste segregation, storage, transport, treatment and disposal practices in the referal hospital.

1. Introduction

Health care waste (HCW) is characterized as any waste produced by a health care facility during the delivery of healthcare services, and it is divided into two types: non-hazardous (general wast) and hazardous HCW (WHO, 2015; Pinto *et al.*, 2010). General waste, also known as non-hazardous waste, makes up the majority of HCW, accounting for 75 to 90% of total HCW. It comes mostly from food storage, administrative, and housekeeping operations, and poses little risk to public health (WHO, 2015; WHO, 2011;Chartier et al., 2014).

Hazardous HCW, on the other hand, includes laboratory wastes, pathological wastes, body fluids, infectious materials, sharps, pharmaceuticals, harmful chemicals, substances with high heavy metal content, and genotoxic material, which make up 10–25 percent of all HCW (Chartier et al., 2014; WHO, 2011; Olufunsho et al., 2016). Healthcare workers, waste handlers, patients, visitors, and the general public can be exposed to infectious agents, toxic effects, and injuries as a result of dangerous and improper HCW management, with nurses and housekeeping employees being the key groups at risk of injury (Chartier et al., 2014; Bassey et al., 2006; EPA, 1998; EPA, 1997; Jang *et al.*, 2006; Lee and Huffman 1992). This indiscriminate handling and unsafe disposal practices could also lead to the pollution of air, soil and water (Tsakona et al., 2007).

The transmission of more than 30 blood borne pathogens has been related to poor HCW management [36]. Poorly handled sharp wastes contaminated with human blood, for example, have been linked to the transmission of HIV and the hepatitis B and C viruses (Chartier et al., 2014). Every year, more than two million healthcare workers are estimated to be exposed to percutaneous injuries as a result of contaminated sharp wastes around the world (Prüss-Üstün, 2005).

Injections with infected syringes caused 21 million hepatitis B virus infections, accounting for 32% of all new infections; 2 million hepatitis C virus infections, accounting for 40% of all new infections; and 260,000 human immunodeficiency virus infections, killing over 5.2 million people worldwide each year, including 4 million children (Prüss-Üstün, 2005).

The presence of hazardous waste in the hospital waste stream, even if it is a small percentage, will result in higher costs in addition to significant public health risks and emissions (Yazie et al., 2019). Implementing appropriate methods, such as successful segregation of hazardous and non-hazardous waste, is linked not only to lower risks, but also to lower waste management costs (Castellani *et al*., 2015; Ibbotson *et al*., 2013; Mosquera *et al*., 2014; Windfeld and Brooks, 2015).

As a result, effective HCW management is critical to maintaining public and environmental health (WHO, 2015). Segregation, collection, storage, transportation, treatment, and disposal are all important aspects of a successful healthcare waste management process (Meleko and Adane, 2018; Olufunsho et al., 2016; Manyele and Lyasenga, 2010; Yazie et al., 2019). HCW is becoming a huge challenge, particularly for many developed countries that are lagging far behind recommended guidelines (Yazie et al., 2019; Azage *et al*., 2013; Haylamicheal *et al*., 2011; De Titto et al., 2012; Townend and Vallini, 2008; Diaz and Fisher, 2005)

Identifying the types and quantities of waste produced in a health-care facility as early as in the planning stage is a crucial first step in safe waste disposal, to estimate the required capacities for containers, storage areas, transportation and treatment technologies, as well as to establish baseline data on rates of production in different medical areas and for procurement specifications, planning, budgeting, calculating revenues from recycling, optimization of waste-management systems and environmental impact assessments (WHO, 2015). A systemic review on the HCW management in Ethiopia by Yazie et al. 2019 indicated that the HCW generation rate was found to be high (the proportion of hazardous waste generated ranged from 21 to 70%) and its management very poor. The major challenges assessed were lack of accessible guideline, waste management utility, adequate training, financial constraint, and poor managerial supports (Yazie et al., 2019; FMOH 2008).

Even if the type and quantities of the HCW data is crucial, it is the most neglected activity in most health facilities in Ethiopia (Yazie et al., 2019; FMOH 2008). Therefore, this study intends to fill the gap in healthcare waste management practiced in Dilla University referral hospital in southern Ethiopia.

2. Materials And Methods

2.1 Study area, design and period

The study was conducted in Dilla University Referral Hospital which is found in Southern Nation Nationality and People Regional State (SNNPRS) in Ethiopia. Among the Hospitals found in Gedio zone, Dilla referral Hospital managed by Dilla University and function as a practical training center for more than five departments and also providing curative services. The hospital provides both outpatient and inpatient services with total bed capacity of 200. The hospital serve as a referral hospital for the health centers and nearby primary hospitals. An institutional based cross-sectional survey was conducted from May 2019 to June 2018 for eight consecutive days to quantify the healthcare waste generation rate and to evaluate its management system.

2.2 Data collection

To determine HCW composition the waste of different classes collected from different service delivery points was poured on a designated area at the back of the hospital for segregation. The weighing was conducted for eight consecutive days and the total weight of waste per level of each department or ward was obtained by adding the weight of waste in each class per day. The trained data collectors conducted the waste segregation at a designated place and weighed the segregated waste. Before segregation of the HCW started, the waste was sprayed with disinfectant solution (0.5% sodium hypochlorite). A supervisor recorded the weight of the waste (in kilograms) by department and service delivery point. Weighting scale was used to quantify the amount of HCW generated. The waste was classified as sharps, infectious, pathological, pharmaceutical and general waste (Such as food waste, plastics papers and other domestic wastes). The waste containers were labeled in order to identify the ward in which the waste is generated. From each ward in every shift the waste containers were transported to the temporary station designated for waste segregation and measuring (Figure 1). Once the wastes are sorted and measured they were finally be disposed and the waste containers were returned to their wards to be ready for the next shift.

Physical observation was carried out to assess the healthcare waste handling, segregation, and transportation and disposal practices. Standardized questionnaire adapted from the WHO for HCW (WHO, 2014) was used. The daily patient load and bed occupancy rate was taken from the hospital triage system and registers. n addition to direct observations five in-depth interviews

were conducted with the hospital administrators (Executive Director, Deputy Director, Nursing superintendent) , senior management involved in infection prevention team which also handle the healthcare the cleaners' coordinator and waste management till the point of saturation. Written consent was obtained prior to the in-depth interviews.

2.3 Data Collection Tools

Data collection tools/standardized questionnaire for the assessment were adapted from the WHO for HCW (WHO, 2014) and physical observation checklist were used to record the weighted healthcare waste and to assess the health care waste handling, segregation, and transportation and disposal practices. Key informants for the in-depth interview were also used for the qualitative data.

2.4 Data analysis

For quantitative data, double data entry was used; data were entered into Excel sheets and SPSS version 20 and the two sets of data were compared for consistency. The analysis was computed separately for each wards and type of healthcare waste. The data distributions were explored for normality test. Descriptive statistics of frequency tabulation, count, mean, standard deviation and percentages were used to summarize generation of HCW into meaningful form. The results were also presented using tables, pie chart, and graph and box plot. The healthcare waste generation rates were reported on the basis of kg/bed/day, kg/patient/day and kg/outpatient/day. Classification of health care waste was done based on (WHO, 2014), criteria for health care wastes. Hazardous and non hazardous was also done accordingly. The qualitative data collected was transcribed and a thematic content analysis was done. After the specific nodes were developed for the questions, the significant findings and responses were aggregate as sub-nodes. These sub-nodes were later developed into themes and the information from different literature and responses were then triangulated.

2.5. Ethical considerations

The ethical approval for this study was granted by Dilla University College of health and medical science Institutional ethical Review board. A supportive written letter was granted to all the concerned departments, involved in the qualitative study. Personal protective equipment's were supplied for data collectors and training on infection prevention was given before the starting of the study.

3. Results

3.1 Health care waste generation

As indicated in (Table 1) data was collected for eight consecutive days and a total of 1212.5 kg of healthcare waste was generated in the teaching hospital. An average of 151.56 (±73.4) kg of health care waste was generated in the study period with the lowest recorded was 51 kg in day two (by coincidence which was a national holiday), and the maximum waste generated was 241.4 kg in day four. Regarding the classification of healthcare waste in study period, general waste was the highest 445.3 kg followed by infectious waste which was 299.5 kg and chemical waste was the lowest generated healthcare waste in DURH which was 60 kg.

Table 1. Daily health care waste generation by department in Dilla university Referral Hospital

Department	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	%	Total
Surgical ward	14.3	1.7	8.6	8.3	0	3.9	20	12.3	5.7	69.1
Medical ward	31.8	5	41	33.6	22.1	0	7.8	40.8	15	182.1
Gynacology ward	13	13.9	20.2	11.7	26.8	5.1	8.6	22.3	10	121.6
Obesterrics	13.2	1.2	20.2	16	14.6	9.6	13.8	8.2	8	96.8
Pediatrics	2.8	0	29.6	32.5	0	15.5	17.9	18.7	9.6	117
OR	1	0	5.3	10	17	2.3	0	7	3.5	42.6
ICU	1.6	0	1.2	0	2.8	0	0	0	0.46	5.6
NICU	7.6	10.9	10	19.5	4.9	8.4	7.6	5.8	6.2	74.6
OPD	13.1	3.3	0	9.1	4	0	5.8	0	2.9	35.3
Medical llabratory	6.3	0	1.6	28.2	60	7.7	1.2	5.1	9.1	110.1
Emergency ward	6.2	15	6	26.6	27.8	12.2	9.7	15.2	9.8	118.7
Radiology	1	0	0	5.8	0	0	0	1.7	0.7	8.5
Psycitry ward	4.3	0	4.7	15.7	0	0	0	4	2.4	28.7
Pharmacy	3	0	40	1.9	2.9	0	0	0	3.9	47.8
Kitchen	10.8	0	2.1	1	39	0	0	20	6	72.9
Office	0	0	0	1.6	0	0	0	5	0.54	6.6
Garden	24	0	0	20	0	0	0	30.5	6.1	74.5
Total	154	51	190.5	241	246.9	64.7	92.4	196.1	100	1212.5

As indicated in (Table 2), Medical ward, gynacology ward and medical Labratory produced the highest waste, with a total waste of 182, 121.6 and 110.1 kg respectively while adult ICU produced the lowest 5.6 kg of health care waste in the hospital in study period.

Medical ward produced the highest amount of both infectious and total waste, as showen in(Figure 2). waste generated from the the radiology department, offices and adult ICU produced the lowest health care waste in the hospital in study period.

Table2. Classification of health care waste by department in Dilla Univeresity Refferal Hospital

	Classification of health care waste in kg						
	Infectious waste	Patological waste	Pharmaceutical waste	Sharp waste	General waste	Chemical waste	Total
Medical Ward	64.7	0	9.5	12.1	95.8	0	182.1
Gynacology Ward	32.1	14.4	8.2	13.8	53.1	0	121.6
Medical Labratory	20.1	0	6.8	11.6	11.6	60	110.1
Emergency Ward	49.5	0	9.1	16.1	44	0	118.7
Pediatrics Ward	17.8	11.3	9.4	5.3	73.2	0	117
Obesterrics Ward	33.7	20.5	8.8	1.4	32.4	0	96.8
NICU	28.1	10.6	9.1	5	21.8	0	74.6
Surgical Ward	27.3	0	6.5	0.7	34.6	0	69.1
OR	15.7	10.5	4.8	1.5	10.1	0	42.6
Psycitry Ward	3	0	2.7	3	20	0	28.7
OPD	4.2	0	5.7	0	25.4	0	35.3
Radiology	1.2	0	1.6	0	5.7	0	8.5
ICU	2.1	0	1.7	0.7	1.1	0	5.6
Garden	0	0	0	0	74.5	0	74.5
Kitchen	0	0	0	0	72.9	0	72.9
Pharmacy	0	0	0	0	47.8	0	47.8
Office	0	0	0	0	6.6	0	6.6
Total	299.5	67.3	83.9	71.2	630.6	60	1212.5

OR= Operation Room, ICU= Intensive Care Unit, NICU= Neonatal Intensive care Unit, OPD= Out Patient Department

With a total of 200 beds and an average bed occopancy rate of 92%, and avrage daily patient load of 271, the waste generation rate for the hospital was calculated as 151.6 kg day^{-1}, 0.866 kg bed^{-1}, day^{-1}, 0.529 kg $patient^{-1}$ day^{-1}, 0.248 $patient^{-1}$ day^{-1} and 0.396 kg bed^{-1} day^{-1}.

Composition of health care waste

Plastic was the highest constituent of the wastes with –kg and paper waste was the least (Table 3).

Table 3. Composition of health care waste in DURH.

Composition	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Min	Maz	Mean	%	Total
Plastic	33.4	21.4	75.8	72.8	42.8	25.5	37.1	54.6	21.4	75.8	45.4	30%	363.4
Bottle and glasses	12.8	2.5	12.3	9.5	4.3	1.1	10	2.1	1.1	12.8	6.82	4.5%	54.6
Paper	3.4	0	3.3	3.6	4.6	1.3	8	6.5	0	8	3.8	2.5%	30.7
Cartoon	11.7	5.2	20	24	18.1	2	5.6	19.5	2	24	13.3	8.7%	106.1
Infectious wastes	32.8	15.9	34.1	19.7	11.5	9.2	9.6	11.9	9.2	34.1	18.1	11.9%	144.7
Food	15.7	3.3	32.3	50	54.1	9	13	38.8	3.3	54.1	27.025	18.1%	219.2
Sharp/niddles	8.7	1.5	5.4	19.2	12.6	6.5	1.8	15.5	1.5	19.2	8.9	5.9%	71.2
Patological wastes	11.5	1.2	6.9	8.4	10.3	7.1	6.2	15.7	1.2	15.7	8.4	5.5%	67.3
Garden waste	24	0	0	20.5	0	0	0	30	0	30	9.3	6.1%	74.5
Chemical waste	0	0	0	0	60	0	0	0	0	60	7.5	4.9%	60
Other	0	0	0.4	10.7	3.6	3	1.1	2	0	10.7	2.6	1.7%	20.8
Total	154	51	190.5	241.4	221.9	64.7	92.4	196.6				100%	1212.5

3.3 Classification of health care waste

General waste with 150.7 kg day^{-1} was the highest type waste produced across the days in the study period followed by infectios waste with 38.3 kg day^{-1}. Day two recorded the lowest generation rate by type as indicated in (Figure 2).

3.4 Hazardous fration of the health care waste

Average hazardous waste generation was 72.74 kg SD (± 32.6). As indicated in (Figure 4) the hazardous fraction of health cae waste for Dilla University Referal Hospital was 48%.

3.5. Health care waste management practice

Findings from the physical observation

Our physical observation result focused on four recommended steps of the healthcare waste management in the hospital. Waste management practices at the teaching Hospital include, the use of waste bins with 20 and 60 liters capacity for storage at the wards, collection from the wards to secondary storage points and transfer to open dump site for disposal by cleaners.

Segregation: HCW was temporarily stored in plastic containors. 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 wards. Each ward has three small color coded waste bins: red for pathological, black for general, yellow for infectious wastes and yellow and white safety box for sharp materials. However, there wasn't any proper labeling on the bins. There were no separate bins for the hazardous waste such as pharmaceutical waste, chemical waste and the radioactive wastes. The red or yellow bins are used for these kinds of wastes. Black waste bin was found at the patient's bed side, and was being used for all sorts of waste. The HCWs were not segregating the infectious waste, as some of the patient's blood stained objects were seen in the general waste bin.

On-site health care waste collection and transport: On-site waste collection is done by the hospitals itself. It is collected twice a day in DURH. There was no wheeled trollies utilized for the transportation of wastes rather, it was simply picked and carried by cleaners and taken to the disposal site as showed in (Figure 5). Three bin (Red, yellow and black) containers were present in most of the wards. Sub-standard containors which are suitable only for office purposes were also observed in most wards. The most common sizes of containers observed were 30 liter containers in each patient rooms and 60 litere containers in the building corridors. The poor HCW segregation practice (mostly sharp materials) in most of the substandard containers, and the absence of transporting health care wastes with out trolly's were the main causes of injuries to cleaners as showen in (Figure 5).

Figure 5.

Storage: There are no separate storage points located in the hospital. All the wastes collected from the wards using small color coded bins are transferred to the big waste bins located at each blocks only to be transported and end up to the disposal site. Washing and disinfecting of waste containers which were used to transport either infectious or non-infectious wastes together were not even washed or disinfected afterwards.

Health care waste treatment: There was no treatment mechanism applied to the healthcare wastes in the hospital before disposal.

On-site health care Waste disposal: The hospital had two incinerators which were not functional at the time of the study and open dumping and then burning was the only means of healthcare waste disposal except the pathological wastes. Pathological wastes were disposed in a placenta pit located in a secured area in the hospital compound as indicated in (Figure 6). Again PPE were not used during the disposal. General wastes such as kitchen and garden wastes were dumped in an open on-site pit prepared for this purpose inside the hospital compound as indicated in (Figure 6).

Ocopational safety

At the time of data collection cleaners were observed wearing heavy duety gloves plastic shoes and approns as shown in (Figure 7), but adequate and proper personal protective equipment's (PPE) long rubber boots, water proof aprons, googles and masks were not available during waste collection. The managment problem in the procurment process was the main reason according to the hospital infection prevention case team leader.

" We always send lists of the right safety materials, and products needed for the infection prevention and control tasks including the health care waste managment but what we get was not what we ordored. This was a challenge that has complicated our task."

Hence, WHO guidelines were not followed at all.

Figure 7. On-site health care waste transportation in DURH

Findings from the in-depth interview

All of the five respondents in the in-depth interviews were male staffs, regular government employees in different leadership positions which were responsible for the management of health care waste which include the medical director, Deputy medical Director, Nursing superintendent, infection prevention team leader and focal person from the cleaners. Thematic results are presented as follows.

Organization and Planning: There is institutional structure for healthcare waste management in the hospital. The healthcare waste management is carried out under the infection prevention and patient safety case team. There is an infection prevention committee organized from all departments and discussed on the prominent issues every month but the impact of the decision of this

committee is limited to make the desired outcome regarding proper HCW. There is annual healthcare waste management plan along with the infection prevention and patient safety plan. But, policies, standard operating procedures and working manuals or guidelines were lacking regarding healthcare waste management in the teaching hospital.

Staff Development: Even if, there were no developed training modules in DURH, two rounds of training has been given for cleaners and the health professionals on basic infection prevention and control which includs health care waste managment. There were no health information materials regarding healthcare wastes to the hospital stuff, the patients as well as the care givers on how to manage healthcare wastes safely.

Waste managment records: One of the basic problems in healthcare waste management in DURH was the absence of daily waste segregation, collection and monitoring records. As a result wastes are neither weighted daily nor monthly and their segregation collection transportation and disposal practices also are not monitored and recorded. The waste collection is scheduled twice a day, which was in the morning and in the afternoon.

4. Discussion

Environmental sustainability and responsibility have emerged as important aspects of Sustainable Development Goals (SDGs) towards the generation of ever-increased wastes are real threat to human and environmental health. While the provision of high-quality health services improves health and well-being overall, unfortunately, it may result in the generation of potentially harmful waste if not managed appropriately (Global Fund, 2020). One of a reliable healthcare waste management plan involves a periodic quantification of the generation rate and information of waste type (Atnafu and Kumie, 2017; Madhia et al., 2015).

On daily basis, averagely151.6 ± (SD 73.41) kg day^{-1} of healthcare waste was generated from the referal hospital. This result was higher than a result obtained in Mizan Tepi University teaching hospital (Meleko and Adane, 2018), Bench Maji (Meleko et al., 2018) and Menilk Hospital (Tadesse and Kumie, 2014) which may be associated with variation of annual patient load, seasonal variation and geographical related health conditions. The daily basis overall average obtained by this study was lowere than with study conducted in Adama city, Ethiopia (228.60 ± 79.36) kg day^{-1}(Hayleeyesus *et al.*, 2016).

the overall average of HCW generation rate was 0.529 kg $patient^{-1}day^{-1}$. This result was higher than the study done in Addis Ababa which was 0.490 kg $patient^{-1}day^{-1}$ as reported by (Atnafu and Kumie, 2017). This difference could be mainly due to the difference in patient load as well as the difference in HCW management systems, waste characterization and classification as well as enforcement of laws and regulation of the country which enables them to follow the same procurement policies for the purchase and consumption of commodities.

The health care waste generation rate was 0.866 kg bed^{-1} day^{-1}. This result is lower than the study done by (Tadesse and Kumie, 2014; Tesfahun et al., 2016) who reported that the generation rate was 6.03 kg bed^{-1} day^{-1} and 2.45 kg bed^{-1} day^{-1} respectively. It was even lower than the national pooled generation rate which was ——bed^{-1} day^{-1} as reported by——. This variation might be due to the difference in patient load, the type and vastness of of the healthcare service delivered, and the type and the nature of waste generated at each case team.

The generation rate was lower from other countries generation rate also from Bauru region Brazil 4.375 kg bed^{-1} day^{-1} (Delmonico et al., 2018) Gorgan region Iran 1.83 kg bed^{-1} day^{-1} (Dehghani and Vafadar, 2017), Gaza Strip Palestine 1.3 kg bed^{-1} day^{-1} (Caniato et al., 2016),

However, it was lower when commpared to Nigeria Lagos, 0.57 kg -bed – 1 day – 1 (Longe, 2012), Pakistan Gujranwala 0.667 kg bed^{-1} day^{-1} (Ali et al., 2016) and India Uttarakhand 0.24 kg bed^{-1} day^{-1} (Thakur and Anbanandam, 2017). The rise that was noted in this study for the average generation rate may be attributed to the lack of intervention in Gedeo zone through the awareness and training programs organized for proper segregation of infectious waste, adequate categorization and disposal of the waste. In contrary, the average healthcare waste generation rates were reported in the range of 1.053 kg $bed^{-1}day^{-1}$ to 2.290 kg $bed^{-1}day^{-1}$ in Abuja, Nigeria (Bassey et al., 2006). The difference for the generation rates could be due to seasonal variation, availability of different facilities,and resource allocation for the managmnet of health care wastes (Tadesse and Kumie, 2014).

The overall average of HCW generated by government hospitals found to be 0.67 kg occupied bed^{-1} day^{-1} in this study. This is inconsistent with (Maamari *et al.*, 2015) who found the highest (2.45 kg occupied bed^{-1} day^{-1}) generation rates in private hospitals with 200 beds or more with overall average 0.97 kg occupied $bed^{-1}day^{-1}$. Various studies confirm that large hospitals (i.e., having more than 200 beds) have the highest generation rate. Maamari et al further describes that small public hospitals with less than 100 beds have smallest generation rates (Maamari *et al.*, 2015).

In present study, relatively higher amounts of HCW generated from medical ward 22.76 kg/day followed by gynecology (15.1kg day^{-1}), emergency (14.86kg day^{-1}), pediatrics (14.63kg day^{-1}) and laboratory (13.76kg day^{-1}) as shown in (Fig. 4). Portion of hazardous waste for the hospitals in Dilla University refferal Hospital was 48%. This proportion is higher than the hazardous waste threshold (10–25%) predicted in 2014 by WHO (WHO, 2015; Global Fund, 2020; KMOH, 2015) while non-hazardous wastes was lower than the threshold ranged from 75–90% (Taghipour *et al.*, 2015; Nuralam et al., 2017). similar higher proportions of hazardous fraction were reported in Brazil 52% (Delmonico et al., 2018), Iran 47% (Dehghani and Vafadar, 2017), Nigeria Legos 51% (Manga et al., 2011). Higher proportions of Health care waste were reported in Kenya Nirobi 65 % (Nkonge et al., 2014) and in India 63.67% (Thakur and Anbanandam, 2017) where as lower proportions (11.2–20.64%) of hazardous waste were reported in Bangladesh HCW (Nuralam et al., 2017; Alam *et al.*, 2013). In this study the higher hazardous waste fraction in healthcare wastes as opposed to the limit set by WHO might resulted from poor classifications and segregation practices of on-site handling systems. This is a clear indication of poor health care waste segregation practice in the hospital.

Our finding was in line with the pooled national data reported in Ethiopia by (Yazie et al., 2019), which indicated that the proportion of hazardous waste ranged from 21 to 70% and its management very poor. The major challenges assessed were lack of accessible guideline, waste management utility, adequate training, financial constraint, and poor managerial supports were.

5. Conclusion

The overall findings of this study indicate that the percentage composition of hazardous healthcare waste generated from DURH is above the threshold set by the WHO. There is lack of appropriate on-site waste handling, segregation, transportation and disposal of HCW in the hospital.

These improper healthcare waste management practices are mostly resulted from either ignorance of applying appropriate practices or due to lack of awareness of the proper healthcare waste management system. This can pose a risk to the public health and environment. Therefore, investment on recomended disposal facilities, continuous monitoring and evaluation of the health care waste managmnet practice, training for both healthcare workers and cleaners is critical to increase their awareness on the proper healthcare waste handling and management practices.

Declarations

Acknowledgment

The researchers would like to extend their deepest gratitude to Dilla University Energy and Environment research center and the research and dissimination office for the financial suporot for this study. The management teams of the hospital also deserved applauds for their support while conducting this research.

Data availability statement

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author’s contribution

All authors contribute equally in the conception, actual data collection, analysis, and write up of the result and the manuscript preparation .

Competing interests

The authors declare no conflict of interest, financial or otherwise.

Funding

Dilla University Research and dissemination office and environment and energy research center have fully funded this research.

Abbrevations

ANOVA-Analysis of Variance

DURH-Dilla University Referral Hospital

HCW-Health Care Waste

ICU-Intensive Care Unit

NICU-Neonatal Intensive Care Unit

OR-Operation Room

OPD-Out Patient Department

SD- Standard Deviation

SDG-Sustainable Development Goals

SNNPRS-Southern Nation Nationality and People Regional State

WHO-World Health Organisation

References

Akter, N. 2000. Medical Waste Management: A Review. 1-25.

Alam M.Z., Islam M.S., and Islam M.R., *Medical Waste Management: A Case Study on Rajshahi City Corporation in Bangladesh.* J. Environ. Sci. & Natural Resources, 2013. **6**(1): p. 173 - 178.

Ali, M., Wang, W., Chaudhry, N., 2016. Management of wastes from hospitals: a case study in Pakistan. Waste Manag. Res. 34, 87–90. https://doi.org/10.1177/ 0734242X15616474.

Asrat Meleko and A. Adane, 2018. *Assessment of Health Care Waste Generation Rate and Evaluation of its Management System in Mizan Tepi University Teaching Hospital (MTUTH), Bench Maji Zone, South West Ethiopia.* Annals of Reviews and Research, 2018. **1**(4).

Atnafu D.D., and A. Kumie, 2017. *Healthcare Waste Composition and Generation Rate in Menellik II Referral Hospital, Addis Ababa, Ethiopia: A Cross Sectional Study.* International Journal of Sustainability Management and Information Technologies, **3**(2): p. 10.

Azage M, Gebrehiwot H, Molla M. Healthcare waste management practices among healthcare workers in healthcare facilities of Gondar town, Northwest Ethiopia. *Health Sci J.* 2013 Jul;7(3):315-26.

Bassey BE, Benka-Coker MO, Aluyi HA. 2006. Characterization and management of solid medical wastes in the Federal Capital Territory, Abuja Nigeria. *Afr Health Sci* ;6(1):58-63.

Caniato, M., Tudor, T.L., Vaccari, M., 2016. Assessment of health-care waste management in a humanitarian crisis: a case study of the Gaza Strip. Waste Manag. 58, 386–396. https://doi.org/10.1016/j.wasman.2016.09.017.

Chartier Y, Emmanuel J, Pieper U, Prüss A, Rushbrook P, Stringer R, et al. 2014. Safe management of wastes from health-care activities. Geneva, Switzerland: World Health Organization

Dehghani, M., Vafadar, M., 2017. Qualitative and quantitative survey and suggested management strategy of hospital solid waste at Hormozgan Province, Iran. Ambient. Sci. 4, 4. https://doi.org/10.21276/ambi.2017.04.1.ra04.

Delmonico, D.V.d.G., Santos, H.H.do., Pinheiro, M.A.P., de Castro, R., de Souza, R.M., 2018. Waste management barriers in developing country hospitals: case study and AHP analysis. Waste Manag. Res. https://doi.org/10.1177/0734242X17739972.

De Titto E, Savino AA, Townend WK. 2012. Healthcare waste management: the current issues in developing countries. *Waste Manag Res*. 30(6):559-61.

Diaz LF, Fisher S. Management of healthcare wastes. *Waste Manag*. 2005;25(6):567-74. Federal Ministry of Health; 2008, Health Care waste management national guidelines. Addis Ababa, Ethiopia: Federal Ministry of Health; 2008 Nov. 126 p.

Global Fund, *Technical Brief: Sustainable Health Care Waste Management*, T.G. Fund, Editor. 2020: Geneva, Switzerland.

Hayleeyesus S.F., and W. Cherinete, *Healthcare Waste Generation and Management in Public Healthcare Facilities in Adama, Ethiopia.* Journal of Health & Pollution, 2016. **6**(10): p. 64–73.

Haylamicheal ID, Dalvie MA, Yirsaw BD, Zegeye HA. Assessing the management of healthcare waste in Hawassa city, Ethiopia. *Waste Manag Res*. 2011 Aug; 29(8):854-62.

Jang YC, Lee C, Yoon OS, Kim H. Medical waste management in Korea. *J Environ Manage* [Internet]. 2006 Jul [cited 2016 May 17];80(2):107-15. Available from: http://www.sciencedirect.com/science/article/ pii/S0301479705002768 Subscription required to view.

Lee CC, Huffman GL. Metals behavior during medical waste incineration [Internet]. Cincinnati, Ohio: U.S. Environmental Protection Agency; 1992 Dec 23 [cited 2015 Sep 16]. Available from: https:// web.anl.gov/PCS/acsfuel/preprint%20archive/ Files/36_4_NEW%20YORK_08-91_1735.pdf

Longe, E.O., 2012. Healthcare waste management status in Lagos State, Nigeria: a case study from selected healthcare facilities in Ikorodu and Lagos metropolis. Waste Manag. Res. 30, 562–571. https://doi.org/10.1177/0734242X11412109.

Maamaria O., et al., 2015. *Health Care Waste generation rates and patterns: The case of Lebanon.* Waste Management, **43**: p. 550-554.

Madhia Aslam, et al., 2015. *Assessment and Characterization of Hospital Waste in Government and Private Hospitals of Rawalpindi City.* International Journal of Environmental Planning and Management, 2015. **1**(2): p. 33-40.

Manga, V.E., Forton, O.T., Mofor, L.A., Woodard, R., 2011. Health care waste management in Cameroon: a case study from the Southwestern Region. Resour. Conserv. Recycl. 57, 108–116. https://doi.org/10.1016/j.resconrec.2011.10.002.

Manyele SV, Lyasenga TJ. 2010. Factors affecting medical waste management in low level health facilities in Tanzania. Afr J Environ Sci Technol. 2010;4:304–18.

Meleko A., Tarekegn Tesfaye, and A. 2018. Henok, *Assessment of Healthcare Waste Generation Rate and Its Management System in Health Centers of Bench Maji Zone.* Ethiop J Sci., 2018. **28**(2): p. 125-134.

Meleko A, Adane A. 2018. Assessment of health care waste generation rate and evaluation of its management system in Mizan Tepi University Teaching Hospital (MTUTH), Bench Maji Zone, South West Ethiopia. Ann Rev Res. 1:1–9.

Nkonge, A.N., Magambo, J.K., Mayabi, A.O., Taratisio, N., 2014. Management of healthcare waste in national teaching and referral hospitals in Kenya. Int. J. Environ. Waste Manag. 14, 199–209. https://doi.org/10.1504/IJEWM.2014.064087.

Nuralam H.M., et al., 2017. *Healthcare Waste Management Practices in Bangladesh: A Case Study in Dhaka City, Bangladesh.* International Journal of Environmental and Ecological Engineering,**11**(6): p. 524-529.

Olufunsho A, Aishat AA, Azuka CO. 2016. Assessment of medical waste management in seven hospitals in Lagos, Nigeria. BMC Public Health. 16:269.

Pinto VN, Joshi SM, Velankar DH, Mankar MJ, Bakshi H, Nalgundwar A. A comparative study of knowledge and attitudes regarding biomedical

Prüss-Üstün A., Rapiti E., Hutin Y., 2005. Estimating the global burden of disease attributable to contaminated sharps injuries among health care workers. *American Journal of Industrial Hygiene*, 48(6):482–490.

Safe handling: cytotoxic drugs and related wastes. Adelaida, Australia: Government of South Australia; 2015 Jun [cited 2015 Sep 21]. 172 p. Available from: http://www.sahealth.sa.gov.au/wps/wcm/connect/ f8aa68004b3f6cf6a340afe79043faf0/SafeHandlingOfC ytotoxicDrugsRelatedWastesGuideline-PHCS-120515. pdf?MOD=AJPERES

Sawalem M, Selic E. 2009. Hospital waste management in Libya: a case study. Waste Manage. 29:1370–5.

Tadesse M.L., and A. Kumie, 2014. *Healthcare waste generation and management practice in government health centers of Addis Ababa, Ethiopia.* BMC Public Health. **14**(1221): p. 1-9.

Taghipour H., et al., 2014. *On-site or off-site treatment of medical waste: a challenge.* Journal of Environmental Health Science & Engineering **12**(68).

Tesfahun, E., Kumie, A., Beyene, A., 2016. Developing models for the prediction of hospital healthcare waste generation rate. Waste Manag. Res. 34, 75–80. https://doi. org/10.1177/0734242X15607422.

Thakur, V., Anbanandam, R., 2017. Management practices and modeling the seasonal variation in health care waste: a case study of Uttarakhand, India. J. Model. Manag. 12, 162–174. https://doi.org/10.1108/JM2-08-2015-0058.

Townend B, Vallini G. Editorial: 2008. Healthcare waste management - the global paradox. *Waste Manag Res*.Jun; 26(3):215- 6.

Tsakona M, Anagnostopoulou E, Gidarakos E. 2007. Hospital waste management and toxicity evaluation: a case study. *Waste manag*. 27(7):912-20.

United States Environmental Protection Agency; 1997. Mercury study report to congress. Vol. 1, Executive summary [Internet]. Washington D.C. Dec [cited 2016 May 17]. 95 p. Available from: https:// www3.epa.gov/ttn/caaa/t3/reports/volume1.pdf

United States Environmental Protection Agency; 1998. Inventory of sources of dioxin in the United States (external review draft 1998). Washington D.C. Report No.: EPA/600/P-98/002Aa. p. 2-13.

World Health Organization; 2004. Safe health-care waste management: policy paper. Geneva, Switzerland: World Health Organization; 2004 2 p.

World Health Organization (WHO) 2011. Some Basic Information on Healthcare Wastes.

WHO, 2014. Safe Management of Wastes From Health-Care Activities, in: Yves Chartier, Jorge

Emmanuel, Ute Pieper, Annette Prüss, Philip Rushbrook, Ruth Stringer, William Townend, Wilburn, S., Zghondi, R. (Eds.). (Geneva, Switzerland). World Health Organization 2015. Status of health-care waste management in selected countries of the Western Pacific Region 2008-2013

Yazie T.D., Tebeje M.G., and Chufa K.A.,2019. Healthcare waste management current status and potential challenges in Ethiopia: a systematic review. BMC Res Notes.12:285 https://doi.org/10.1186/s13104-019-4316-y

Figures

Figure 1

Labled health care waste containers before waste measurment at DURH

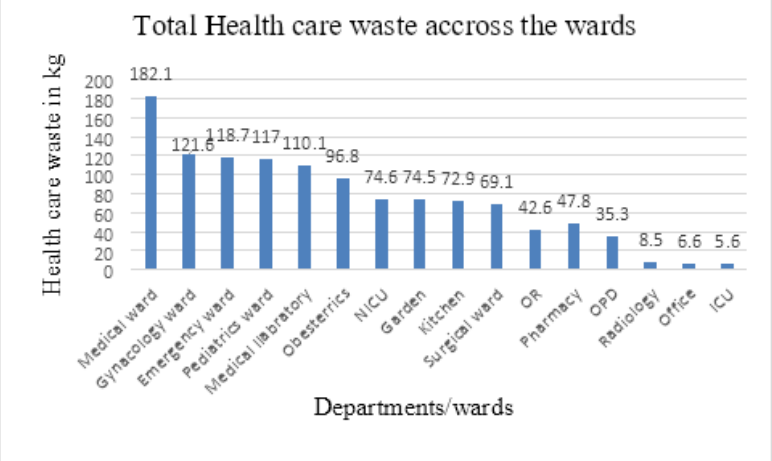

Figure 2

Total Health care waste generated across all the wards in DURH

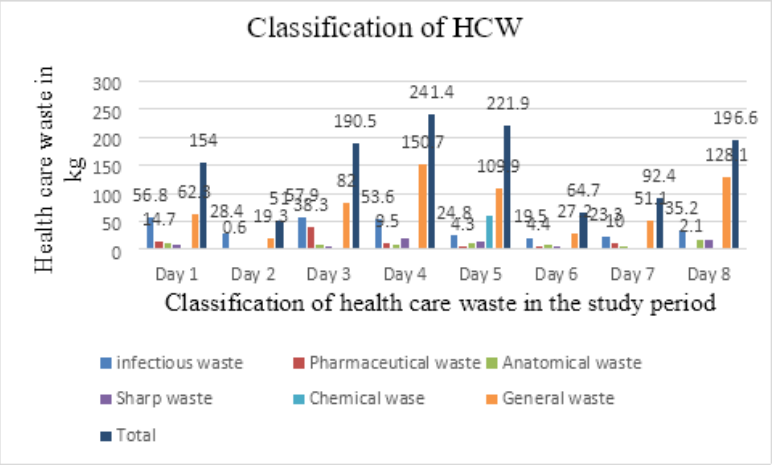

Figure 3

Classification of health care waste in DURH

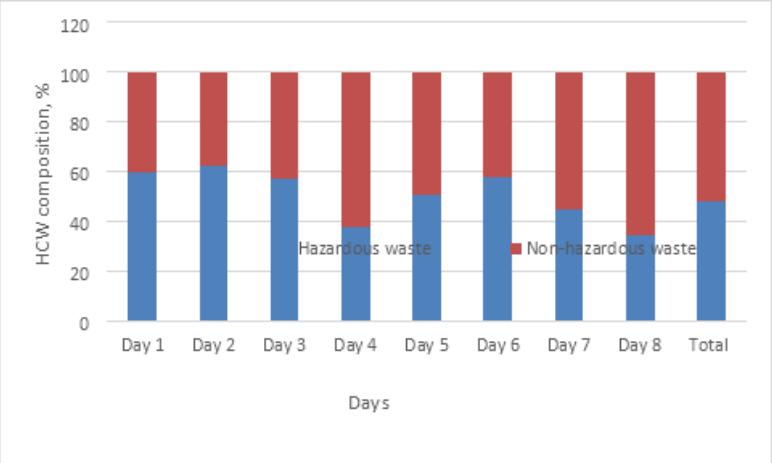

Figure 4

Hazardous and non-hazardous fraction of health care wase in DURH.

Figure 5

Disposal of health care waste in DURH