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COLLEGE OF HEALTH SCIENCE

SCHOOL OF PUBLIC HEALTH

ASSESSMENT OF HEALTHCARE WASTE GENERATION RATE, COMPOSITION AND ITS MANAGEMENT SYSTEM IN MENELLIK II REFERRAL HOSPITAL, ADDIS ABABA, ETHIOPIA.

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ADDIS ABABA UNIVERSITY
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LIST OF ABBREVIATIONS

AARHB	Addis Ababa City Administration Health Bureau
CASH	Clean and safe hospital
EFMHACA	Ethiopian Food, Medicine and Healthcare Administration and Control Authority
EOPD	Emergence Out Patient Department
FEPA	Federal Environmental Protection Authority
HAI	Hospital Acquired Infection
FMOH	Federal Ministry of Health
HBV	Hepatitis B virus
HCFs	Health Care Facilities
HCW	Health Care Waste
HCWM	Health Care Waste Management
HIV	Human Immune Virus
IPD	Inpatient department
IPPS	Infection prevention and patient safety
JICA	Japan International Cooperation Agency
KEPI	Kenya Expanded Program on Immunization
MCH	Maternal and child Health
MMIS	Making Medical Injections Safer
OPD	Outpatient department
OR	Operating Room
PPE	Personal Protective Equipment
UN	United Nation
WHO	World Health Organization

Abstract

Background: Healthcare facilities provide health service and prevent the public from health risk such as communicable disease. However, hospitals by virtue of handling patients generate hazardous waste which is potentially harmful to the environment if not handled and disposed properly. The amount and type of waste generated from the healthcare facilities is not well documented and managed in Ethiopia.

Objective: The objective of this study is to assess the health care waste generation rate, composition and its management system in Menelik II referral hospital, Addis Ababa.

Methods: An institutional based descriptive cross-sectional study design using both quantitative and qualitative methods was employed to assess the waste generation rate and management system in Menelik II referral hospital in Addis Ababa City. Standard weighing scale was used to quantify the generation rate of healthcare waste for seven days and observational check list for participatory walk through survey. The key informant interview guide also conducted to assess healthcare waste management practice. Data collectors and supervisor were recruited and trained. Data was entered in to Microsoft office excel version 2007 and transported to SPSS version 20 for analysis. Mean generation rates were determined based on important factors, the type of case teams. Patient flow, healthcare waste and its type generation rate among case teams were compared using Kruskal Wallis test and relation of visitors and amount of healthcare waste were determined by Pearson correlation.

Results: The mean waste generation rate was found to be 1.94 Kg/bed/day \pm 0.335, comprised of 40.9% general and 59.1% hazardous wastes. The amount of waste generated was significantly increased as the number of patient flow increased ($r=0.835$, $p<0.05$). Inpatients generated high proportion of total healthcare wastes than outpatient case teams ($t=4.353$, $p<0.01$). The mean waste generation rate was significantly varied among case teams ($X^2=56.558$, $p<0.0001$). The staff wrong attitude, resistance to wards waste segregation, collection and treatment practice, and lower managerial commitment resulted in poor healthcare waste management system.

Conclusions: The mean generation rate in the hospital is comparable to other studies in Ethiopia but higher than Sub Saharan African countries and the management of healthcare waste was poor. The composition of hazardous waste was 1.5 that of general waste ($t=2.8$, $P<0.05$) and the generations vary with patient load. The hospital should audit generation of waste to develop and implement effective and efficient waste management systems and conduct periodical surveillance of health care waste management practices.

1. INTRODUCTION

1.1. Background:

In pursuing aims of reducing health problems and eliminating potential risks to people health, healthcare facilities in rural or urban deliver health care service and on the other hand it inevitably generates waste that may itself be hazardous to health. The waste produced in the course of healthcare activities carries a higher potential for infection, injury and harmful environmental effects such as poisonous emissions from improper burning of medical waste , contamination of soil and water sources than any other type of waste (1,10) and are the second dangerous after radiation wastes in the world (2- 4).

Health care waste includes all wastes generated as a result of diagnosis, treatment or immunization of both human beings and animals. Health care facilities such as hospitals, research laboratories, medical and dental clinics, nursing homes, ambulance, mortuary and autopsy centers, etc. produce varying levels of health care wastes (1).

The report at United Nation (UN) general assembly explained approximately 75 to 80 % of the total waste generated by health-care facilities is general waste and does not pose any risk to public health or the environment, the remaining waste is regarded as hazardous and may create a variety of health risks if not managed and disposed of in an appropriate manner (1, 3, 5).

Unlike general wastes that do not require special handling, improper management of health-care wastes from hospitals, clinics, and other health facilities poses occupational and public health risks to patients, health workers, waste handlers, haulers, and communities (1, 3). In developing countries, scavenger families who make a living of recycling materials from open dumpsites are at great risk especially from sharps waste. The World Health Organization (WHO) estimates that unsterilized syringes cause between 8 to 16 million cases of hepatitis B, 2.3 to 4.7 million cases of hepatitis C, and 80,000 to 160,000 cases of HIV every year (1,6). Five point two million People in the world (including 4 million children) die each year from waste-related diseases (3)

In many countries, significant challenges persist with regard to the proper management and disposal of health-care waste. The amount of waste generated by healthcare facilities in developing countries is increasing because of the expansion of health-care systems and services, a

situation exacerbated by the lack of adequate technological and financial resources to ensure that health-care waste is managed and disposed of in a manner that is safe for human health and the environment (5, 7). As a result, majority of Health Care Facilities (HCFs) in developing countries suffer a variety of deprivations of health care waste management (HCWM) system starting from the point of waste generation up to the final disposal. An assessment done in 22 developing countries by WHO shows the proportion of HCFs that do not use proper waste disposal methods ranges from 18% - 64% (1, 8, 9). A study conducted in Metro Manila revealed that although most of the hospitals perform waste segregation, less than 50% of the 144 hospitals studied did not have the proper mechanisms for proper waste handling and segregation. Incineration and landfill were used for final disposal of wastes. Only two out of five hospitals had an existing waste management committee and a separate budget allocation for waste management program (1).

Similarly, studies conducted earlier in Kenya by Japan International Cooperation Agency (JICA) and the Kenya Expanded Program on Immunization (KEPI) in conjunction with WHO reveal that the HCWM practices encountered in most of the health care facilities do not comply with the international requirements to guarantee a safe and environmentally sound management of HCW (36).

In most HCFs in Ethiopia, waste is not separated according to proper segregation methods and it is difficult to quantify the type and amount of waste produced (11). The solid waste generation of Addis Ababa City was about 0.5 k.g per capita per day and its density ranges from 205-370 Kg/m³ with a total 1,000,000 m³ volume of solid waste per annum. The existing collection capacity was only 65 % of the total wastes generated and are transported to disposal site. The remaining wastes were dumped along the streets, on vacant plots, along streams, in ditches, bridges in a manner of polluting the environment (17).

The total quantity of HCW generated at hospitals of Addis Ababa studied in 2011 was a median of 182.5 kg/day with a non risk -HCW (median: 58.69%, range: 46.89–70.49%) and risk HCW (median: 41.31%, range: 29.5 – 53.12%)(12) and a similar study conducted in Amhara region by Tesfahune et al showed 56.4 % as hazardous waste (18). The management of health care waste at hospitals in Addis Ababa city was poor resulting in increment of the proportion of generation of hazardous HCW far from UN report is deleterious to the public health and environment(12).

Issue of HCWM is inadequately studied in Ethiopia. There is paucity of information to the public on generation rates, waste composition, environmental health risks, and factors of waste management. Observation indicates that medical waste is handled like any other municipal waste in many urban settings of Ethiopia. Public healthcare facilities that are increasing from time to time in the city were not established with standardized buildings and infrastructures to manage and dispose of HCW rather they dispose of HCW indiscriminately together with municipal wastes and even rarely in to the rivers(11,17). This study was conducted to reveal the gap of healthcare waste management system of Menelik II referral hospital in Addis Ababa city that could be used as baseline information about waste management system and how health care wastes handled from generation to ultimate disposal because the hospital was among the largest of the health bureaus' and the only forensic pathology service provider in the country.

1.2. Statement of the Problem.

HCW is an environmental as well as public health issue that attracts attention in both Industrialized and developing countries. It can not only impair the quality of life of the community, but can also affect the welfare of the entire population and the national economy.

On the other way health care institutions in recent times have increased tremendously in number, capacity and specialty with increasing health care services and number of hospital beds. There are 13 public hospitals of which the 6 are under Addis Ababa city Administration and the remaining to the FMOH and 35 private hospitals with varying services that are continuously providing preventive and curative health services to the people in Addis Ababa City and Ethiopia at large. Most of the health institutions and hospitals are concentrating around the cities specially Addis Ababa areas. These increasing healthcare institutions results in increasing load of medical waste generation, because of the increased consumption of disposable materials as a result of the spreading trend of (HIV/ ADIS), Hepatitis B Virus (HBV) and other agents associated with blood borne diseases including Ebola. Lack of onsite segregation practices, proper disposing system, and in general carelessness and least attention given on scientific medical waste management practice by healthcare facilities.

In Ethiopia, there are not many studies that show the current practices of HCWM. The few studies available are based on observation and are descriptive in nature. There is not sufficient recorded information on HCW management methods, quantity of HCW generation and technologies or infrastructures for treatment or disposal and this fact hinders the planning, implementation for better management of HCW (12). In addition in local situation of Ethiopia particularly Addis Ababa city, legislations and regulations concerning HCWM that are ratified were remained on paper and yet not implemented as expected more from the respective bodies: poor monitoring, supervision and enforcement of the laws (30). So it is necessary for Ethiopia to examine such HCWM in broader perspectives from generation to collection, storage, transportation, treatment and disposal. The management of medical waste therefore, should be of major concern due to potentially high risks to human health and the environment context of healthy medical facility decrease the number of health-care settings associated infections.

Therefore, this study was conducted to evaluate the present HCW management practices in Menellik II referral hospital, Addis Ababa city, to determine the daily quantity of waste generated, its composition, to identify factors affecting it and forward an appropriate HCW management approach for health institutions specially hospitals.

1.3. Rational of the Study

The mismanagement of healthcare waste poses considerable risks to public health and the environment. Healthcare workers, patients, waste handlers, and haulers etc are exposed to health risks from infectious waste such as sharps, chemicals and other special healthcare wastes.

Management of healthcare waste is becoming an issue of growing concern particularly in urban areas. The amputated body parts, blood and other body fluid, placentas, used syringes and scalpel blades are randomly dumped in the general waste landfill sites and rarely to rivers from health institutions so that to confirm the fact that healthcare wastes are being mismanaged and it is also an indication that there is urgent and critical need for the proper disposal of healthcare waste.

Therefore, the study has two main significances. First it gives some base line information to policy makers, health care waste handlers (hospitals) and environmental protection authorities about existing situation of healthcare waste management of the hospital. The study was also important in putting base line information to researcher who would like to conduct detailed and comprehensive studies either in public or private health institutions.

2. LITERATURE REVIEW

2.1. Understanding a healthcare waste

All human activities produce waste and we all know that such waste may be dangerous and needs safe disposal. Industrial waste, sewage and agricultural waste pollute water, soil and air; it can also be dangerous to human beings and environment. Similarly hospitals and health care facilities generate lots of waste which can transmit infections, particularly HIV, Hepatitis B and C and Tetanus, to the people who handle it or come in contact with it (1, 6). Open burning and incineration without adequate pollution control expose waste workers and the community to toxic contaminants in air emissions and ash (13).

HCW is the total waste stream from a health care facility that includes both potential infectious waste and non-infectious waste materials (14).

Infectious wastes include infectious sharps and infectious non-sharp materials. Infectious sharps consist of syringe or other needles, blades, infusion sets, broken glass or other items that can cause direct injury. Infectious non-sharps include materials that have been in contact with human blood, or its derivatives, bandages, swabs or items soaked with blood, isolation wastes from highly infectious patients (including food residues), used and obsolete vaccine vials, bedding and other contaminated materials infected with human pathogens. Human excreta from patients are also included in this category. Non-infectious wastes may include materials that have not been in contact with patients such as paper and plastic packaging, metal, glass or other wastes which are similar to household wastes (14-16).

2.2. Physical composition and characterization of healthcare waste

Healthcare waste is a small fraction of urban municipal waste. There should be a greater consensus on how much of the waste generated is actually infectious or hazardous. Infectious or hazardous hospital waste represents only a small part of total healthcare waste; yet, because of ethical questions and potential health risks, it is a focal point of public interest. Most hazardous and toxic waste is coming from clinic and hospital. Only a small amount is from domestic or industrial sources. According to WHO approximately 85% of hospital wastes are actually non-hazardous, 10% are infectious, and around 5% are non-infectious but hazardous (13-15).

Even though there is a variation of waste management practice, economy, life style, patient flow etc, the proportion of general and hazardous waste were also varied in similar setting in the US for example, about 15% of hospital wastes are regulated as infectious waste. In India this could range from 15 to 35% (25). In Pakistan about 20% of hospital waste is found to be potentially infectious or hazardous. 75-90% of waste is classified as 'domestic' in nature, 20-25% is deemed to be hazardous in Turkey and in Iran is about 29.89% (3). In Bangladesh, 36.03% in diagnostic centers and higher clinics was hazardous waste and around 200 metric tons of hospital wastes were generated per day in the city of Dhaka, Bangladesh. Of this amount, roughly 20% is infectious and hazardous (3). where as in Nigeria 26.5% , Sub-Saharan Africa countries about 2-10 % and about 50% in Tanzania constituted hazardous waste (3, 20, 40). Besides, a study conducted at two hospitals in Tanzania revealed that Ligula's hospital average generation rate was computed to be 2,482 kg/day. Its composition varied to general waste, the highest about (33%), followed by infectious waste (27%), pathological waste (19%), sharp waste (14%), chemical waste (3%), pharmaceutical (2%), radioactive waste 1% and pressurized containers (1%) where as in Amana the composition HCW was 33 % general, 29 % infectious, 19 % pathological, 14% sharp, 2 % pharmaceutical, 1%, radiological, 2% chemical and 0% pressurized containers(20).

In general, more than half of general waste from hospitals is paper, cardboard, and plastics, and the rest is food, metal, glass, cloth, wood, and other types of solid waste. Some have estimated that plastics could be as high as 60% especially in developed countries. Food waste accounted for 12 to 17% but could be as high as 25%. If properly segregated most general wastes from healthcare facilities are recyclable or compostable (13). But the study conducted in hospitals of Amhara regional state revealed that the total generation rate of HCW ranged from 0.25 to 2.77 kg/bed/day (median: 1.67 kg/bed/day) for inpatients to 0.21–0.65 in kg/patient/day (median: 0.31 kg/patient/day) for outpatients. It was also showed that the waste generation rate in private hospitals was (median 3.9 kg/bed/day) and in government hospitals (median 1.5 kg/bed/day) (18). A similar survey conducted in hospitals of Addis Ababa found 46.89%-70.49% (median: 58.69% general and 29.5-53.12% (median: 41.31%) hazardous waste composition (12). Besides, this was comparable to the findings of Hailemicheal et al (Median: 226.9 Kg/day, Range=189.9-318.3Kg/day) studied in HCFs in Hawassa city (19).

Even if there is variation of proportion of generation rate of HCW around the world, a research by WHO showed approximately 80% is non infectious and the remaining does pathological 15%, sharp 1%, pharmaceutical 3% and pressurized containers less than 1% (15).

2.3. Healthcare waste generation gate

The amount of solid wastes generated is usually directly related with the wealth of a society. The wealthier the country or community is, the greater will be the rate at which it generates wastes (14). As per WHO estimations, the total health-care waste per person per year in most low income countries is from 0.5 kg to 3 kg (36). Country wide average rates of waste generation in most industrialized countries lie between 0.8 and 1.4 kg per capita per day. In developing countries the average generation rate is within the range of 0.3 to 0.5 kg per capita per day (14.). Low income areas in urban centers in developing countries frequently generate the smallest quantities of waste; at times, as little as half the average of the city (21). However, an assessment of health care waste generation rate data from around the world shows that about 0.5 kg per bed per day is produced in hospitals (13).

A study done in Iran teaching hospitals shows that an average of 2.75 kg bed⁻¹ day⁻¹ (standard deviation, ± 0.176) of which 0.344 kg bed⁻¹ day⁻¹ (standard deviation ± 0.094) infectious waste was generated with the proportion of general waste about 85 to 90% (average, 87.49%), and the medical waste constituted up to 20% of the total (average, 12.51%). Similar to this, approximately 1.35 kg/bed/day of HCW is produced on average in the Pakistani hospitals which produce about 250,000 tons of HCW per year. Even if denominator, hospital specialty, no of beds affects the generation, hospital in Iran generates more HCW than Pakistan but with WHO standard proportion (4, 22). The estimated HCW generation in Nigeria was between 0.562 to 0.670 kg/bed/day (23).). A study done at 6/2 hospitals in Tanzania by Mato and Kassenga in (1997/2011) showed that health care waste generation rate ranges from 0.84 to 5.8/1.9 Kg/bed/day (20, 24,).

The health care waste generation rate in Ethiopia, a study done by Debere et al at hospitals in Addis Ababa was between 86.15 to 278.85kg./day (12). In lower-income countries, as well as poorer parts of middle-income nations such as Ethiopia, an estimated of 30 to 50% solid waste produced in urban areas is left uncollected. Some viral and other infectious diseases are associated with waste and also serve as habitat formation for breeding insects and mosquitoes (11).

The total and infectious waste generation rate is varying with type of facility in Tanzania, low income countries- larger in hospitals(0.14 kg/patient/day, 0.08 kg/patient/day) and smaller in Urban dispensaries (0.02 kg/patient-day, 0.01 kg/patient-day) respectively (15). It is also similar for middle-income countries South Africa varies from 1.24 kg/patient-bed-day relatively larger in National central hospital and 0.024 kg/patient-day smaller in Public community health centre (15).

Generally, the annual HCW generation (kg/head of population) is different according to income level (with a range of high-income countries: 1.1-12, Middle-income countries: 0.8–6.0 and Low-income countries: 0.5–3.0) (15).

2.4. Factors affecting healthcare waste generation rate

Waste generation data are used in estimating the required capacities for containers, storage areas, transport or treatment technologies. Waste generation data have been used to establish baselines and for procurement specifications, planning, budgeting, calculating revenues from recycling, optimization of waste management systems, and environmental impact assessments. They are also used for national assessments and national planning. level of activity (often measured in terms of the number of occupied beds plus number of outpatients per day, total number of patients per day, and/or number of staff); this is also linked to the average length of stay of patients which may reflect the intensity of care; type of department (e.g., general ward, surgical theatre, office, etc.); type or level of facility (e.g., clinic, provincial hospital, etc.); location (rural or urban); regulations or policies on waste classification; monitoring and enforcement by local or national authorities; extent of use of disposable materials; procurement policies; segregation practices; extent of recycling, inventory control and other waste minimization activities; temporal variations (e.g., week day versus weekend, seasonal) and level of development of the country (13).

2.5. Health care waste management system

Segregation is the key to efficient healthcare waste management. Other elements of healthcare waste management are: waste classification, waste minimization, containerization, color coding, labeling, handling, transport, storage, treatment, and final disposal (11, 13, 26, 27 and 28). Planning and implementation of a healthcare waste management system must address compliance with regulations, defining roles and responsibilities of healthcare staff, specific

procedures, and training (21, 29). The process of institutionalization of a good healthcare waste management system entails a waste assessment and evaluation of existing practices, evaluation of waste management options, development of a waste management plan, promulgation of institutional policies and guidelines, allocation of human and financial resources, implementation of plans according to a set timelines, a program of periodic training, monitoring, evaluation, and continuous improvement (11, 29).

Iran has neither a satisfactory waste disposal system nor a waste management and disposal policy (22). Lack of separation between hazardous and non-hazardous waste, an absence of the necessary rules and regulations applying to the collection of waste from hospital wards and on-site transport to a temporary storage location, a lack of proper waste treatment, and disposal of hospital waste along with municipal garbage, were the main disparities in Iran (22).

Although healthcare waste management directive (June 2005) and solid waste management proclamation (513/2007) were approved and implemented by Ethiopian Food, Medicine and Healthcare Administration and Control (EFMHACA), Federal Environmental Protection Authority (EEPA) respectively, waste management was not yet soundly disposed according to the principle in Ethiopia specially Addis Ababa (12, 30)

The WHO recommended storage periods between the generation and treatment of health-care waste were for temperate climate: maximum 72 hours in winter; maximum 48 hours in summer and for warm climate: maximum 48 hours during the cool season maximum 24 hours during the hot season. But, anatomical waste should be stored at a temperature of 3° C to 8° C. All infectious waste must be refrigerated at a temperature of 3° C to 8° C if stored for more than a week (14, 28). Whereas in Our country study done at Addis Ababa both government and private hospitals stores HCW for a day in most hospitals and a week in few hospitals (12).

Observation of a study in hospitals of Iran showed that none of the hospitals routinely segregated general and HCW and used two types of waste segregation and temporary storage materials (22). The lack of segregation between general and infectious waste, an absence of rules and regulations applying to the collection of waste and the on-site transport to a temporary storage location, a lack of proper waste treatment, disposal of HCW along with municipal garbage, insufficient training of personnel, insufficient personal protective equipment (PPE) and lack of knowledge about the proper use of such equipment are among the factors contributing to poor HCW management in Addis Ababa hospitals (12).

The HCW should be segregated for collection by using colored bags and containers (plastic, metal or paper) (24, 31). A study in four hospitals of Nablus city revealed that segregation of all waste materials was not conducted according to definite rules and standards. None of them used color coding. Although treatment technologies and disposal methods differ for each type of HCW, segregation at source into different items reduces the management, operation and treatment costs along with the risk of infection with these contaminants (4, 27, 29). Most African countries, waste disposal system were not successful. A study conducted in HCFs in Tanzania has shown that in Ilala only 54% and in Kinondoni only 10% of the surveyed HCFs have waste disposal sites (21). Some of the waste is disposed off in open areas and some into latrines and in rubbish pits. A report by Making Medical Injections Safer (MMIS) project conducted in District health facilities in Ethiopia showed that the most common methods of HCW disposal were open burning in a hole

54%, low-temperature incineration 52% and open air burning on the ground 18% (26). A study conducted in Hawasa in 2012 revealed that 89% of the HCF used low combustion, single chamber incinerators for disposing wastes while the rest used open burning and other methods (19). Management of HCW has received attention in many developing countries. However, in Ethiopia systematic and comprehensive studies on HCW management are lacking. There is not sufficient recorded information on HCW management methods and technologies and this fact hinders the planning for better management of HCW (2).

2.6. Risk of HCW on occupational safety and public health

Poor management of health-care waste can cause serious disease to health-care personnel, to waste workers, patients and to the general public. The greatest risk posed by infectious waste is accidental needle stick injuries, which can cause hepatitis B and hepatitis C and HIV infection (31). There are however numerous other diseases which could be transmitted by contact with infectious health-care wastes (16). In addition to the health risks, due consideration must be given to the impact on the environment and especially to the risk of pollution of water; air, soil etc and aesthetic harm too (22, 32).

2.7. Conceptual frame work

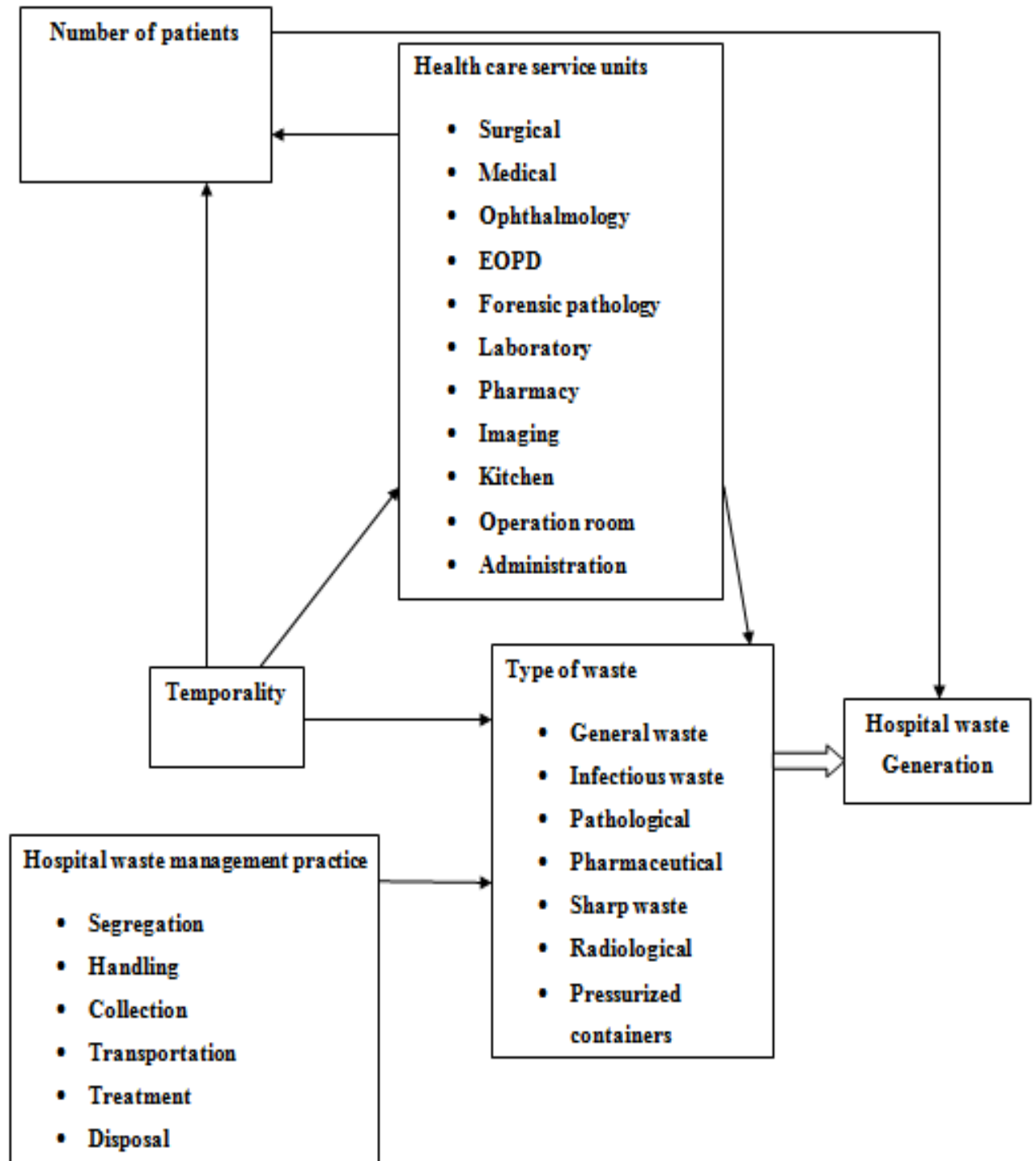


Figure 1: Factors that determine healthcare waste generation and management in Hospitals, Addis Ababa, Ethiopia (Source 12, 33).

3. OBJECTIVES

3.1. General Objective:-

To assess the healthcare waste generation rate, composition and its management system of Menelik II referral hospital, Addis Ababa, Ethiopia, 2015.

3.2. Specific Objective:-

1. To assess the amount of healthcare wastes generated in the hospital.
2. To identify the type and composition of HCW generated in the hospital.
3. To assess factors affecting HCW generation rate of the hospital.
4. To assess the healthcare waste management system of the hospital.

4. METHODS AND MATERIALS

4.1. Study Area and population

The study was conducted in Addis Ababa, the Capital City of the Federal Democratic Republic of Ethiopia, diplomatic capital of Africa and the seat of numerous international and regional organizations. Addis Ababa has population of 3,384,569 with annual growth rate of 3.8 % and population density of 5,165.1/km² within area of 527 km² (2007 census). In the City there are 48 Hospitals, 84 health centers and 647 clinics (Addis Ababa FMHACA). Of the hospitals 5 of them are specialized and they are under the governance of FMOH, 6 are under Addis Ababa city Administration Health Bureau (ACAHB), 1 to the defense, 1 to the police and 35 hospitals are privately owned. Among the private hospitals; 22 were general, 10 MCH, 2 cardiovascular and 1 orthopedic hospital and that of the government except Amanuel psychiatry hospital provide general healthcare services.

Menelik II referral hospital, under the administration of Addis Ababa City Administration Health Bureau, was the first hospital in Ethiopia. The hospital was providing its first healthcare services in a tent to treat people who participated in the battle of Adwa specially soldiers with the support of Russian Red Cross workers on March 16, 1898 GC. But the service was not continued for years because of interruption of the support from Russian government. Later on the hospital was reestablished again in the present location without external support by Ethiopian government in 1909 GC.

At present the hospital is providing almost general healthcare services except pediatrics and maternity cases. Surgical, medical, orthopedics, ophthalmology, ENT, dental, ART, psychiatry, neurology, forensic pathology -the only in the country etc were among healthcare services provided in it.

Menelik II hospital has around 199 functional beds, a total of 645 permanent and contract employees. Of which 360 are health workers (20 specialist, 34 general practitioner, 7 health officers, 222 nurses, 15 anesthetist, 22 laboratory, 13 radiotherapy, 20 pharmacy, 2 environmental health and others workers), 257 support and 28 contract employees. The bed occupancy was 73.7% (the 2014/15 midyear report).

4.2. Study Design and Period

A cross-sectional institution based survey was conducted to quantify waste generation rate and assess HCW management system qualitatively from February 17 to 24, 2015 in Menellik II referral hospital of Addis Ababa City.

4.3. Source population:

All public hospitals under Addis Ababa City Administration, its HCW generation and management system. In the city Administration, there are 6 public hospitals.

4.4. Study population

Menellik II referral hospital that was providing healthcare service in the city administration, the HCW generated at the hospital and case teams in it. The study participants included an environmental health officer, waste handlers, management members and key case team leaders.

4.5. Sample size and sample size determination

In Addis Ababa city Administration, there are 6 hospitals which have similar settings in infrastructure and administration. Menellik II referral hospital was selected purposefully for the study because it was the only hospitals providing forensic pathology had largest number of beds and staff assuming increased rate of waste generation. A similar assumption was also followed by Haylamicheal et al. (2011). The resource and feasibility was considered for the selection of the studied hospital. Generation rate quantified and management practices assessed in all the case teams. Key informants from each case team and administrator in the hospital were selected for the assessment of HCWM system. By assuming all case teams (OPD, IPD,OR, laboratory, imaging, pharmacy, forensic pathology, kitchen, etc) as points of HCW generation, one key informant from each case team a total of 11 workers or administrator were selected in the hospital from correspondence healthcare service and administration case teams for the assessment of HCW management practice.

4.6. Sampling procedures

Of the public hospitals delivering healthcare service currently in the city administration, Menelik II referral hospital was selected purposively. Therefore 7+1 days of HCW measurements were conducted, the earmarked WHO's standard number of measurements for one hospital. A similar assumption was followed by Tesfahun E. et al (2014) and debere et al (2012). A total of 11 key informants were also interviewed to assess HCWM system from various case teams. The sampling frame work was as follows.

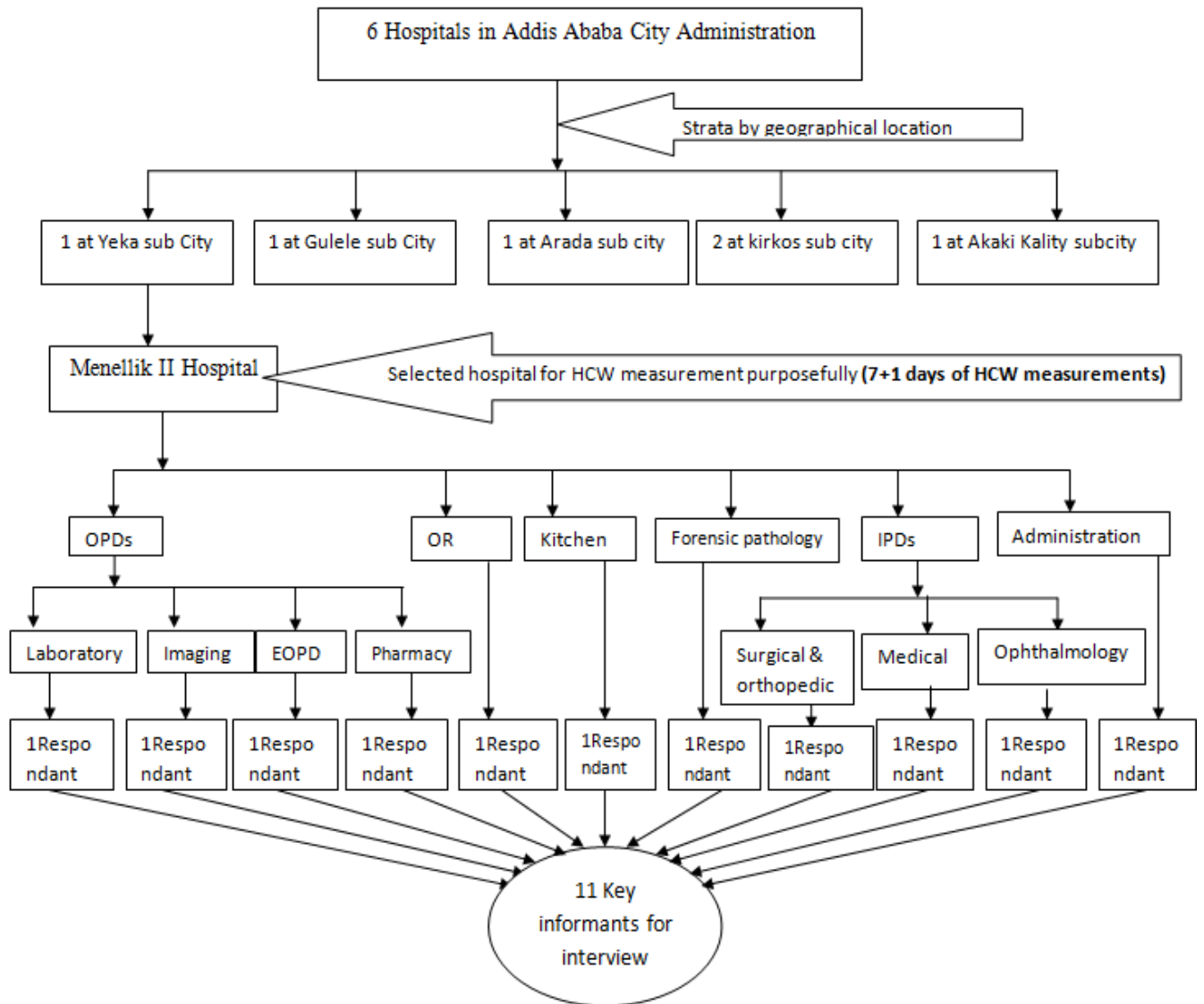


Figure 2: Sampling framework of studying public hospitals in Addis Ababa

4.7. Inclusion and exclusion criteria

4.7.1. Inclusion criteria: Any case team generating waste in hospital and permanent workers were studied and interviewed respectively.

4.7.2. Exclusion criteria: The liquid healthcare waste generated was not studied.

4.8 Data collection tools and procedures

Observational checklist, key informant interview guide and weighing scale recording format data sheet were used to assess composition, type, management practice and quantify generation rate. The daily generation of waste together with the number of beds occupied and patients treated in outpatient case teams were recorded daily from liaison, triage and registration case teams for denominator. The number of bed being occupied (bed occupancy) were used to calculate the daily waste generation rate. One environmental health professional for supervision and three college completed data collectors were recruited then trained for a day course about HCW measurement and field data collection. Data collection tools and protocols were demonstrated for data collectors and supervisor.

A. Walk through survey

An English version observational checklist for participatory walk through survey (on-site observation) was used by trained data collector of an environmental health background to inspect the healthcare waste management system in terms of segregation, storage, collection, treatment, general facilities' sanitary condition and availability of sanitary facilities. An assessment in the hospital was conducted to identify the type of HCW generated. All healthcare case teams were inspected i.e. OPDs, pharmacy, Imaging, laboratory, forensic pathology, inpatients (medical, surgical, ophthalmology, orthopedics), kitchen, lounges operating rooms and administration offices.

B. Interviews on Waste handling practice, materials used for waste management system, waste management policy and type of HCW generated variables

Key informant interview guide was used for interviewing health care workers and janitors from healthcare service and administration case teams by trained data collectors to evaluate the status

of the current waste handling practice of the hospital whether healthcare workers or janitors handle and manage HCW properly, what materials they used etc.

C.HCW Measurement

Standard weighing scale of N electronic balance XY 1000JB number 1210223 readability 0.1g capacity ranges of 1.1 Kg and UNICEF donated balance—EK5-fonds Des Nations Unies Pour L’Enfance” with capacity range of 120 kg calibrated with a known 0.50 kg and 1 kg weight were used after assessment of HCWM system. Graduated cylinders, 20 litter capacity range, were also used for volumetric measurement.

Waste was collected from each case teams and measured from February 17 to 24, 2015 G.C (to consider temporal variation) at 8:00 am every morning for eight consecutive days. Only the seven days HCW measurements were used for quantification of generation rate by dropping the first day generation for clearing cumulated wastes.

Four plastic buckets of different colors (red, yellow, blue, black) were arranged with biohazard plastic bags for each studying case teams: OPDs, IPDs, laboratory, pharmacy, operation room, emergency, food catering and administration office. A yellow safety box was also used for sharps and syringe handling. All waste collection buckets, safety boxes and biohazard bags obtained for the study were labeled to indicate the different categories of healthcare waste, date of collection and name of case team. The labeled black bin were used for non risk/ infectious waste or general waste (paper, packaging, food, boxes, glass, water bottle plastic, etc.); yellow bin for infectious clinical waste (Any materials containing blood or body fluids such as gauze, dressings, IV lines, gloves, anatomical waste, used specimen container); red bin for highly infectious amputated body parts, and glands , anatomical; blue bin for Chemicals (Formaldehyde, pathological, chemical, solvents, organic and inorganic chemicals) and safety boxes for sharps and needle waste (syringes, needles, lancets, blades, scalpels, broken glass, etc).

4.9. Variables

Dependent variable

- ❖ HCW generation rate
- ❖ Healthcare waste management practice
- ❖ Type of healthcare waste

Independent variable

- ❖ Availability of materials for HCWM
- ❖ Type of materials used for waste management system
- ❖ Presence of waste management policy and guideline.
- ❖ HCW segregation practice
- ❖ Number of inpatients
- ❖ Number of beds and bed occupancy rate
- ❖ Type of service or specialty of hospital

4.10. Operational Definitions

Infectious waste: is suspected to contain pathogens (bacteria, viruses, parasites, or fungi) example includes samples from laboratories, waste from pathology and dialysis from infected patients.

Pathological waste: Human tissues, organ or fluids e.g. body parts; blood and other body fluids

Sharp waste: e.g. needles; infusion sets; scalpels; knives; blades; broken glass

Pharmaceutical waste: Waste containing pharmaceuticals and chemicals that are expired; contaminated pharmaceuticals and packaging containers (e.g. tins, bottles, boxes, bags)

Pressurized containers: Gas cartridges; aerosol cans (flit, air fressioner).

Radiological waste: e.g film developer, fixer, film paper and ultra sound jell.

Hazardous waste: The wastes generated that poses substantial or potential threats to public health and the environment (all wastes other than general or non risk waste).

General waste: wastes largely composed of domestic or house hold type of waste which is not infected, contaminated with blood or body fluid and non-hazardous to human beings

Segregation: keeping noninfectious waste out of the infectious waste stream

Handling: The functions associated with the movement of waste materials.

Color coding: Designates the use of different colors for the storage of various types of HCW.

Storage: The placement of waste in a suitable location where isolation, environmental and health protection and human control are provided. This is done with the intention that the waste will be subsequently retrieved for treatment and disposal.

Disposal: Intentional burial, deposit, dumping, release of any waste material on land, water, air.

Treatment: Any technique or process for altering the biological, chemical or physical characteristics of waste to reduce its hazard and the costs of disposal. E.g. incineration for volume reduction and microbial destruction; disinfection using bleaching agent or disinfectant etc.

Healthcare waste management practice: when four indicators for healthcare waste management system are exercised i.e. (always using PPE during handling of waste, segregate wastes with the available containers, treating infectious wastes and using always the available waste bins).

Outpatient: Department that provides healthcare service for only ambulatory patients (for 24 hrs).

Inpatient: Department that provides healthcare service for only admitted patients (more than 24 hrs)

Case team: A collection of two or more specialized workers making a team in HCF as separate unit.

Day: A 24 hours starting from 8:00 AM.

4.11. Data Management

Data cleaning was performed by running each variable to check the accuracy, inconsistency and missed values. The overall sum of the analogue of each measurement was checked for accuracy of data. The raw data recorded and collected from the field was coded first and entered in to Microsoft office excel version 2007 for data cleaning, tabulation and organization then transported to Statistical Package for the Social Sciences (SPSS) version 20 software for summarization and analysis.

4.12. Data Analysis

The analysis was computed separately for each case teams grouped by inpatients and outpatients, and type of healthcare waste. The data distributions were explored using normality test which showed that the data were normally distributed.

Descriptive statistics of frequency count, mean, standard deviation, tabulation and percentages were used to summarize generation of HCW into meaningful form. The result was also presented using tables, pie chart, graph, pictures and box plot. The healthcare waste generation rates were

reported on the basis of kg/bed/day, kg/patient/day and kg/outpatient/day, as described by Pruss and Tesfahune et al (14, 18).

The relationship between the quantities of total HCW generated and number of patients was tested using Pearson correlation coefficient. The number of patients visited the hospital, the total amount of waste generated and its type among various case teams was compared using Kruskal Wallis test because the data distribution was not homogeneous (with unequal variance) even when transformed. Therefore ANOVA was not used for comparison in such cases. Evaluation of waste management system was performed manually. The waste characterization was conducted in accordance with (WHO) guidelines (14) based on the characterization the waste composition was reported using different descriptive statistics such as percentages to evidence segregation practice. Statistical test for significance was based on 5% level of significance (95% confidence level) and r also reported for strength and direction of linear relationship of patient flow and HCW generation rate.

4.13. Data quality assurance

To assure data quality, standardized check list adapted from WHO and FMOH assessment tool was used for data collection.

Pre-test was conducted for one day prior to the actual data collection period to assure accuracy and validity of the weighing scale recording data sheet, observational checklist and key informant guide. Weighing scale was checked for calibration using known 0.50kg, and 1 kg weighed objects every morning before the actual measurement started during data collection day. The walk through inspection and key informant interview guide was conducted before the measurement of HCW to minimize informant bias.

The quality of data was also maintained through recruiting and training of college completed data collectors and an environmental health professional supervisor. HCW data collection manual was provided for all data collectors and supervisor. There was a meeting with data collectors every day after completion of the daily data collection process to check data inconsistencies. The principal investigator monitored or maintained the overall activity.

4.14. Ethical consideration

Ethical clearance was obtained from School of Public Health, Addis Ababa University. Permission for data collection was taken from Addis Ababa City Administration Health Bureau and hospital

administration. Verbal and written consent was obtained from the manager of the hospital. HCW data collection manual was prepared and data collectors were provided and trained to use personal protective devices while measuring healthcare wastes. The supervisor was made alert for the provision of medical assistance for sharps and needle stick injuries. On job health education related to hazardous waste management was given to workers immediately after data collection. Recommendation was given to hospital managers for poor HCW management practice what was observed during the assessment.

4.15. Dissemination of results

The result of the study was submitted to the School of Public Health, Addis Ababa University. In addition, the study will be disseminated to the concerned body such as Addis Ababa regional health bureau, Addis Ababa environmental protection authority, Addis Ababa food, medicine and health care administration and control authority and the hospital. The study will be presented to the reviewed publication committee. Effort will also exert to publish the findings on peer reviewed scientific journals.

5. Results

5.1. Profiles of healthcare waste by source

All healthcare delivery case teams were included in the study to quantify healthcare waste generation rate in terms of weight and volume, and to assess its management system. Medical, surgical, ophthalmology, orthopedic, laboratory examination, radiological investigations, ART/VCT, pharmacy, forensic pathology were the type of service that had been given and considered during the study period. During provision of healthcare services in the study period different type of HCW were generated.

Menellik II referral hospital has 199 beds and the midyear 2014/15 bed occupancy was 73.7 % while the bed occupancy in the seven days data collection was 82.63%.

A total of 4524 patients visited in all case teams, of which 1151 (25.44%) patients admitted to IPDs in the hospital within seven days. The average daily patient attendance over all in the hospital, inpatient and outpatient case teams were 646.29(\pm 284.85), 164.43(\pm 7.74), 481.86(\pm 279.67) respectively (Table 1).

Table 1: Daily distribution of patient flow in IPDs, OPDs and all case teams (%) in Menellik II referral hospital, Addis Ababa, February 2015.

Days of HCW measurement	No of Inpatients/ day	Outpatient attendance / day	Patient flow/day in all case teams (IPD+OPD)
Wednesday*	168(21.27)	622(78.73)	790(17.46)
Thursday	165(22.60)	565(77.40)	730(16.14)
Friday	159(19.56)	654(80.44)	813(17.97)
Saturday	151(56.13)	118(43.87)	269(5.95)
Sunday	163(77.25)	48(22.75)	211(4.66)
Monday	171(21.98)	607(78.02)	778(17.20)
Tuesday	174(18.65)	759(81.35)	933(20.62)
Total	1151	3373	4524
Mean	164.43	481.86	646.29
Standard Deviation	(\pm 7.74)	(\pm 279.67)	(\pm 284.85)

* Starting day of data collection

5.2. Healthcare waste generation rate

5.2.1. Daily generation rate of HCW

The total quantity of weight and volume of HCW generated at the hospital was a mean of 318.11 kg/day (± 49.3) and 1.98 m³/day (± 0.311) respectively yielding a density of 160.95 kg/m³ (Table 2). Two types of HCW were generated: general (mean: 130.20 Kg/day, SD: 38.22) and hazardous (mean: 187.89 Kg/day, SD: 38.85). The composition was 40.9% accounted to general HCW and the remaining 59.1% was hazardous HCW. Generation of hazardous waste was nearly 1.5 times that of general waste ($t=2.796$, $p<0.05$). The highest generation was occurred on Thursday (17.09%) and the smallest at the weekend on Saturday (9.97%). Generally, the generation of percentage by weight of hazardous HCW was higher than the percentage by weight of general HCW in most days of HCW measurement period (Table 2).

Table 2: Daily healthcare waste generation (%) in 7 days of HCW measurement in Menelik II hospital, Addis Ababa, February 2015.

Days of HCW Measureme nt	Total HCW		General HCW		Hazardous HCW	
	Weight (kg)	Volume (m ³)	Weight (Kg)	Volume (m ³)	Weight (Kg)	Volume (m ³)
Wednesday	336.877(15.13)	2.15(15.55)	146.39 (43.45)	1.02(19.1)	190.491 (56.55)	1.13(13.75)
Thursday	338.684(15.21)	2.23(16.12)	100 (29.533)	0.74(13.14)	238.684 (70.47)	1.5(18.22)
Friday	331.50 (14.89)	1.96(14.17)	118.6 (35.78)	0.8(14.30)	212.906 (64.22)	1.159(14.1)
Saturday	222.09(9.97)	1.61(11.64)	69.6 (31.34)	0.48(6.64)	152.049 (68.66)	1.13(13.74)
Sunday	297.046(13.34)	1.58(11.42)	174 (58.58)	0.605(10.7)	123.046 (41.42)	0.97(11.83)
Monday	319.956(14.37)	1.89(13.67)	127.9 (39.97)	0.78(13.9)	192.056 (60.03)	1.11(13.48)
Tuesday	380.602(17.09)	2.41(17.43)	174.5 (45.85)	1.18(21.0)	206.102 (54.15)	1.23(14.92)
Mean	318.11	1.98	130.20	0.801	187.89	1.174
SD	49.34	0.311	38.22	0.2359	38.85	0.161
Total	2226.77	13.83	911 (40.91)	5.61	1315.7 (59.09)	8.221

From the hazardous waste category, the majority was infectious (0.265 Kg/total patient/day) and sharp (0.0087 kg/total patient/day) and the rest radiological, pharmaceutical and pathological were (0.0083 Kg/total patient/day), (0.0068 Kg/total patient/day) and (0.0025 Kg/total patient/day) respectively (Table 3). The mean total HCW generation rate of the hospital was computed to be 0.493 kg/staff/day, 1.94 Kg/bed/day and 0.49 Kg/total patient/day by weight, and 0.012 m³/bed/day by volume. Of Which 0.79 Kg/bed/day (40.91%) was general waste and 1.15 Kg/bed/day (59.09%) was accounted hazardous HCW (Table 2, 3). Whereas, of the volume of HCW generated, infectious waste was the largest volume 55.65 % (0.0067 m³/bed/day) and the smallest one was pressurized containers which accounted to 0.02168 % (0.000002 Kg/bed/day).

Table 3: Daily generation rates of types of HCW (Mean, SD) in Menelik II referral hospital, Addis Ababa, February, 2015.

Type of HCW	Mean	SD	Kg/bed/day	Kg/OT**/day	Kg/TP*/day	m ³ /bed/day
General	130.20	38.22	0.79	0.27	0.201	0.0049
Infectious	170.93	35.48	1.042	0.355	0.265	0.0067
Pathological	1.643	2.688	0.01	0.0034	0.00254	0.000097
Sharp	5.63	3.638	0.034	0.0117	0.0087	0.000180
Pharmaceuticals	4.37	2.86	0.027	0.0091	0.00677	0.000197
Radiological	5.36	0	0.033	0.0111	0.0083	0.000061
Pressurized containers	0.254	-	0.00022	0.000075	0.000056	0.000002
Total	-	-	1.94	0.66	0.49	0.012

*TP= Total patient (IPD+OPD)

**OT=Outpatient only

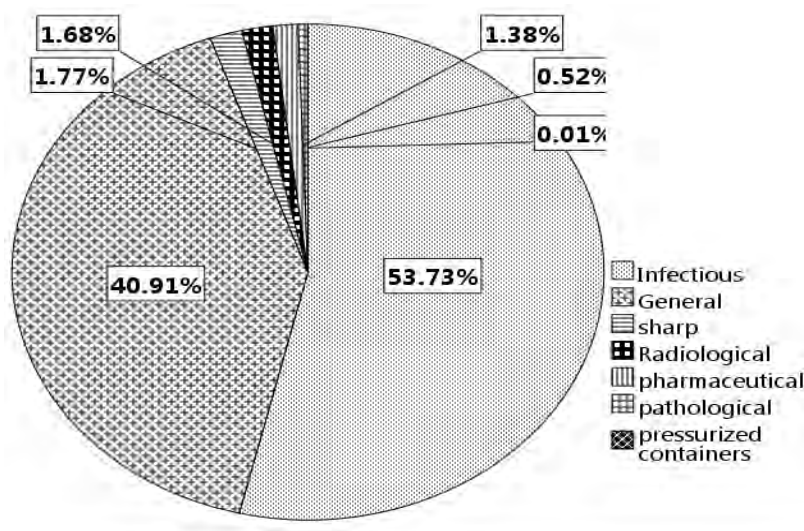
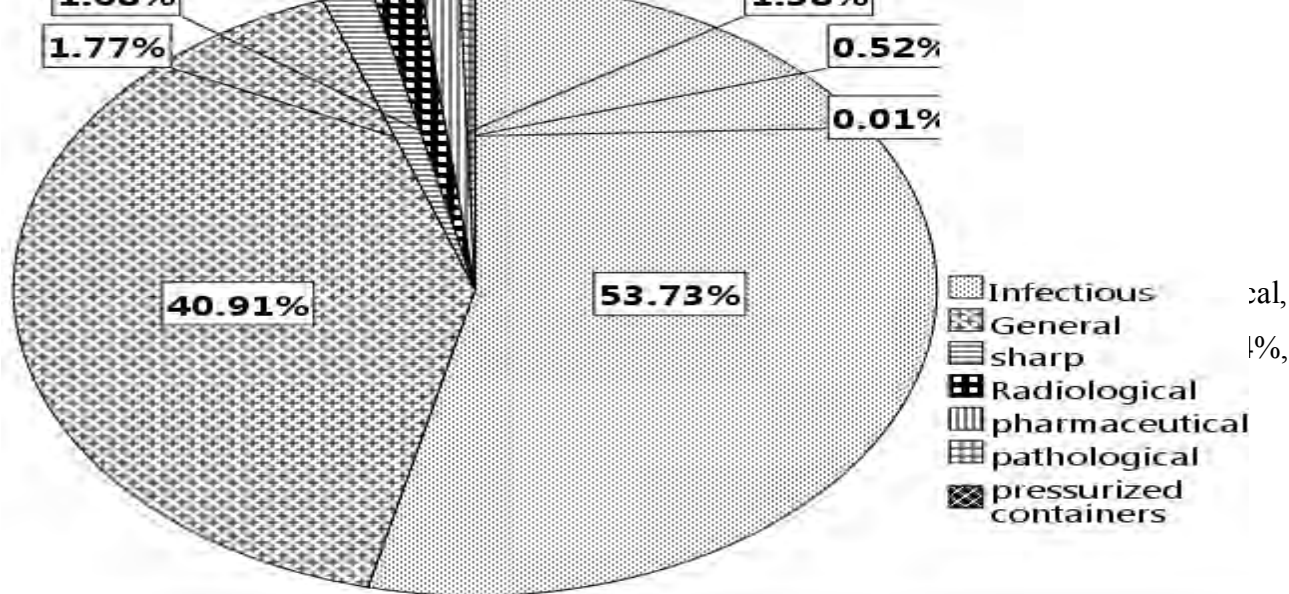


Figure 3: The percentage contribution of types of HCW generation in the total HCW stream in Menelik II hospital, Addis Ababa, February 2015.

In most of the case teams, general waste was the second leading generated waste next to infectious waste than the rest category of waste (Table 4). Pathological waste was generated only in operating room (4.47%) and laboratory (4.87%) where as sharp waste was larger in laboratory (12.31%), outpatients (5.13%) and surgical IPD (2.21%). The largest generation of HCW by volume was occurred in medical IPD 0.39 m³/day (19.94%) and Outpatients 0.308 m³/day (15.59%).

Table 4: Amount of HCW generated and their composition by type of HCW (Kg/ 7 days) (%) in each case team in Menellik II hospital, Addis Ababa, February 2014

Names of Case teams	Composition of HCW (Kg/ 7 days) (%)							Volume (m ³ /day)
	General	Infectious	Pathological	Sharps	Pharmaceutical	Radiological	Pressurized container	
Orthopedic IPD	64.5 (26.94)	174 (72.68)	-	0.901 (0.38)	-	-	-	0.186 (9.42)
Medical IP	151.19 (31.81)	310 (65.27)	-	7.838 (1.65)	6 (1.26)	-	-	0.3939 (19.94)
Surgical IPD	67.56 (25.63)	184.29 (69.63)	-	5.83 (2.21)	6 (2.28)	-	-	0.2873 (14.54)
Ophthalmology IPD	66.3 (61.75)	40.5 (37.72)	-	0.58 (0.54)	-	-	-	0.053 (2.68)
OPD	112.9 (35.30)	190.3 (59.49)	-	16.42 (5.13)	-	-	0.254 (0.08)	0.308 (15.59)
Laboratory	8.5 (16.56)	28 (54.56)	2.5 (4.87)	6.38 (12.31)	6 (11.69)	-	-	0.054 (2.73)
Forensic pathology	12 (12.12)	87 (87.88)	-	-	-	-	-	0.086 (4.35)
OR	28.14 (13.99)	155.5 (77.31)	9 (4.47)	1.5 (0.75)	7 (0.48)	-	-	0.264 (13.37)
Imaging	10 (18.01)	8 (14.41)	-	-	-	37.52 (67.58)	-	0.027 (1.37)
Laundry	-	19 (100)	-	-	-	-	-	0.02 (1.1)
Food catering	99 (100)	-	-	-	-	-	-	0.04 (2.03)
Lounges	228 (100)	-	-	-	-	-	-	0.15 (7.6)
Administration	17 (100)	-	-	-	-	-	-	0.03 (1.3)

The highest generation among category of HCW in the facility was infectious waste accounted 170.93 Kg/day while the lowest was pressurized containers which accounted 0.036 Kg/day. The density of healthcare waste generated was 160.95 Kg/m³. Pathological waste was the denser (713.04 Kg/m³) and pressurized containers was the lighter one (83.72 Kg/m³) (Table 5).

Table 5: Daily generation of different categories of HCW in Menellik II referral hospital, Addis Ababa, February 2015.

Types of HCW	HCW generation				
	Weight (Kg/day)	Volume (m ³ /day)	% by weight	% by Volume	Density (Kg/m ³)
General	130.14	0.8012	40.91	40.56	162.43
Infectious	170.93	1.0998	53.73	55.67	155.42
Pathological	1.64	0.0023	0.52	0.12	713.04
Sharp	5.63	0.0295	1.77	1.49	190.85
Pharmaceutical	4.37	0.0323	1.37	1.64	135.29
Radiological	5.36	0.01	1.68	0.51	536
P .containers	0.036	0.00043	0.01	0.022	83.72
Total	318.11	1.98	99.99	99.99	160.95

The amount of healthcare waste generation rate in each case team was different. The mean (\pm SD) HCW generation rate in each case team was 26.31 ± 19.07 kg/day. The largest generation of HCW was at Medical IPDs (21.33 %) where as the lesser amount of HCW was generated at administration office (0.76%). There was statistically significance difference of HCW generation rate in each case team in the facility ($X^2=57.471$, $p<0.0001$, $df=13$). The percentage of hazardous waste generation rate was higher than generation of general waste in most case teams. The highest generation rate of HCW among IPDs (0.16388 Kg/bed/day) was recorded in Medical IPD while the lowest rate (0.0782 kg/bed/day) was found in Ophthalmology IPD (Table 6).

Table 6: Summary of daily HCW generation rate and percentages of HCW composition by point of generation (case teams) in Menelik II Hospital, Addis Ababa, February 2015.

Point of HCW generation	Total HCW in 7 days (kg)	Mean \pm SD HCW (kg/day)	% of generation of HCW/ total case teams (%)	Percentage/case teams		Total Patient
				General (%)	Hazardous (%)	
Orthopedic IPD	239.401	34.14 \pm 9.24	10.75	26.94	73.06	245
Medical IPD	474.94	67.71 \pm 10.44	21.33	31.81	68.19	414
Surgical IPD	263.58	37.57 \pm 10.80	11.85	25.63	74.37	296
Ophthalmology IPD	107.38	15.43 \pm 9.502	4.82	61.75	38.25	196
OPD	319.87	45.57 \pm 20.34	14.36	35.30	64.70	3275
Laboratory	51.317	7.43 \pm 2.149	2.30	16.56	83.44	-
Pharmacy	51.621	7.57 \pm 7.871	2.32	89.11	10.89	-
Forensic pathology	99	16.5 \pm 6.473	4.45	12.12	87.88	98
OR	201.14	28.71 \pm 11.51	9.03	13.99	86.01	-
Imaging	55.52	7.57 \pm 2.44	2.49	18.01	81.99	-
Laundry	19	9.5 \pm 2.121	0.85	0	100	-
Food catering	99	49.50 \pm 65.76	4.45	100	0	-
Lounges	228	32.57 \pm 14.35	10.24	100	0	-
Administration	17	8.5 \pm 4.95	0.76	100	0	-
Mean \pm SD		26.31 \pm 19.07				
X ²	57.471					
df	13					
p-value	0.000					

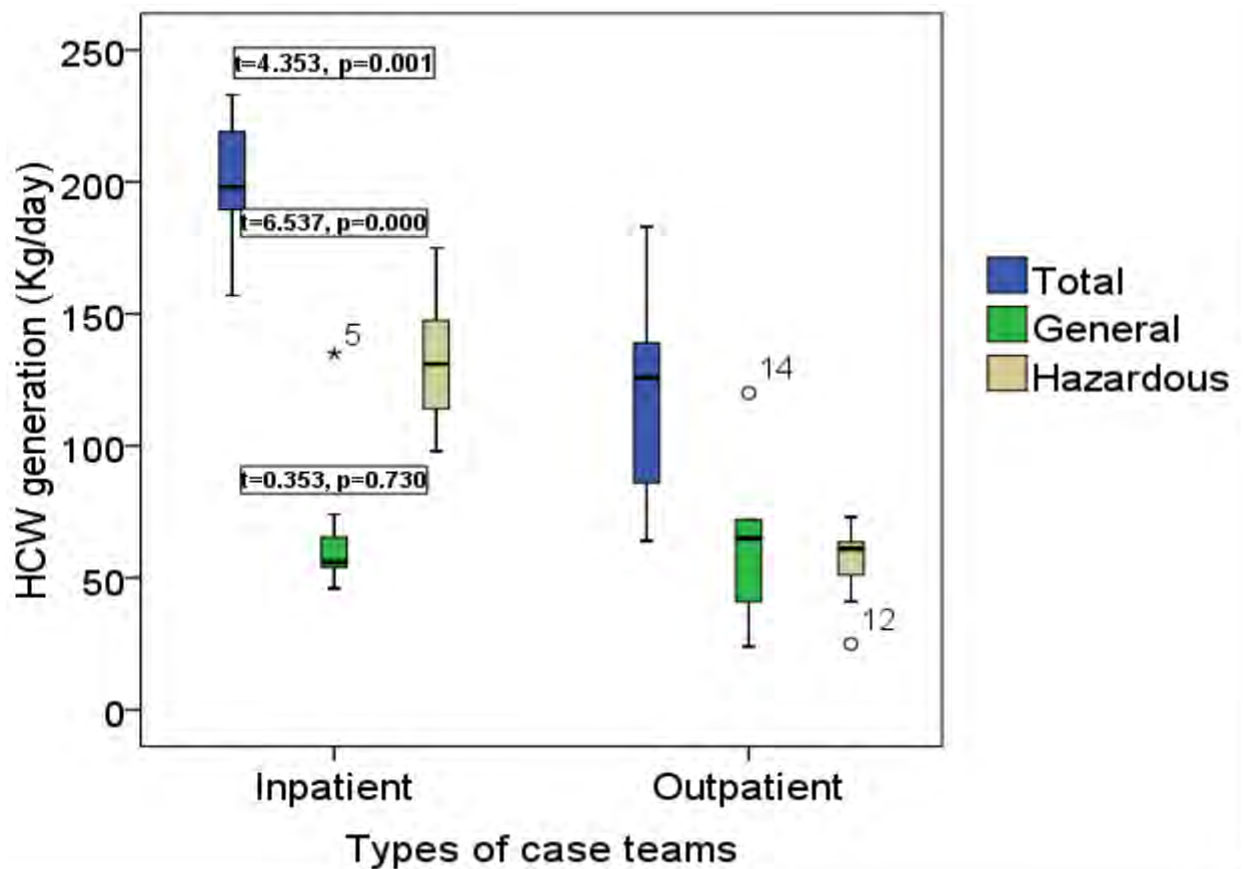
5.2.3. Comparison of healthcare waste generation rate among case teams

Patient flow, total healthcare waste and its types (general and hazardous waste) were compared among different case teams Kruskal Wallis test to check for the presence of statistically significant difference of generation of HCW. There was statistically significant difference of mean of patient flow ($X^2=37.859$, $p<0.0001$), total healthcare waste ($X^2= 56.558$, $p < 0.0001$), general HCW ($X^2=32.474$, $p<0.0001$) and hazardous waste ($X^2= 49.987$, $p < 0.0001$) among different case teams (Table 7). This showed that a type of case teams was a factor for generation of HCW.

Table 7: Comparison of patient flow, total HCW generation and its type using Kruskal Wallis test in each case teams in Menelik II Hospital, Addis Ababa, February 2015.

Types of Case teams	Mean Rank			
	Patient flow	Total HCW	General HCW	Hazardous HCW
Medical IPD	32.79	71.71	41.64	61.93
Surgical IPD	25.21	52.29	27.00	44.79
Orthopedic IPD	18.86	50.21	21.79	40.64
Ophthalmology IPD	11.00	28.71	21.71	22.00
OPD	37.14	57.50	33.58	47.57
OR	-	42.43	15.63	41.07
Imaging	-	13.79	10.50	18.57
Forensic pathology	4.00	29.67	29.00	30.25
Laboratory	-	13.50	3.75	18.29
Pharmacy	-	13.57	25.00	4.50
Lounges	-	48.86	46.43	-
X^2	37.859	56.558	32.474	49.987
df	5	10	10	9
P-value	0.000	0.000	0.000	0.000

There was statistically significant higher mean generation of total HCW ($p<0.01$) and hazardous HCW ($p<0.0001$) (kg/day) for IPDs than OPDs case teams as shown below. The generation rate of general HCW in OPDs was similar to IPDs (Figure 4).



☆ =Outliers O=outliers

Figure 4: Box plots of HCW generation (kg/day) of IPD and OPD case teams in Menellik II hospital, February 2015.

5.2.4. Relation of patient flow with HCW generation rate

The patient flow (bed occupancy) with amount of generation of total healthcare waste and its type (general and Hazardous) was evaluated for their linear relationship Pearson correlation coefficient(r) (Table 8). The correlation coefficient showed that there was a positive linear relationship as number of patients visited (beds occupied) increased, total healthcare wastes and general also increased in most case teams even though not statistically significant. A strong positive statistically significant linear relationship was observed between number of outpatients and total HCW generated at OPDs case team ($r=0.901$, $p < 0.01$) which was a bit far from a perfect

linear relationship ($r=1$) where as a negative linear relationship was observed at Orthopedic IPD ($r=-0.248$). There was also a statistically significant strong positive linear relationship between number of patients and generation of general HCW in surgical IPD ($r=0.988$, $p < 0.01$). A negative linear relationship was seen in most case teams except OPDs case team in the case of patient flow and hazardous HCW. There was no relationship between patient flow and HCW generated in Ophthalmology IPD.

Table 8: Correlation of visitors and quantity of waste (total HCW, general HCW, and Hazardous HCW) generated (Kg/day) in each case teams in Menellik II hospital Addis Ababa, February, 2015.

Name of Case teams	Total HCW		General HCW		Hazardous HCW	
	Pearson Correlation coefficient(r)	P-value	Pearson Correlation coefficient(r)	p-value	Pearson Correlation coefficient(r)	p-value
Medical IPD	0.112	0.81	0.221	0.634	-0.041	0.93
Surgical IPD	0.545	0.206	0.988*	0.002	-0.062	0.894
Orthopedic IPD	-0.248	0.592	0.393	0.383	-0.374	0.408
Ophthalmology IPD	0	-	0	-	0	-
OPDs	0.901*	0.006	0.654	0.159	0.748	0.053
Forensic Pathology	0.327	0.527	0	-	-0.381	0.456

**P < 0.01-statistically significant*

The Pearson correlation coefficient ($r=0.835$) showed that there was a positive statistically significant linear relationship between number of patients and quantities of total HCW generation rates ($p < 0.05$) as well as hazardous HCW ($r=0.845, p<0.05$) in the hospital. There was no significant linear relationship between total amount of HCW($r=0.331, p=0.468,$) and any type of waste generated in inpatients and number of hospital beds occupied. Statistically significant positive linear relationship was observed between outpatients and total HCW generation ($r=0.927, p<0.01$) and in all category of HCW. A positive linear relationship was observed between number of patients and generation of general HCW in the hospital ($r=0.211$) (Table 9).

Table 9: Summary of Correlation of patient flow (at all case teams, inpatients and outpatients) and quantity of waste (total HCW, general HCW, Hazardous HCW) generated using Pearson correlation in Menellik II hospital Addis Ababa, February, 2015.

Point of generation	Total HCW		General HCW		Hazardous HCW	
	Pearson correlation Coefficient(r)	P- value	Pearson correlation Coefficient(r)	P- value	Pearson correlation Coefficient(r)	P- value
All case teams (hospital)	0.835**	0.019	0.211	0.649	0.846**	0.016
Inpatients	0.331	0.468	0.1	0.831	0.205	0.659
Outpatients***	0.927*	0.003	0.788**	0.035	0.916*	0.004

* $P\text{-value} < 0.01$ -statistically significant

** $p\text{-value} < 0.05$ -statistically significant

*** *Outpatient includes laboratory, imaging waste*

Figure 5 was a scatter plot between the daily amounts of HCW generated and the number of patients that visited the hospital for healthcare services. A linear trend was evident between total HCW generation and total number of patients, with a calculated (statistically significant, $P < 0.05$; $R^2 = 0.698$). The fitted model was also adequate. Therefore, the number of patients

visited the hospital daily can be used as a predictor of HCW generation rates in Menellik II hospital. This R^2 also showed a moderately strong linear relationship between numbers of patients visited the hospital and amount of HCW generated in particular, 69.8% of the variability among the observed values of HCW generation in seven days of HCW measurement was explained by the linear relationship between numbers of total patients visited the hospital and generation of HCW ($P < 0.05$). The remaining 30.2% of the variation was not explained by this relationship.

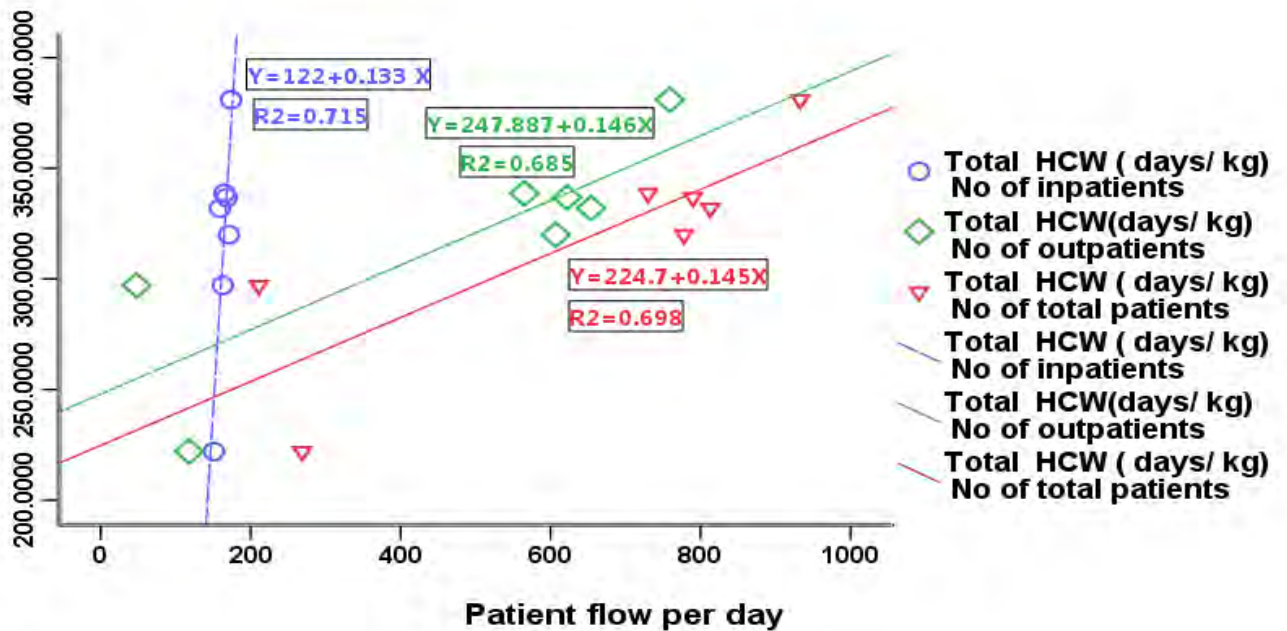


Figure: 5 Scatter plot of total HCW generation (Kg/day) versus number of inpatients, outpatients and total patients visited in Menellik II hospital, February 2015.

5.2.5. Predictive model for the hospital HCW generation rate

As presented at the conceptual frame work, the variables that affect the quantity of HCW generated from the hospital were patient flow, type of services (specialty) and case teams, type of HCW, temporality, and HCW management practice. However, patient flow, type of case team (whether inpatient or outpatient) and type of HCW (whether general or hazardous) was important predictor variables used to develop predictive model for the hospital waste generation rate. The temporality because of cross-sectional study and management practice due to consideration of qualitatively were unlikely important as a factor for the predictive model. Therefore, the predictive model for considering patient flow only as a factor was:-The model was adequate ($p < 0.05$) or 95 % (0.037, 0.255).

$$Y = 224.7 + 0.145 * \# \text{ total patient}$$

Using type of case team (inpatient verses outpatient) as a predictor:-

$$Y = -279.495 + 3.389 * \# \text{ inpatients} + 0.085 * \# \text{ outpatients}$$

However the coefficients were not significant so that lacks adequacy of best fit model by adding this predictor variable.

The model using type of HCW was; only the constant was not significant (95% CI (-7.483, 2.802) or $t = -1.264$, $p\text{-value} = 0.275$):-

$$Y = -2.341 + 1.013 * \text{general (kg/day)} + 1.004 * \text{hazardous (kg/day)}$$

Using all factors at a time the generation predictive model was:

$$Y = -13.156 + 0.088 * \# \text{ inpatients} + 2.059E-005 * \# \text{ outpatients} + 0.998 * \text{general (kg/day)} + 0.995 * \# \text{ hazardous (kg/day)}$$

All the coefficients were not significant and the model was not adequate as predictive best fit.

Therefore among the above models, the first one was the best fit model that used to estimate the generation rate of the hospital. It was adequate.

5.3. Status of healthcare waste management system in the hospital

5.3.1. Healthcare waste segregation and interim storage

HCW containers was cleanable made of polyethylene with a volume 20 liters to 91.4 liters capacity and the colors of plastic buckets were black, yellow, red, and blue. But there was no availability of completed color coding system in all case teams even there was perforated baskets in some case teams: minor OR, ICU, all OPDs and some IPDs. The healthcare waste management practice in the hospital was weak, no segregation of HCW in to general, infectious, pathological, pharmaceutical etc waste category to the available color coded waste containers at the point of generation except the sharp waste with puncture proof safety box. This was because of staff low awareness, attitude and resistance for segregation, inaccessibility of all the type of color coded waste containers to the users; the containers were without labeling in particular and there were no visual aids or instructions at waste receptacles in general. The interim HCW storage bin with large capacity of liters was easily clean and with covers. In most OPDs (especially ophthalmology, orthopedic), minor OR and

food catering the waste was stored for over 48 hrs without being treated while EOPD, major OR made storage only for 8 hours and all IPDs for 24 hours. The facility also had dedicated place of onsite HCW storage without fence. HCW especially infectious was stored onsite to municipal garbage tank capacity of 8 m³ by mixing of different types of HCW which was potentially infectious and hazardous (Figure13).

5.3.2. Healthcare waste handling, collection and transportation

HCW was collected daily at the morning in most case teams except the major operating room and EOPD made within average of 8 hours. The waste collection bin washed clean with 0.5% chlorine solution unless there was shortage of commodities. Safety boxes were not securely closed, disposed when $\frac{3}{4}$ th full. Waste handlers had all the necessary protective devices except boots and goggle even though some of them were not wearing while handling HCW. The equipment for onsite transport was closed bin with wheel transported manually without separating it for each HCW category (general, infectious, pathological etc). The HCW was transported onsite to the municipal garbage tank, incinerator, amputation pit, and open dug well. The waste on municipal garbage tank (totally infectious) was stored for minimum of a week and maximum of three weeks before finally transported by out sourced private company in to the city municipal disposal site. It was confident to say that potentially infectious waste was transported to municipal disposal site.

HCW bin put in the street or pedestrian was not emptied and clean daily even when full their capacity. This might be due to loosen supervision and coordination (Figure 6).



Figure 6: HCW interim(primary) storage and transportation materials of Menelik II hospital, February 2015.

5.3.3. Healthcare waste recycling and reusing

There were different type of HCW generated that must be recycled and reused. Packaging containers of bleaching agents and drugs, IV bags, thermometer mercury, suction tubes, pack, cards, water bottle plastics, silver were among the items.

Healthcare waste minimization at the source of generation, reusing and recycling was not employed by any of the case teams except recycling of plastic water bottles and film developer; and reuse of packs, suction tubes because of poor practice of separation of HCW (Figure 7). Lack of commitment to initiate a recycling program was also the main factor of HCWM. For instance drugs supplied to the hospital was shipped with non reusable containers, pressurized containers like aerosol cans not recycled and food waste was not composted for natural fertilizer.



Figure 7: Water bottle plastics stored for recycling dispersed near the incinerator in Menellik II Hospital, February 2015

5.3.4. Healthcare waste treatment and disposal

Waste bins after the wastes had been emptied during shortage of supply and infectious HCW before disposal were not disinfected with bleaching agent (Bara kina, H₂O₂ etc). Incinerator, open dug well and amputation pit were the technologies used for waste treatment and disposal means in the hospital. The main HCW treatment and disposal mechanism was incineration, open burning; burring in to amputation pit and open dumping on municipal dumping site as well as on the hospital back yard (Figure:8-11). The hospital has functional low combustion,

single chamber incinerator incinerating all type of the wastes together without separating especially infectious waste (Figure-9). There was no pit for ash removal. The incinerator was made of bricks, reinforced concert slab and had air inlets for combustion of wastes. The incinerator has relatively smaller chimney to its size, the door for the waste feeding opening had broken and no door for ash removing. The incinerator was not fenced to control the unauthorized access.

The incinerator and municipal garbage tank was located near the laundry which disturbed them with their foul odor nuisance. The wind carries foul odor and smog from incinerator to the hospital. There was no separate incinerator for the incineration of sharps waste (syringes, needles, blade & lancet) or needle pit. The forensic pathology case team has no incinerator for infectious waste treatment rather burned it openly fumigating the surrounding (Figure-8).

The pathological waste was buried into amputation pit with secured cover. Its case made of masonry work, and reinforced concrete slab. It has vent pipe for control of fly and odor nuisance but its latchet percolate in to underground water. Expired drugs were disposed through burning locally.

Furthermore, the hospital was not in compliance with applicable regulations such as prohibiting open burning, open dumping, malpractice of segregation of HCW etc.



Figure 8: Open burning of HCW practice in Forensic pathology and orthopedic ward case teams in Menellik II hospital, February 2015.



Figure 9: A newly built incinerator for HCW incineration of Menellik II Hospital, February 2015.



Figure 10: Open dumping of HCW at the back yard of Menellik II Hospital, February 2015.



Figure 11: Amputation pit for disposal of pathological waste in Menellik II hospital, February 2015.

5.3.5. Responsibilities, budget allocation and training on HCWM

The responsibility of HCW management was considered only for the waste handlers and sanitarians of the facility but after launching of CASH program by FMOH in January 2015, there was a common belief on responsibility of HCWM among workers. In service training about healthcare waste management was given for 63 support staff including waste handlers and 25 technical workers even if it was not sufficient for 645 workers of the hospital. HCWM regulations, as well as any applicable facility based policy for healthcare waste management were not found in the facility. There was HCWM committee and HCWM guideline in the study health facility. Sufficient budget was not allocated in title separately for healthcare waste management but when required it was transferred for allocation. The facility sanitarians made supervisions for HCWM once a week .The hospital did not conduct HCW generation assessment and waste audit in the last 3 years.

5.3.6. Healthcare waste processing and handling (process flow of HCWM) Practice in the hospital

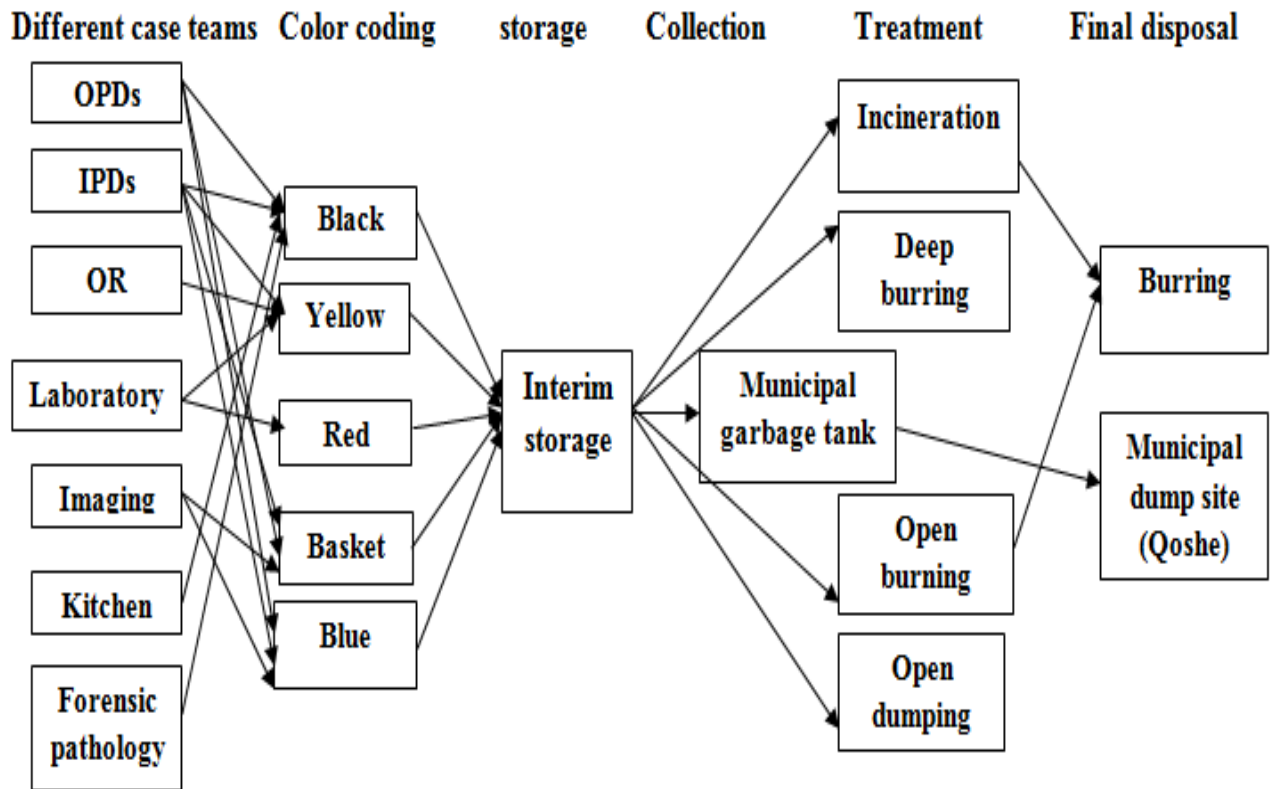


Figure 12: Flow diagram of the Practices of HCWM in Menellik II hospital, February 2015

5.3.7. Challenges of HCWM in the hospital

The main problems encountered in management of HCW in the study institution were low awareness, negligence and carelessness of the health workers, cleaners and patients. An attitude problem of health professionals especially for the segregation and disinfection of HCW was the bottle neck in the safe disposal of HCW. Resistance to wear protective gears, to use the available waste segregation bins, turnover of cleaning staffs and lack of human resource was another problem of HCWM. As shown in the figure below, the municipal garbage storage tank was over full and droppings of refuse around the surrounding led to pollution because of delay in offsite transportation service to the municipal disposal area Qoshe during this data collection period (Figure: 13).



Figure 13: Municipal garbage tank with mixture of all type of HCW, over full and droppings of refuse around the surrounding in Menellik II hospital, February 2015.

5.3.8. Public health impact and occupational health

All staffs had information about HAI occurred as a result of malpractice of HCWM. The hospital gave HVB vaccine of 3 doses to all staffs however 13 workers had sharps and needle stick injuries in the past 6 months during handling of wastes and delivering healthcare service. Post exposure prophylaxis was the main treatment measure given after injury. The hospital also used toxic x-ray developing system which was not digitalized. There was no allocation of material safety data sheet for employees. The open burning exercised at the yards of the facility polluted the surrounding because of the fogs, mists by product. In complete combustion of non segregated HCW that had PVC content induce emissions such as dioxin/furan, CO which posed health problem that attack the human organ.

6. Discussion

The mean healthcare waste generation rate was 318.11 ± 49.47 kg/day, of which (40.91 %) 130.14 ± 38.22 kg/ day was general waste and (59.09%) 187.97 ± 38.85 kg/day was hazardous.

The median quantity of HCW generation (0.43 Kg/patient/day or 2.01 Kg/bed/day) was in the range of median generation of the study conducted in public and private hospitals of Addis Ababa (0.361–0.669 kg/patient/ day) of which 58.69% was hazardous waste and 41.39% general) (12) and a study in Hawassa city HCFs by Hailemichael et al (1.48-8.19 kg/bed/day) of which 48.73% was infectious and 6.16% sharps (19). This result was also almost similar to reported by Tesfahune et al (0.31Kg/patient/day) 43.4% general and 56.4% hazardous (18). The similarity in generation rate and ratio of composition of waste was due to similar in HCW management systems, procurement policies, use of similar commodity, waste characterization and classification, enforcement of laws and regulation of the country, similar socio economic conditions.

The mean of HCW (0.49kg/patient/day or 1.94 Kg/bed/day) in this study was greater than what was recorded studies done in Khartoum state hospitals (0.38kg/beds/day) (10), Sub-Saharan countries (0.3-1.5 kg/bed/day) (14), Pakistani hospitals (1.35 kg/bed/day) (4), and Nigeria between 0.562-0.670 kg/bed/day (23) but lower than Iran teaching hospitals ($2.75 \text{ Kg/bed/day} \pm 0.176$) (22). The variation in mean waste generation could be attributed to the differences in resource inputs to health facilities, season of the year the studies was undertaken, range of services offered in the facilities, geographical area, numbers of beds, HCWM system, level and specialty of hospitals, gross domestic product, social status of the patients, availability of recycling program, waste characterization (13).

The amount of healthcare waste generation rate in different case teams was significantly varied ($X^2=56.558$, $p<0.0001$). Large amount of HCW was generated in MedicalIPD 0.164Kg/patient/day (21.33%). This was greater than what was generated in Nigeria primary HCFs labor ward (0.003 ± 0.002 kg/person/day) (37) and smaller than the result found by Komilis et al, 2012 in pathology clinic (0.66 kg/bed/day)(38). The variation of generation among hospitals' case team may be attributed to a variety of reasons: the type of healthcare hospital and department, the numbers and health condition of patients, kind of healthcare delivery, type and nature of waste generated, segregation practice. Komilis et al., mentioned in their report that it is risky to make comparisons

with HCW records from other countries, due to the variability in the definitions and methods of classifications of HCW throughout the world (38).

Similarly, there was also a difference in generation rates of HCW between OPDs and IPDs. The total quantity of HCW generated from IPDs (1.22kg/bed/day) was significantly more than OPDs (0.244 kg/outpatient/day). The mean generation rate in kg/bed/day (IPD) was therefore nearly five times greater than the generation rate estimated in kg/outpatient/day (OPD) ($t= 4.353$, $p < 0.01$). Therefore type of point of HCW generation was a significant predictor of generation rate. This was support by the study conducted in hospitals of Amhara regional state that revealed the total generation rate of HCW from inpatients ranged from 0.25 to 2.77 kg/bed/day (median:1.67 kg/bed/day) was higher than 0.21–0.65 in kg/patient/day (median:0.34 kg/patient/day) from outpatients(18). This generation in the outpatient was also higher than in primary HCFs of Nigeria outpatient unit (0.02/kg/outpatient/day) (37), This difference between case teams could be due to the differences in resource allocation and materials used, type of waste generated, average length of stay of patients, presence of patients' care giver and nature of health care provided, number of staff and health status of patient (14).

The total HCW produced in Menellik II hospital was found to be consists of 59.09 % hazardous HCW, 53.73% infectious waste and 1.77 % sharps which was substantially above the WHO recommendation for developing countries: 10-25% hazardous waste, 15% infectious and 1% sharps waste (13-15). Weak waste management system: absence of complete color coding bins, lack of separation of infectious and non-infectious wastes at Menellik II hospital in comparison with other HCFs in other developing countries, as shown by Debere et al(12) and Haylamicheal et al (19) was the likely explanation for the relatively high proportion of hazardous HCW in the hospital. Similar trends were reported by Azage (2) in his study. All the waste collected which was a mixture of infectious and general waste was treated and recorded as infectious waste in accordance with WHO recommendations (15). By designing and implementing an exact segregation program in the hospital, the quantity of hazardous waste that needed to be treated would be reduced significantly. In addition, the monetary costs, public health risks and environmental pollution would be decreased similarly.

The proportion of hazardous waste generated in the Menellik II hospital (Table 2) was at the high end of the spectrum (nearly 1.5 times its non risk waste ($t=2.796$, $P<0.05$)) when compared with that found in hospitals of other developing countries: 20% in Pakistan (25), 20-25% in Turkey (3),

20% in Bangladesh (3), 26.5% in Nigeria (23), 50% in Tanzania and 2-10% in SSA (14, 40). This showed that type of HCW category was factor for total HCW generation. The difference may be regulations, policies and methods on waste classification, monitoring and enforcement of HCWM system by respective bodies, extent of use of disposable materials, procurement policies, segregation practices, inventory control, life style of the community, extent of recycling. The higher hazardous HCW generation rate at Menellik II was also probably due to the fact that it was the only forensic pathology service in it and thus serving a larger number of people in comparison with other hospitals.

The mean HCW generation at Menellik II hospital estimated 0.49 kg/patient/ day, the density was 160.95 kg m^{-3} and the volume of HCW was recorded 0.0031 m^3 /patient/day. This volume and density generation was different from the study conducted about solid waste generation rate in Addis Ababa city in 2014, the generation was 0.5 kg/ capita/day, the density between 205 to 370 kg m^{-3} , the volume was 0.00079 m^3 /patient/day (17). The reason might be due to deference in, type and nature of waste generated, compaction rate, and waste collection efficiency.

The quantity of total HCW generated per day in Menellik II hospital was increased as the number of patients ($r=0.835$) and the number of beds occupied ($r=0.331$) increased with being the former statistically significant ($p < 0.05$). This result was in agreement with a study conducted by Debere et al in similar settings showed a statistically significant positive linear relationship between quantities of HCW generation rates and number of patients ($r_s=1$, $p < 0.05$) as well as number of hospital beds ($r_s=0.943$, $p < 0.05$) (12). This fact was also supported by another study conducted by Hailemichael et al, the quantity of waste generated per day increased as the number of patients and bed occupancy increased with the latter statistically significant ($p < 0.001$)(19). In a study by Komilis et al, there was a positive correlation between the total medical waste generation rates and the number of beds (38).

On the other hand, the study showed a strong positive relation of patient flow and total HCW generation in outpatient case teams ($R^2=0.859$, $P < 0.01$), than inpatients ($R^2=0.109$, $p=0.468$, not significant) in spite of the magnitude of waste generated. This was opposite to the result found by Tesfahune et al that explained stronger positive correlation of healthcare waste generation rate with the number of inpatients ($r = 0.842$, $P < 0.0001$) than with the number of outpatients ($r = 0.538$, $P < 0.0001$)(18). This is owing to the number of sample size in Tesfahune et al was larger used nine hospitals in large geographical area could result strong statistical association and other

factors like season of year and average length of stay might be other potential reason for the difference. Average length of stay was larger in inpatients could result stable number of patients during study period might cause week association in inpatients. Average length of stay which increased amount of HCW generated did not a guarantee for existence of strong correlations between patient load and generation rate.

Segregation of the HCW into complete color coding system was not implemented satisfactorily. It was consistence to the report in Hawassa city that 67% of the HCFs did not segregate waste at source (19). The reason behind was similarity in HCWM system, resource allocation and followed by the same healthcare management system.

All of the case teams in Menellik II hospital used safety boxes for collection of sharps waste. This was in line with what was reported by Debere et al (12). It was also better than the study done by Hailemicheal et al, Hawassa city, 67% of the HCFs did not use safety boxes for sharps (19). This variation may be due to continuous supply of safety boxes to case teams, the risk of used needles and sharps related with improper collection might be given better attention by governmental health system and other Non-governmental organizations to reduce the transmission of HIV and other related disease, as shown by Azage et al (2), and increased risk perception of sharps waste among workers in the hospital as supported by a study conducted in Gondar (7).

The way HCW transported in the hospital was better than Hawassa city HCFs which used open plastic containers from the site of generation to the treatment area. In contrast to this relationship waste was also transported in most case teams every morning once a day in lesser frequency as compared to the Hawassa city HCFs that seven of the HCFs collect waste twice a day whereas the other two conduct collection three to four times a day (19). This was in agreement to the WHO recommendation of storage of HCW in warm climate for a maximum 48 hours during the cool season and maximum 24 hours during the hot season (14, 28).

The main HCW treatment and disposal mechanism in the studied hospital was low combustion incineration, open burning, burring in the pit and open dumping. This was similarly reported by MMIS project in Ethiopia HCFs; open burning in a dug hole 54%, low-temperature incineration 52% and open-air burning 18% (26). It was also supported by a study conducted in hospitals of Addis Ababa city (2012) that 83 % of the hospitals treat their HCW using low to medium combustion incinerators. The study in hospitals of two regions Ilala and Kinodoni in Tanzania showed that 70 % of HCFs in Ilala burn wastes in poorly designed incinerators and open pit while in Kinodoni 83 % of the facilities bury wastes in the pits (21).

The reason behind may be lack of elaborated, legal policy and institutional framework for HCWM. This inadequate and sub-standard HCW treatment and disposal facilities were also due to absence of obligation and enforcement of Stockholm, Basel and Rotterdam Conventions that treatment and disposal of HCW does not cause harm to human health and the environment(41).

A study in Tanzania indicated that about 60 % in Ilala and 70% Kinondoni municipalities surveyed HCFs incinerators were not fenced. 50% of them being of low capacity with some parts missing as well as 9 and 47% of the healthcare facilities in Ilala and Kinondoni, respectively; do not have the standard operating procedures for incineration of HCW (21) was supported what actually present in Menellik II hospital that the incinerator without fence worked polluting the environment, equipped with no ash pit, broken waste loading cover, no ash removing doors and no sufficient air-inlets for complete combustion of HCW. This low combustion single-chamber incinerator which may release dioxins, furans, heavy metal and acidic gasses was against the Stockholm convention on persistent organic pollutants (POPs) (15).

There was sharps and needle stick injury on about 13 workers in the hospital within last six months. Different studies showed in developing countries that the data available related this injury was very few and under estimation of the real risks (2). The needle stick injury may be related with improper segregation and disinfection of wastes particularly sharps at the source of generation. Sharps and needle stick injuries are the commonest vehicle for HIV, Hepatitis B and C and recently Ebola infection in health institutions especially for healthcare workers and waste handlers (27). This was supported by WHO study that unsterilized syringes cause 8 to 16 million cases of hepatitis B, 2.3 to 4.7 million cases of hepatitis C, and 80,000 to 160,000 cases of HIV every year (1, 6). 5.2 million People in the world (including 4 million children) also die each year from waste-related diseases (3).

7. Strengths and limitations of the study

7.1. Strengths of the study

1. Data were collected with measurement (weighing scale) for seven days which made the collected data more reliable than other methods.
2. Day to day supervision was conducted during data collection.
3. Calibration of weighing scale at every morning and movement of measurement was done during data collection.

7.2. Limitation of the study

1. The limitations of this study was that being cross sectional, it did not take into account changes in waste generation across the seasons, as there may be seasonal changes in hospital attendance.
2. Since the hospital was the only forensic pathology service provider, the result found might not be generalized to others facilities.

8. Conclusion and Recommendation

8.1. Conclusion

- ❖ The mean healthcare waste generation rate of the hospital was comparable in amount to other studies in Ethiopia but higher than Sub Saharan African countries with similar setting.
- ❖ Infectious waste, general, sharps, pharmaceutical, pathological and radiological wastes were the types of healthcare waste generated in the hospital.
- ❖ The generation of hazardous waste was nearly 1.5 times that of general waste, four times WHO estimation, indicated segregation was not well practiced as result the health care waste leaving from the hospital as a whole was both potentially infectious and potentially hazardous.
- ❖ The generation rate of HCW in the hospital was varied with the flow of patients.
- ❖ There was workers resistance; in adequate governance and attention to HCWM in the hospital that mismanagement of the waste brought problems to public health and environment.
- ❖ The main treatment and disposal method was incineration in to low combustion single chamber incinerator that led to in incomplete combustion of HCW, open burning and open dumping. In such practice the release of pollutants in the environment is more likely.

8.2. Recommendation

- ❖ The hospital should segregate HCW with complete color coding containers at the point of generation so that HCWM practices need to be maintained.
- ❖ The hospital should maintain documents pertaining to the quantity of waste generated (waste audit).
- ❖ The hospital should not use such incinerator, burn waste open for disposal of all type HCW (specially containing chlorine and heavy metals), and the residual ash should be buried in cased pit. There for the hospital should adopt a De Montfort or similar incinerator design for proper healthcare waste treatment.
- ❖ The hospital management should support healthcare waste management system and conduct periodical supportive supervision or surveillance of healthcare waste management practices.
- ❖ The hospital should give training on HCW waste management for all hospital staffs.
- ❖ The environmental regulators: EPA should draft laws, promote and enforce safe disposal of HCW.

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Annexes

Annex I: Generation rate of HCW in different countries and facilities

I. Approximate percentage of waste type per total waste in health care facilities (WHO) (15)

Non-infectious waste	80%
Pathological waste and infectious waste	15%
Sharps waste	1%
Chemical or pharmaceutical waste	3%
Pressurizes cylinders, broken thermometers ,radioactive, broken thermometer , used batteries, cytostatic etc	less than 1%

II. Total and Infectious Healthcare Waste Generation Rates by Type of Facility for Low-Income Countries (Tanzania) (15).

Type of facility	Total HCW Generation	Infectious waste generation
Hospitals	0.14 kg/patient-day	0.08 kg/patient-day
Health centre (urban)	0.01 kg/patient-day	0.007 kg/patient-day
Rural dispensaries	0.04 kg/patient-day	0.02 kg/patient-day
Urban dispensaries	0.02 kg/patient-day	0.01 kg/patient-day

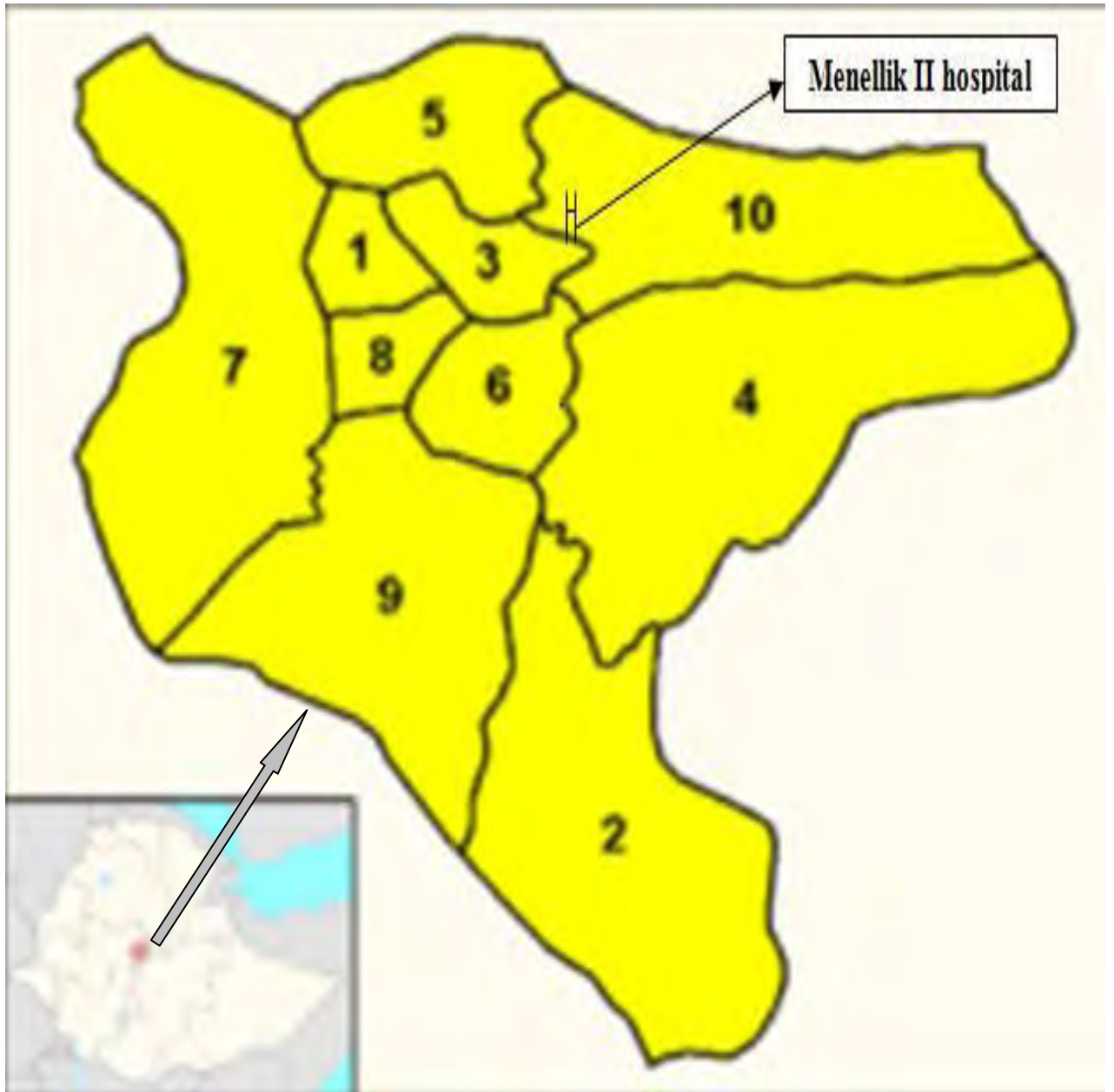
III. Total and Infectious Healthcare Waste Generation Rates by Type of Facility for middle-income Countries (South Africa) (15)

Type of facility	Infectious waste generation
National central hospital	1.24 kg/patient-bed-day
Provincial tertiary hospital	1.53 kg/patient-bed-day
Regional hospital	1.05 kg/patient-bed-day
District hospital	0.65 kg/patient-bed-day
Specialized hospital	0.17 kg/patient-bed-day
Public clinic	0.008 kg/patient-day
Community health centre	0.024 kg/patient-day
Private day-surgery clinic	0.39 kg/patient-day
Private health centre	0.07 kg/patient-day

IV. Health-care waste generation according to national income level (15)

National income level	Nature of waste	Annual waste generation (kg/head population)
High-income countries	all health care waste	1.1–12.0
	hazardous health care waste	0.4–5.5
Middle-income countries	all health care waste	0.8–6.0
	hazardous health care waste	0.3–0.4
Low-income countries:	all health care waste	0.5–3.0

Annex II. District map of Addis Ababa and the study hospital location



Annex: III. Participants' Information Sheet

Hello. My name is _____ and I am MPH student in Addis Ababa University, College of Health Science, and School of Public Health. I am conducting survey on the assessment of healthcare waste generation and its management system in Menelik II referral hospital in Addis Ababa. The result that will come out of this study will be used by the government and the city health office to base their rational decision to develop appropriate strategies to combat this problem. The research is intended to benefit the hospitals including the health workers that will be participating in this research and will introduce no risk to the participant. The interview requires the maximum of 20 minutes to complete. The hospital is selected purposefully from public hospitals in the city by the researcher. Your participation is entirely voluntarily, and you can quit from the study any time you want. You will have no penalty if you fail to show desire to participate. I, however, do hope that you will participate in the study since the data that will come from you will be important for us. The information we will collect from you will completely be kept confidential and will not be disclosed to any third person other than the people participating in this study. For any question you want to ask us, you can use the contact address here under.

May I now begin the interview?

If yes, continue interviewing

If No, thank and stop interviewing

Name of the interviewer _____ Sign. _____ Date _____

Name of the supervisor. _____ Sign. _____ Date _____

Addresses

Tel:+251910477921

Email:destad2a@gmail.com

abarakumie2@gmail.com

Annex: IV. Consent Form

Name of Hospital-----

Serial No-----

I (the respondent), the undersigned, am told that the researcher is going to conduct study in this hospital to assess healthcare waste generation and its management system in Menellik II hospital in Addis Ababa and s/he acquainted with me the first time s/he meets. I am also informed that the result of the study will be used by both the government and the city health bureau to commence appropriate strategies to alleviate the problem. I am also, told that the research will benefit the hospital in general including me, the respondent, and that the research will not inflict any harm to me. Besides, I am briefed that I will be interviewed for not more than 20 minutes. And also, I am let know that the hospital and I was selected purposefully by the investigator. Moreover, I am notified that my participation in the study is entirely voluntarily, and that I can quit from the study any time I want. Likewise, I am enlightened that I will not be subjected to any form of punishment following my failure to participate in the study. In the same way, I am explained that the information collected from me will not by any means be disclosed to any people other than those participating in the study unless obtained permission from me. Equally, I am told that I can ask them questions I found difficult or any type otherwise. Could I have your permission to continue?

a) Agree _____ b) Disagree_____

If disagree, skip to the next respondent by writing reasons for his/her refusal_____

Informed consent Certified by:

Interviewer name_____Signature_____

Date of interview_____Time started_____Time completed_____

Result of interview: 1. Completed 2. Respondent not available 3. Refused 4. Incomplete

Checked by supervisor: Name_____Signature_____Date_____

Additional instructions to the Interviewers:

1. The interview will continue only after the respondent will agree on the consent
2. Fill the questionnaire only with pen
3. Circle the answer from the options of possible responses
4. Strictly follow the skipping pattern

For any convenience and problem you can contact the principal investigator.

Phone -0910477921 E-mails- destad2a@gmail.com

Annex V. Amharic version Consent form

በአዲስ አበባ ከተማ በሚገኙ የመንግስት ሆስፒታሎች ያለውን የጤና ተቋማት ቆሻሻ ምርት ምጣኔና አወጋገድ ስርዓት ለማጥናት የተዘጋጀ መጠይቅ ነው።

መለያ _____

የሆስፒታሉ ስም _____

መጠይቁ መሞላት ከመጀመሩ በፊት የተሳታፊውን ፈቃደኝነት መጠየቂያ ቅጽ

ሰላም እንደምን አለህ/አለሽ? እኔ ----- እባላለሁ። እዚህ የመጣሁት ይህን ጥናት ከሚያካሂደው የአዲስ አበባ ዩኒቨርሲቲ የህብረተሰብ ጤና የትምህርት ክፍል ነው። ከጤና ተቋማት ቆሻሻ ምርት ምጣኔና አወጋገድ ስርዓት ጋር በተያያዘ በዚህ ሆስፒታል ውስጥ ምን አይነት የጤና ተቋማት ቆሻሻ፣ እንዲሁም መጠኑም ምን ያህል እንደሆነ እና የአወጋገዱ ስርዓት ምን እንደሚመስል መረዳት እንፍልጋለን። በመሆኑም ይህን መረጃ ለማግኘት በዚህ ሆስፒታል ውስጥ ይህን መጠይቅ በማካሄድ ላይ እገኛለሁ። የዚህ ጥናት ውጤት በከተማችንና በሆስፒታሉ ውስጥ የሚደረገውን የቆሻሻ አወጋገድ ስርዓት ለማሻሻል ከፍተኛ እገዛ ይኖረዋል። ስለሆነም ለቆሻሻ አወጋገዱ ስርዓትና ለሂሁ የሚያስፍልጉ ግብዓቶችን በተመለከተ የተወሰኑ ጥያቄዎችን ለማንሳት እወዳለሁ። በአጠቃላይ መጠይቁ 20 ደቂቃ ያህል ይፈጃል። የሚሰጡት ማንኛውም መረጃ ለማንም ተላልፎ አይሰጥም። በተጨማሪም በተቃረኑ መልኩ ፈጽሞ አይተረጎምም፤ ስምዎን መመዝገብ አያስፈልገኝም ። ተሳትፎዎ ሙሉ በሙሉ በፈቃደኝነት ላይ የተመሰረተ እንደመሆኑ መጠን እንዲመልሱ ብለን በምንም አይነት መልኩ አንገፋፋዎትም መመለስ በማይፈልጉበት ሰዓት መጠይቁን የማቋረጥ መብት አለዎት።

ስለዚህ ለመቀጠል ፍቃደኛ ነዎት 1. አዎ 2. አይደለሁም

የጠያቂው ስም _____ ፊርማ _____

መጠይቁ የተሞላበት ቀን _____ የተጀመረበት ሰዓት _____ የተጠናቀቀበት ሰዓት _____

የመጠይቁ ግምገማ 1. ተሟልቷል 3. ተጠያቂው አሌተገኘም 2. ተቋውሞ 4. በከፊል ተሟልቷል

የአረጋገጠው ስፕሮቫይዘር ስም _____ ፊርማ _____ ቀን _____

ለማንኛውም ችግር እና ግልጽ ላልሆነ ነገር ከታች ባለው አድራሻ ማነጋገር ይችላሉ።

ዋና የጥናቱ ተሳታፊ ደስታ ደባልቄ

ስልክ - 0910477921 ኢ.ሜል destad2a@gmail.com

Annex VI. Data Collection Tools

Addis Ababa University College of Health Science

School of Public Health

A. Health care waste management Observational Checklist for Walk through Survey Assessment of the Hospital

Assessment date: _____

1. General Hospital's Information

Name of the Hospital: Menelik II P.O. Box: 433 Tel: 011 1 234272

Specialty: Almost General Case Teams: _____

No of beds: _____ No of Occupied beds: _____ Total No of staff: _____

No of Health professional staff: _____ No of sanitarian: _____

No of waste handlers: _____ No of catering workers: _____ No of Laundry workers: _____ No of admitted patients in last year: _____

Ser. No	Questions	Response	Skip to
2	HCW Segregation and Interim storage		
2.1	Is waste segregated at the point of generation?	1. Yes 2. No	
2.2	Is general HCW collected using black bin?	1. Yes 2. No	
2.3	Is infectious HCW collected using yellow bin?	1. Yes 2. No	
2.4	Is chemotherapy waste collected separately?	1. Yes 2. No	
2.5	What type of container is used for sharps, needle waste?	1. Puncture proof 2. Non Puncture proof	
2.6	For which type of HCW red bag used which dep't?	_____	
2.7	Are all types of bins are located in every service unit convenient/accessible site for users?	1. Yes 2. No	
2.8	Do all color coded bins are clearly marked or labeled?	1. Yes 2. No	
2.9	Is interim HCW storage bin with cover available?	1. Yes 2. No	

2.10	Are HCW storage bins made from washable, leak proof, puncture proof, plastic or galvanized materials?	1. Yes	2. No	
2.11	Is interim HCW storage bin easily cleanable?	1. Yes	2. No	
2.12	Are visual aids/ instructions present near the waste receptacles for the proper segregation?	1. Yes	2. No	
3	HCW Handling, Collection and Transportation			
3.1	Does the facility have waste collection point?	1. Yes	2. No	
3.2	Is the waste collection done with time table of time and frequency of collection?	1. Yes	2. No	
3.3	Are HCW bins/ safety boxes securely closed or sealed when ¾ full respectively?	1. Yes	2. No	
3.4	Are HCW bins/ safety boxes emptied and disposed respectively when ¾ full?	1. Yes	2. No	
3.5	Are the bins washed clean with disinfectant solution when necessary?	1. Yes	2. No	
3.6	Do all waste handlers wear PPE while handling HCW?	1. Yes	2. No	
3.7	What are the equipments for on-site transport of HCW?	1. Cart/trolley	2. Open bin	
		3. Closed bin	4. other Specify	
3.8	Does infectious HCW and non risk HCW are transported in separate transportation equipment?	1. Yes	2. No	
3.9	Where HCW transported on-site?	1. Municipal garbage tank		
		2. Treatment facilities		
		3. Dug hole	4. other specify	
3.10	Is HCW stored on site for more than a few days before final disposal?	1. Yes	2. No	
		3. If yes how long?		

3.11	Who transport the HCW off site?	1. HCF 2. Municipal servi 3. Private company	
3.12	How often off site transport of HCW made?	1. Once a week 2. Twice week 3. Other, specify _____	
4.	On Site HCW storage		
4.1	Does the facility have dedicated place for onsite storage?	1. Yes 2. No	
4.2	If yes does it has fence not o access anima unauthorized?	1. Yes 2. No	
4.3	Is HCW stored based on segregation with out mixing?	1. Yes 2. No	
4.4	Is the healthcare waste stored for more than 24 h before being treated/ disposed?	1. Yes 2. No	
5	Treatment and disposal of HCW		
5.1	What method is used for onsite HCW treatment?	1. Crushing 2. Disinfecti 3.Incination 4 Sterilizati 5.Burring 6 Other specify	
5.2	Where HCW are finally disposed?	1. On-site 2.Off-site 3. Both	
5.3	What on site disposal method is used for HC disposal?	1. Open dumping 2. Sanita landfill 3. Small burial Shallow pit burning 5.cased p 6 .Other, specify	
5.4	If incinerator is used, does it have sufficient air inlets the side?	1.Yes 2 No	
5.5	What type of HCW is burned in the incinerator?	1 infectious 2 pathological 3 syringes 4 plastics 5 All	

5.6	Is there ash pit?	1. Yes	2. No	
5.7	Is there needle pit?	1. Yes	2. No	
5.8	Is there placenta/ amputation pit?	1. Yes	2. No	
5.9	Is disposal area/incinerator fenced to prevent community access? If yes what kind?	1. Yes	2. No	
5.10	Is the existing treatment/ disposal facility adequate?	1. Yes	2. No	
5.11	Is the hospital in compliance with applicable regulation? -Is open burning prohibited? -Is access to the disposal site is controlled with signs?	1 Yes	2 No	
6	HCW Recycle and Reuse			
6.1	Does the facility have HCW recycling/reuse program?	1. Yes	2. No	
6.2	If yes, how much?	_____		
6.3	What are HCW components recycling (paper, plastic, metals, cardboard, pallet, food waste etc)?	_____		
6.4	Are drugs supplied in reusable shipping containers?	1. Yes	2. No	
6.5	Is food waste used for compost /recycled?	1. Yes	2. No	
6.6	Is there a program to collect and recycle batteries?	1. Yes	2. No	
7	Pharmacy			
7.1	Is inventory maintained as first in/ first out?	1. Yes	2. No	
7.2	Where expired drug supplied for disposal?	1. Manufacturer 2 other specific		
7.3	Is non PVC or IV bags purchased?	1. Yes	2. No	
7.4	Is there any procedure for the safe handling or disposal?	1. Yes	2. No	

	of cytotoxic drugs?		
8	Radiology		
8.1	Has the facility investigated using non toxic x-r developing /digital system?	1. Yes 2. No	
8.2	Do you capture and recycle silver x-ray film fro radiology?	1. Yes 2. No	
9.	Environmental Health		
9.1	Is HCW generation assessment done last year?	1. Yes 2. No	
9.2	If yes, how much_____		
9.3	Is the hospital performed a waste audit in last 3 years?	1. Yes 2. No	
9.4	Do you have HCW reduction strategy?	1. Yes 2. No	
9.5	If incineration is used, is there a plan not to u incineration as waste treatment method?	1. Yes 2. No	
9.6	Are material safety data sheets maintained and ma readily available to all employees?	1. Yes 2. No	
10	HCWM (Over all)		
10.1	Who is responsible of HCWM at the facility?	1.Sanitarian 3.Medical direct 2.Administrator 4.Others	
10.2	Who does the supervision?	_____	
10.3	How frequently does the supervision?	1. Every day 2. Once a we 3.monthly 4.yearly	
10.4	Is there HCWM committee?	1 Yes 2 No	
10.5	Do you have HCWM regulation/operational standard?	1Yes 2 No	
10.6	Do you have HCWM guideline?	1 Yes 2 No	

10.7	Do you have HCW operational manual?	1 Yes 2 No	
10.8	Do you think sufficient budgets are allocated for HCWM?	1 Yes 2 No	
10.9	What are the problems encountered in management HCW practice in the facility?	_____	
11	HCWM Training		
11.1	Is training of staff available regarding HCWM?	1. Yes 2. No	
11.2	If yes, what kind of training is given?	1. In service training 2. Pre-service training 3. Others specify	
11.3	For how money staff the training given?	_____	

B. Key Informant Interview Guide for interviewing of health care workers, Cleaning staff and Administrators to assess practicability of HCWM

S. No	Questions	Response	Skip to
1	For Health Workers		
1.1	Work experience in the hospital	_____	
1.2	Name of working department/case teams	_____	
1.3	Do staffs trained about HCWM?	1 Yes 2 No	
1.4	Do staffs have waste collection bins or sharp boxes a used properly in the working area?	1 Yes 2 No	

1.5	Do health workers segregate HCW according to t guideline for disposal of waste?	1 Yes	2 No	
1.6	Do the staffs use PPE while handling waste?	1 Yes	2 No	
1.7	Do staffs know about HAI due to mishandling HCW?	1 Yes	2 No	
1.8	Do workers injured with sharp and syringe whi handling HCW in the last six month? How money?	1 Yes	2 No	
1.9	What measures taken after injury?	_____		
1.10	What are the types of waste generated in your worki area? List them	_____ _____		
2	For Cleaning Staff			
2.1	Do staffs trained about HCWM?	1 Yes	2 No	
2.2	If yes, do you handle and manage wastes according guideline?	1 Yes	2 No	
2.3	Do you have appropriate PPE and waste segregatio collection and transporting materials and commoditi for waste handling?	1 Yes	2 No	
2.4	Do you clean your waste handling materials proper with 0.5% chlorine solution?	1 Yes	2 No	
2.5	Do staffs know about HAI due to mishandling HCW?	1 Yes	2 No	
2.6	Do workers injured with sharp and syringe whi handling HCW in the last six month?	1 Yes	2 No	
2.7	What measures taken after injury?	_____		
2.8	What are the types of waste you handle?	_____		
3	For Administrators			
3.1	Do you trained about HCWM?	1 Yes	2 No	
3.2	Is there any policy or guideline about HCWM?	1 Yes	2 No	

3.2	Is adequate budget allocated for HCWM?	1 Yes	2 No	
3.3	Do your hospital has annual plan about HCWM?	1 Yes	2 No	
3.4	Is there any periodic supervision carried out in ea health care service unit?	1 Yes	2 No	
3.5	If yes, how often?	_____		
3.6	Do you recruit adequate staff for HCWM in t hospital?	1 Yes	2 No	

C. Weighing Scale Recording Format (Data sheet) for HCW generation

Data collector's Name: _____ Date: _____ Name of health-care facility: Menelik II
 Week from: _____ to _____ 2015. No of Beds: _____ Occupied beds _____
 Waste collection point/Service unit/ Case team: _____ No of clients visiting the hospital/out patients: _____

Date of Waste Collection		Quantity of waste generated per day (weight)													
		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday	
		Wt(kg)	Vol(Lit)	Wt(kg)	Vol(Lit)	Wt(kg)	Vol(Lit)	Wt(kg)	Vol(Lit)	Wt(kg)	Vol(Lit)	Wt(kg)	Vol(Lit)	Wt(kg)	Vol(Lit)
No of inPatients /outpatients															
Waste category (specify)	General														
	Infectious														
	Pathological														
	Sharp														
	Pharmaceutical														
	Radiological														
	Pressurized containers														
	Others														
	Total														

Declaration

I, the undersigned declared that this my original work, has not been presented for degree in this or other university and that all source of materials used for this thesis has been fully acknowledged.

Name: Desta Debalkie

Signature _____

Place: Addis Ababa, Ethiopia

Date of submission _____

This thesis has been submitted for examination with my approval as university advisor.

Name: Abera Kumie (MD,Msc,PhD)

Signature _____