HEALTHCARE SOLID WASTE GENERATION RATE AND ITS MANAGEMENT PRACTICES IN THREE HEALTH CENTERS OF WONDO GENET WOREDA, SIDAMA REGIONAL STATE, ETHIOPIA

M.Sc. THESIS

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HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

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HEALTHCARE SOLID WASTE GENERATION RATE AND ITS MANAGEMENT PRACTICES IN THREE HEALTH CENTERS OF WONDO GENET WOREDA, SIDAMA REGIONAL STATE, ETHIOPIA

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DECLARATION

I declare that this thesis is my original work and has not been presented for a degree in any other university, and that all sources of material used for the thesis have been duly acknowledged.

Name: Tsega Mesafint

Signature: _____

DEDICATION

This thesis work was dedicated to my beloved mom and brothers/sisters who deserves to see my academic success.

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LIST OF ACRONYMS

BLSH Black lion Specialized Hospital

CWM Clinical Waste Management

EPA Environmental Protection Agency

GMH Gandhi Memorial Hospital

HCW Healthcare Waste

HCWM Healthcare Waste Management

HHCW Hazardous Healthcare Waste

IRC International Committee the Red Cross

MSW Municipal Solid Waste

UNEP United Nation Environmental Program

WGARDO Wondo Genet Agricultural Resource Developmental Office

WHO: World Health Organization

Y12MH: Yekatitm12 Memorian Hospital

ABSTRACT

In many developing countries, the inadequacy of data regarding the quantity and composition of healthcare waste is one of the major reasons for improper healthcare waste management. The problem of poor healthcare solid waste management in health centers has become a critical issue as it poses potential health risks and damage to the environment in developing countries. This study aimed to assess healthcare solid waste generation rate and its management system in selected three health centers of Wondo Genet Woreda. A cross-sectional study design was applied to assess the healthcare solid waste generation rate and its management practices in three selected health centers. The study used quantitative and qualitative approach methods. The quantitative data were collected for seven consecutive days using questionnaires and direct measurement of healthcare waste and the qualitative data were collected by using an observational checklist and key Informant Interview. The SPSS version 21 and Microsoft Excel Version 2010 were used to analyze data. Descriptive statistics such as frequency, percentage, mean, and standard deviation were used for analyzing and interpretation of data. Pearson Correlation used to correlate the relationship between observed number of patient flow and quantities of healthcare solid waste generated from case teams. One-Way ANOVA was applied to perceive variation in healthcare solid waste generation rate among the three health centers. The numbers of patients were recorded from Basha HC, Aruma HC and Kella HC was 623, 579 and 519 patients per week respectively. The total weight of general, sharp, infectious, pathological and Pharmaceutical health care wastes generated from three selected healthcare centers. The findings revealed that the management of healthcare Solid waste in the health centers is poor. The total healthcare solid waste generated from Basha, Aruma and Kella healthcare center was 10.32kg/day or 72.23kg/week, 9.72kg/day or 68.04kg/week, 7.27kg/day or 50.9kg/week respectively. The total healthcare waste generation rate was 0.33Kg/patient/day. Although waste segregation at source of generation was crucial to improve waste management practices, it was observed that in this study, healthcare centers onsite segregation of healthcare solid waste was not practiced appropriately. Similarly, status of healthcare solid waste management practice with regard to storage, collection, treatment and disposal were not coherent with the WHO guideline. 66%) of the respondents responded that HCWs were poorly segregated in each case team, 93% of them also responded that there were no sufficient waste containers, 82.2%) of respondents responded that there was a temporary HCW storage and 95.9%) responded that there were no sufficient storage areas in health centers. Therefore, the management at the healthcare facilities along with the woreda health office officials should work together to properly implement the healthcare solid waste management as per the recommendation of the WHO healthcare solid waste management rules for keeping human health as well environmental sustainability.

Keywords: *Healthcare center, healthcare waste, healthcare waste generation rate, healthcare waste management*

1. INTRODUCTION

1.1. Background of the Study

Healthcare waste is waste generated from health institutions which involves both infectious waste and non-infectious waste materials (WHO, 2014). Healthcare waste is also referring to as healthcare center waste, hospital waste or clinical waste (WHO, 2005).

Healthcare waste generated from health-related activities can be broadly grouped as general waste and hazardous waste. This remains true if and only if there is proper on-site handling, such as segregation, separation, and storing with a unique color-coded storage system. There are different estimates regarding the share of hazardous and non-hazardous constituents of healthcare waste (Mesfin Kote *et la.,* 2011).

Infectious waste is produced from the hospitals during the diagnosis, immunization, surgical procedures and treatment of patients, and can transmit the infections to the hospital staff, attendants, and the nearby public. In the process of performing these activities, health facilities generally generate healthcare wastes (HCW) (WHO, 2014). However, such residues could be potentially harmful to healthcare workers, the public, and the environment and also it can transmit diseases and present additional risk to patients, healthcare workers and communities (Patil and Pokhrel, 2005).

Healthcare Solid Waste includes Syringes, Live Vaccines, and other waste contaminated with Bodily Fluids, Culture Dishes, Sharp Objects, Discarded Surgical Gloves, Discarded Surgical Instruments and others (WHO, 2014). The collection, segregation and disposal of healthcare solid waste involves labor intensive operations, relating many possibilities of direct contact with the waste increasing the risk of infections to the waste handlers (Abor and Bouwer, 2008; Nriagu and Udofia , 2013).

The public health impacts of HCW were determined by the overall waste management strategy adopted by the hospitals or health centers (Hossain *et al.,* 2013). Healthcare Waste Management (HCWM) at healthcare facilities is lagging behind in developing nations compared to the developed (Awad *et al.,* 2010). Unlike the developed countries, most developing nations tend to have both clinical and non-clinical wastes handled and disposed of together (Da Silva *et al.,* 2005) there by breaching the Health Care Waste Management (HCWM) standards and best

practices (WHO, 2014). A WHO survey (WHO, 2014) in 22 developing nations found that about 18% to 64% of healthcare centers use inappropriate clinical waste treatment and disposal technologies. This phenomenon poses public health risk due to the infectious nature of clinical waste (Da Silva *et al.*, 2005; Alhumoud, 2007).

Healthcare solid Waste Management involves management of a range of activities, which are mainly engineering functions such as collection, transportation, treatment of processing systems and disposal of waste. However, in most cases, initial segregation and storage activities are the direct responsibility of nursing personnel. If the infectious component gets mixed with the general non-infectious waste, the entire mass becomes potentially infectious. According to WHO (2007) report, it is estimated that around 23 million infections occurred due to improper management of healthcare waste globally.

The growing concern on waste management increased the importance of proper health care management practices, especially in healthcare establishments due to its potential hazardous nature (Dasimah, 2012). It is known that the basic role of health care system is preventing and controlling of disease across the community (Mumtaz, 2014). However, in the process of performing these activities, health facilities generate hazardous waste that could be potentially harmful to healthcare workers, the public and the environment (Dasimah, 2012). All wastes generated from services in health-care facilities are not hazardous or infectious wastes. About 75% and 90% of the waste produced by healthcare providers is comparable to domestic waste and usually called “non-hazardous” or “general health-care waste”. The remaining 10–25% of health-care waste is regarded as “hazardous” or “infectious” which may result in a variety of human and animal health risks, and environmental problems (WHO, 2014).

Improper management of solid waste can risk healthcare staff, employees who handle healthcare waste, patients and their families, and the neighboring population (WHO, 2004; ICRC, 2011). The production of highly toxic wastes has become a serious issue today due to the lack of attention given to and the sparing use of technology for healthcare waste management, particularly in Africa and the majority of developing and underdeveloped nations like Ethiopia (Awodele *et al.*, 2016). Conversely, the dumping of medical waste in uncontrolled areas can have a direct environmental effect by contaminating soils and underground waters (WHO, 2005).

Similarly, during incineration, if no proper filtering is done, it can be the primary source of some very toxic pollutants like Dioxin which is the main cause of cancer (Hossain, 2010).

Accordingly, inadequate information, lack of awareness and motivation among the waste handlers and each Healthcare Facilities (HCFs) contributing more to the poor healthcare waste management system (HCWMS) (Bassey *et al.,* 2006). As a result of these problems, mostly in many developing countries wastes are disposed of inappropriately here and there and also Infectious Waste is mixed with Non-HW illegally (Bassey *et al.,* 2006). In most of the Healthcare Facilities (HCF), there is a lack of HCWM guidelines, an appropriate treatment system, and a disposal mechanism (Kishore *et al.,* 2014). Currently, much evidences (Oyekale *et al.,* 2017) showed that HCWMP in Africa continent is still inadequate. These all are the main challenges in the management of healthcare solid wastes. Generally, due to inappropriate waste handling, the prevailing waste handlers and healthcare professionals (HCPs) are highly at risk of surviving in a good health condition (Kishore *et al.,* 2014; Joshi *et al.,* 2015).

The characteristics of waste generation depends on number of factors such as established methods of waste management, type of healthcare establishment, degree of health facility specializations, proportion of reusable items employed in healthcare, seasonal variation and patient work load. In middle and low-income countries, healthcare waste generation is usually lower than that of high-income countries (Muluken Azage and Abera Kumie, 2015). One of the primary causes of insufficient healthcare solid waste management in most hospitals in Ethiopia is the problem of awareness to the healthcare workers and the waste handlers (Desta and Abera, 2017). In Wondo Genet Woreda there was no research that was previously conducted on healthcare solid wastes management practices. Health professional and wastes handlers in Wondo Genet woreda selected healthcare centers are not aware of the potential impact of healthcare wastes on human health and environment. Therefore the aim of this study was to assess of healthcare solid waste generation rate and its management practices in three healthcare centers in Wondo Genet Woreda, Sidama Regional State, Ethiopia.

1.2. Statement of the Problem

Healthcare waste management in most healthcare institution is the priority for ensuring safety of the public health as well as environment, however; healthcare waste segregation practice, collection, transport and disposal in Sub-Saharan countries don not follow WHO directives of HCWM perspective (WHO, 2014). The mismanagement of healthcare solid 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. 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 solid wastes are being mismanaged and it is also an indication that there is urgent and critical need for the proper disposal of healthcare solid waste (WHO, 2014).

It is estimated that more than two million healthcare workers are exposed to percutaneous injuries with infected sharps every year (WHO, 2014). Apart from serious public health consequences stated above, inadequate and inappropriate handling of healthcare solid waste, on the other hand, may have a significant impact on the environment including soil and water pollution. According to the finding of the Ethiopian ministry of health (MOH, 2006) on an assessment of HCWM conducted in 16 health centers and 48 clinics report indicated that most of the health facilities did not have proper liquid and solid waste disposal facilities. Accordingly, there are inadequate information, lack of awareness and motivation among the waste handlers and each healthcare facility.

In the selected healthcare centers of Wondo Genet woreda healthcare solid wastes are mixed and dumped with a great mixture of substances, including, Syringes, gloves, glass, hard board, textiles, papers and plastic (Pre-survey). In those healthcare centers improper healthcare solid waste management practices were alarming, because there is a lack of awareness of waste handlers and materials such as color coded bins, protective coat, and etc. The perception of the local community and patients about waste generation, waste disposal and effects of the waste on their healthy as well as local environment is very poor.

Healthcare waste management practice includes all activities involved in waste generation, segregation, transportation, storage, treatment and final disposal of the waste generated in

selected healthcare centers is not adequate and in the health centers, hazardous and general solid wastes are still handled and disposed together with in a single waste disposal site. The final disposals are fenced appropriately. The smell of wastes placed out of site during dispose of waste is another problem that can easily pollute the air and may attack the respiratory organs of patients and workers when the healthcare solid wastes are burnt in open places like small pits serving in the health centers.

Improper management of wastes generated in health care facilities can have direct health impacts on the community, the personnel working in healthcare facilities, and on the environment. In addition, environment polluted by inadequate treatment of waste can cause indirect health effects to the community. If adequate measures are taken, the risks to this segment of the population should be low. In general, all the problems mentioned above about managing healthcare solid waste in selected health centers may cause serious health problems on patients, healthcare workers and the public. At present, there was no available information that describes the actual healthcare solid waste generation rate and its management practices in healthcare centers of Wondo Genet Woreda. Therefore, this study was conducted to assess the healthcare solid waste generation rate and its management practices, to determine the daily quantity of waste generated and its management practices in three selected healthcare centers of Wondo Genet Woreda.

1.3. Objectives of the Study

1.3.1. General Objective of the Study

The general objective of this study was to assess healthcare solid waste generation rate and its management practices in three healthcare centers of Wondo Genet Woreda, Sidama Regional State Ethiopia.

1.3.2. Specific Objectives of the Study

1. To identify the composition of healthcare solid waste in selected health centers of Wondo Genet Woreda;
2. To assess the amount of healthcare solid waste generated at selected health centers;
3. To assess the healthcare Solid waste management practices at the study health facilities.
4. To assess the status of awareness of healthcare workers in the healthcare solid waste management in the selected health centers of Wondo Genet Woreda.

1.4. Research Question

The results of the present study attempted to address the following research questions:

1. What are the compositions of healthcare solid waste in selected health centers in Wondo Genet Woreda?
2. What is the healthcare solid waste generated at selected health centers?
3. What are healthcare Solid waste management practices at the study health facilities?
4. What is status of awareness of healthcare workers in the healthcare solid waste management in the selected health centers in Wondo Genet Woreda?

1.5. Significance of the Study

Healthcare Solid waste management is challenging in developing countries where there is lack of reliable data on factors such as generation rate, characterization and management of healthcare waste. The lack of sufficient recorded information on healthcare waste management hinders the planning for better management of waste. The results of the present study would provide information on generation rate, types of waste and management of healthcare Solid wastes in health centers of Wondo Genet Woreda. It would help the health centers managers, healthcare workers, support staff and waste collectors to plan for better management practices, that will in turn keep the health centers as well as the surrounding environment clean and safe for all workers in the health centers, patients (and those who accompany them) as well as those community members that reside in close proximity to the study healthcare facilities. The results will also provide baseline information for other researchers to conduct similar or related studies elsewhere.

1.6. Scope of the Study

This study was conducted in three health centers of Wondo Genet Woreda, Sidama regional state, Ethiopia. The study ascertained the HCW generation rate, HCW type, and its management system (segregation, collection, storage, transportation, treatment and disposal) by using questionnaire survey, interviews of key informants and observation checklist at the study health centers. The scope of this study focuses only on the assessment of healthcare solid wastes generation rate and its management practices in case of three healthcare centers (Basha HC, Aruma HC and Kella HC) in Wondogenet Woreda. Therefore, the findings of this particular study may not be representative of all other healthcare centers in the Wondogenet Woreda.

Some difficulties have been faced to collect secondary data and some basic information from the Healthcare centers office because of displacement of responsive experts. There is a limitation to get published articles and journals from study area in this field of study for literature review and to be used for comparison of the result obtained. Money and shortage of time were the key constraints on the thesis. The monetary overhead was particularly limiting because the researcher had to finance all research related expenses out of own pocket.

2. LITERATURE REVIEW

2.1. Conceptual Definition of Concepts

2.1.1. Solid Healthcare Waste

Has been referred to as any waste discarded solid material generated from activities involving health protection, medical diagnosis, treatment, and scientific research, dental and veterinary.

Healthcare waste is waste generated from health institutions which involves both infectious waste and non-infectious waste materials (WHO, 2014). Healthcare waste is also referring to as medical waste, hospital waste or clinical waste (Soncuya *et al.*, 1997; WHO, 1999; WHO, 2005). Whereas, Hospitals produce a tremendous amount of HCW that is defined as any solid waste which is generated as a result during patient diagnosis, treatment, or immunization of humans or animals (Soncuya *et al.*, 1997; WHO, 1999).

General Waste is defined as non-risk HCW includes all the waste that has not been infected like general office waste, packaging, or left-over food. Hazardous waste means waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical or infectious characteristics, cause ill health or increase mortality in humans, fauna and flora, or adversely affect the environment when improperly treated, stored, transported or disposed of (Godfrey, 2003). Infectious waste includes infectious materials that can cause disease to humans (WHO, 2005). Infectious waste means healthcare risk waste which is suspect to contain pathogens and which normally causes or significantly contributes to the cause of increased morbidity or mortality of human beings and includes but is not limited to sharps waste and anatomical waste; but excludes baby nappies and sanitary pads (Godey, 2003).

Pathological waste is consists of tissues, organs, body parts, human fetuses and blood, and body fluids. Within this category, recognizable human or body parts are also called anatomical waste. This category should be considered as a subcategory of infectious waste, even though it may also include healthy body parts (WHO, 1999). Health institution or healthcare facility includes hospitals, medical or research laboratories, clinics, offices of physicians and dentists, veterinarians, long term care facilities (Soncuya *et al.*, 1997; WHO, 1999).

Healthcare waste management is a process that helps ensure proper hygiene in the health institution and safety of healthcare Workers and communities (Sanitation Connection, 2002). Waste disposal refers to the final placement of treated waste (Johannessen *et al.*, 2000; WHO, 2005). Treatment of wastes is mainly reducing direct exposure of waste to become less dangerous to humans, at recovering recyclable materials and at protecting the environment (Johannessen *et al*., 2000).

2.2. Sources of Healthcare Waste

Different types of healthcare facilities can be viewed as major or minor sources of healthcare waste, according to the quantities produced.

2.2.1. Major Sources of HealthCare Waste

Major Sources of HealthCare Waste are Hospitals: University hospital, General hospital, District hospital and primary hospital. Related laboratories and research centers: Medical and biomedical laboratories, Biotechnology laboratories and Medical research centers (Johannessen *et al*., 2000).

2.2.2. Minor and Scattered Healthcare Waste

These sources typically have some common features: They rarely produce radioactive or cytostatic waste; Human body parts are not normally produced and sharps consist mainly of hypodermic needles. However, it should be recognized that the quantities of waste from the home treatment of medical conditions and long-term home-based care are rising significantly in many countries (WHO, 2014). Some of them area convalescent nursing homes, psychiatric hospitals, disabled persons' institutions, activities involving intravenous or subcutaneous interventions, cosmetic ear-piercing and tattoo parlous and Illicit drug users and needle exchanges, funeral services, ambulance services and Home treatment (WHO, 2014).

2.3. Types of Healthcare Waste

Health care waste can be classified as major or minor sources according to the waste quantities produced. The major source of health care waste are generated at major hospitals (e.g. university teaching hospital, general and districts hospitals) and other health centers (i.e. emergency medical care services, health care center and dispensaries etc.) (Katoch and Kumar, 2008; Cheng *et al.*, 2009) The minor sources of clinical waste are generated at small health care establishment (such as physicians' officer, dental clinics, acupunctures, chiropractors

etc.) and non-health activities involving intravenous or subcutaneous interventions basically with low waste generation (Katoch and Kumar, 2008).

The WHO classifies medical or healthcare waste into common waste or general waste and special waste. Common or general waste is all solid waste not including infectious, chemical, or radioactive waste. This waste stream can include items such as pack ageing materials, bedding,

office supplies, and other substances that do not pose special handling problem hazard to human health or the environment (WHO,1999).

2.3.1. Chemical Waste

This type of waste consists of discarded solid, liquid, and gaseous chemicals, for example from diagnostic and experimental work and from cleaning, housekeeping, and disinfecting procedures. Chemical waste from healthcare may be hazardous or nonhazardous; in the context of protecting health. It is considered to be hazardous if it has at least one of the following properties:

- Toxic;
- Corrosive (e.g. acids of pH< 2 and bases of pH>12);
- Flammable;
- Reactive (explosive, water-reactive, shock-sensitive); and
- Nontoxic (e.g. cytostatic drugs)

Non-hazardous chemical waste consists of chemicals with none of the above properties, such as sugars, amino acids, and certain organic and inorganic salts (WHO, 1999).

2.3.2. General Healthcare Waste

This type of waste comes mostly from the administrative, kitchen and housekeeping functions at healthcare facilities and may also include packaging waste and waste generated during maintenance of healthcare buildings. Between 75% and 90% of the waste produced by healthcare providers is comparable to domestic waste. This waste stream can include items such as packaging materials and office supplies. Generally, this stream can be disposed of in a communal landfill or other such arrangement (WHO, 2014).

2.3.3. Hazardous Healthcare Waste

10–25% of healthcare waste produced in healthcare facilities is regarded as hazardous and may pose a variety of environmental and health risks. Hazardous healthcare wastes (HHCW) include several different waste streams, some of which require more stringent care and disposal. Special Healthcare waste consists of several different subcategories: Infectious waste, Pathological wastes, Sharps waste, radioactive waste, Chemical waste, Cytotoxic waste, Pharmaceutical and Genotoxic waste (WHO, 2014).

2.3.4. Geno-toxic Waste

It is highly hazardous and may have mutagenic, teratogenic, or carcinogenic properties. It raises serious safety problems from both inside hospitals and after disposal, which should be give special attention. Genotoxic waste may include certain cytostatic drugs, vomit, urine, or faeces from patients treated with cytostatic drugs, chemicals, and radioactive material. Cytotoxic drugs, the principal substances in this category, have the ability to kill or stop the growth of certain living cells, and are uses in chemotherapy of cancer. They play an important role in the therapy of various neoplastic conditions but there is also finding wider application as immune suppressive agent sin organ Tran's plantation, and in treating various diseases with an immunological basis. Cytotoxic drugs are most often used in specialized departments such as oncology and radiotherapy units, whose main role is cancer treatment; however, their use in other hospital departments is increasing and they may be used outside the hospital setting (WHO, 1999).

2.3.5. Heavy metals Waste

Heavy metals waste: content fall under hazardous chemical waste, and are usually highly toxic. Mercury wastes are typically generating from spillage from broken clinical equipment but their volume is decreasing with the substitution of solid-state electronic sensing instruments (thermometers, blood-pressure gauges, etc.). Whenever possible, spilled drops of mercury should be recovered. Residues from dentistry have high mercury content. Cadmium waste comes mainly from discarded batteries. Certain "reinforced wood panels" containing lead is still used in radiation proofing of X-ray and diagnostic departments. A number of drugs container arsenic, but these are treated here as pharmaceutical waste (WHO, 1999).

2.3.6. Infectious Waste

Infectious waste: contains pathogens (bacteria, viruses, parasites, or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts. This category includes cultures and stock of infectious agents from laboratory work, waste from surgery and autopsies on patients with infectious diseases. Waste from infected patients in isolation wards, waste that has been in contact with infected patients undergoing home dialysis (e.g. dialysis equipment such as tubing and filters, disposable towels, gown sand aprons, gloves and laboratory coats) and waste that has been in contact with animals inoculated with an infectious agent or suffering from an infectious disease (WHO,1999).

2.3.7. Pathological Waste

Pathological waste: Consists of tissues, organs, body parts, human fetuses and animal carcasses, blood, and body fluids. Within this category, recognizable human or animal body parts are also called anatomical waste. This category should be considered as a subcategory of infectious waste, even though it may also include healthy body parts (WHO, 1999).

2.3.8. Pharmaceutical Waste

Pharmaceutical waste: include pharmaceutical products, drugs, and chemicals that have been return from wards, have been spilled, are out dated contaminated, or are to be discarded because they are no longer required. These also include discarded items used in the handling of pharmaceuticals, such as bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials (WHO, 1999).

2.3.9. Radioactive

Radioactive materials are wastes containing radioactive substances. These include solid, liquid, and gaseous waste contaminated with radionuclides generated from vitro analysis of body tissues and fluids, in vivo body organ imaging, tumor localization, and therapeutic procedures (WHO, 1999).

2.3.10. Sharps Materials

These are items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Whether or not they are infected, such items were usually considered as highly hazardous healthcare waste (WHO, 1999).

2.4. Healthcare Solid Waste Generation Rate

Healthcare activities lead to the production of waste. The generation rate varies across the different types of hospitals. There exists different generation rate that does not only vary from country to country, but also within a country (Alagozand Kocasoy, 2008).

In addition, the research confirmed that healthcare waste generation rate depends on the level of economic development of a country, location of healthcare establishment, proportion of disposable substance used in healthcare activities and season of the year; This seasonal variation may be due to the fact that with change in season the nature of illness of patients being admitted to hospitals also changes (kotoch *et al.* 2007).

The generation rate of middle-income countries compared to low-income countries indicates that lower in low-income countries. However, the range of values for countries of similar income level is probably as wide in high income countries as in less wealthy countries (WHO 2005).

The WHO assessment of healthcare waste generation rate indicated that 80% is general healthcare waste, 15% pathological and infectious waste, 1% sharps waste, 3% chemical or pharmaceutical waste, and less than 1% special waste, such as radioactive or cytostatic waste, pressurized containers or broken thermometers and used batteries (Annet *et al,* 2013).

A study conducted in Sylhet city, Bangladesh (2006) observed that the average waste generation rate for hospitals was 0.934 kg/bed/day; the percentage of non-hazardous waste produced in the Hospitals was 77.08% and hazardous waste 22.92% (45).

A survey done in Irbid, Jordan, showed the generation rates of healthcare waste in three hospitals 6.904 kg/pat/day (4.315 kg/bed/day) at the Princess Basma Hospital, 5.718 kg/pat/day (3.212 kg/bed/day) at PrincessBade'ah Hospital, and 4.532 kg/pat/day (2.556 kg/bed/day) at Ibn Al-Nafis Hospital (Bdour *et al,* 2007).

A study conducted on healthcare waste generation rate in Chittagong Medical College Hospital, Bangladesh (2008) showed the generation rate was 1.28 kg/ bed/ day and the rate was 0.57 kg /outpatient/day for the evaluation of outpatient numbers. The observed significant P values (P>0.05) indicates that the evaluation of the waste streams in healthcare services based upon outpatient numbers did not show any reasonable change according to service category. From the total healthcare waste 37% was infectious. The amount of healthcare waste was positively correlated with the number of inpatients treated in the hospital (patwary *et al,* 2009). Another study done in Dhaka, Bangladesh (2009) showed that the proportion of hazardous waste was found to be approximately 21%. The amount of waste, and the proportion of hazardous waste, was found to vary significantly with the size and type of a healthcare establishment (Patwary *et al.,* 2009).

The healthcare waste generation rate in Nigeria (2011) in eight hospitals found in Ibadan Metropolis revealed that the public hospitals generated waste was between 0.37 to 1.25m kg/patient/day, while private hospitals generated between 0.12 to 0.28 kg/patient/day. Regarding the composition of healthcare waste, infectious waste represented 26 to 37% (Wahab and Adesanya, 2001). In Kenya, the amount of infectious waste was higher than the general waste which indicates lack of proper segregation of waste. A study done in Amana District Hospital, Tanzania showed that the average medical waste generation rate was 1.8kg/patient/day (Kagonji, 2011).

The study conducted in Hawassa City, Southern Nations, Nationalities and Peoples Region (SNNPR) Ethiopia (2011) showed that 48.73% (range: 41.0-67.7%) was infectious and 6.16% sharps (range: 2.12-9.98%) (Israel Deneke *et al.,* 2011). A study done in Gondar University Teaching Hospital (2007) indicated that the average generation rate of solid healthcare waste estimated based on the number of inpatients was 0.95 kg/bed /day and 0.142 kg/outpatient/day. There was statistically significant correlation between patient flow and the generation rate of solid healthcare waste with P-value less than 0.002 (Dagnew Endale *et al.,* 2007).

A study conducted in Addis Ababa, Ethiopia (2011) revealed that non-hazardous healthcare waste (median: 58.69%, range: 46.89–70.49%) and hazardous healthcare waste (median: 41.31%, range: 29.5 –53.12%), the majority of which was infectious (median:13.29%, range:

6.12-20.48%) and pathological waste (median:10.99%, range:4.73-17.25%) and the rest sharps and pharmaceutical were (median: 8.74%, range:6.41-11.07%) and (median: 6.14%, range:3.54- 8.73%) respectively. The total quantity of healthcare waste generated from public hospitals was significantly more ($p<0.05$). But, there was no a statistically significant difference between the amount of healthcare waste generated from public versus private hospitals (Debre Mekonnen *et al.,* 2013).

This review confirmed that hospitals' healthcare waste generation rate varies from hospital to hospital, even in same country. According to the study of Esubalew Tesfahun (2015) the compositions of healthcare waste in public hospitals were 46.4%, 34.3%, 3.8%, 9.1%, 6.2% and 0.2% for general, infectious, sharps, pharmaceutical, pathological and radioactive wastes respectively. The compositions of healthcare waste in private hospitals were 45.3%, 29.7%, 6.7%, 17.3%, 0.5% and 0.5% for general, infectious, sharps, pharmaceutical, pathological and radioactive wastes respectively (Esubalew Tesfahun, 2015). Study conducted in Shashemene Town indicated composition of healthcare waste in government hospital was 52.4%, 1 4.8%, 1 4 %, 6.3%, and 1 2.5% were general, infectious, Pharmaceutical, sharps and pathological waste respectively while in private hospitals 57.1 %, 1 0.9 %, 1 3.2%,7.9%, and 1 0.9% were general, infectious, Pharmaceutical, sharps and pathological waste respectively. 52.4% was general and 47.6% waste was hazardous waste in governmental hospital and 57.1% general and 42.9% was hazardous in private hospital. The hazardous amount of waste was not coherent with the value stated by WHO (Gudete Eli and Daniel Fitamo, 2018).

Similarly, study conducted in Haromaya University indicates that on average, all hospitals under the study produce a daily average waste of 0.57kg/pt/day. The proportion of hazardous waste in hospitals range between 35.12% and 45.61% (Tadesse Alemayehu, 2015). According to the study of Muluken Azage and Abera Kumie (2007) the HCW generation rate indicated that 52% were general waste and 48% were hazardous waste. Therefore, in order to determine healthcare waste generation rate of hospitals, it is required to deal with the nature and purpose of hospitals; that is, private, public, district, zonal, referral or teaching hospitals in the Ethiopia context.

4.5. Healthcare Solid Waste Management

In all healthcare facilities, the most basic elements of the HCW management system included: waste segregation, waste minimization, containerization, color coding and signage, handling, transport, storage, treatment, and final disposal of waste. Healthcare facilities need to address each component of the waste management system (UNEP).

2.5.1. Healthcare Waste Segregation Practice

Waste segregation is the key to efficient healthcare waste management (HCWM). It entails the separation of different types of waste (infectious, sharps, chemically hazardous, radioactive, non- hazardous) at the point of generation, with specific requirements for handling, treatment and disposal and avoid mixing of wastes during disposal (Azage Muluken *et al.*, 2015.)

However, studies in different countries and different healthcare facilities indicate that the segregation of wastes at the source is not sufficient. The use of a color-coding system for HCW containers was not practiced and there was no labeling practice for hazardous waste. Segregation of HCW by type at the point of generation and pre-treatment of infectious waste was also not practiced. Moreover, sharps are required to be disposed of in a safety box, but this was not practiced (Samuel Fekadu and Wondemagegn Chernet, 2016). Waste segregation was practiced partially; throwing wastes into any container nearby was common. Thus, waste is not sorted in the distinct color-coded containers. It was also a common practice to place wastes sorted in different containers together during final disposal. Only 20% HCFs strictly used colored waste bins (Esubalew Tesfahun; 2015, Tadesse Alemayehu, 2015).

A study conducted in the health center of Addis Ababa, Ethiopia 2014 showed that half or 5 of health centers segregate waste at the source of generation. However, a similar study done in the health centers of Bench Maji Zone, Ethiopia 2018 showed that only two (2), out of ten (10) health centers segregated wastes at the source of generation (Azage kumie, 2010; Sisay Abebe, 2017). Whereas, in Adama none of the health centers segregated wastes at the source of generation (Sisay Abebe, 2017).

Table 1: Types of wastes, color of containers and type of container for handling of HCW

Types of wastes	Colour of container and marking	Types of container
Infectious and pathological waste	Yellow, marked "infectious"	Strong, leak-proof plastic bag or container capable of being autoclaved
Sharps	Yellow, marked "sharp"	Puncture- proof container
Chemical and pharmaceutical wastes	Brown, marked "hazardous"	Plastic bag or container
Waste with high content of heavy metal	Brown, marked with the specific heavy metal content and hazardous	Puncture and corrosive proof container, separate containers for different heavy metal content
Radioactive and genotoxic waste	Red, marked with radioactive symbol	Lead box, labeled with radioactive symbol
Pressurized containers	Black	Plastic bag; could mix with general waste
General wastes	Black	Plastic bag

Source: WHO (2002)

According to Azeb Tayawork, (2016) studied hospitals (Black lion special hospital, Yekatit 12 memorial hospital and Gandhi memorial hospital) segregation of sharp waste, infectious waste and general waste was practiced. Placentas and blood-stained cotton pads were kept in separate containers in three hospitals. The use of waste containers with a color code and labeling at the point of generation was implemented in all hospitals.

There are some factors which affect the proper segregation of wastes in healthcare facilities. These are age, work experience, working hours, educational level, lack of awareness and availabilities of color-coded containers (Azage Muluken *et al.,* 2013). Healthcare workers lack knowledge on segregation and some look segregation as a tedious job in their sections (Kagonji

et al., 2016). Lacking of colored waste bags were of the main shortcomings (Odette *et al.,* 2014). Lack of initial training of nurses and new personnel, while service sectors personnel were constantly changed or replaced (Farzadkia *et al.,* 2015). The color-coded bins were not placed on stand as well as closed fitting covers on them were missing. The segregation practices of waste were not satisfactory as it was primarily done by sweepers only (Srivastav *et al.,* 2012). Proper segregation is achieved by making use of actual colored containers or colored liners to effectively separate infectious waste from general/domestic waste (Awodele *et al.,* 2016).

2.5.2. Temporary Storage

Healthcare waste produced in healthcare facilities should be stored in appropriate place until it was treated or disposed. Intermediate storage takes place in a specially designed storage area min order to avoid biodegradation, odors, and the attraction of insects and rodents. However, studies conducted in different countries indicates challenges in doing so (Esubalew Tesfahun, 2015). Most of the HCW at the hospitals was found to be collected and transported in perforated plastic bins. Waste temporarily stored in open and substandard dustbins for about 12 hours. Pathological and sharp wastes were stored in closed plastic containers and collected in less than an hour. Public hospitals use standard safety boxes to store sharp wastes, while private hospitals use non-standard storages, such as carton boxes that can be easily damaged or torn out (Azage Muluken *et al.,* 2013; Sisay Abebe *et al.,* 2017). Waste bags and sharps containers should be filled to no more than three quarters full. The central storage area should be hard-standing impermeable easily cleanable floor with good drainage (away from watercourses), fenced, lockable, inaccessible to insects' animals, and isolated from patients and the public (Shalini, 2012).

Some hospitals temporarily stored all waste in open and substandard dust bins for about unlimited time. Pathological and sharp wastes were stored in closed plastic containers and collected in till the safety boxes are filled. The sampled hospitals use non-standard storages, such as carton boxes that can be easily damaged or torn out. In all hospitals, lack of proper and purpose-built waste storage areas was apparent (Azeb Teyework, 2016).

According to Esubalew Tesfahun (2015) all public and private hospitals temporarily stored all waste in open and substandard dustbins for about 12 hours. Pathological and sharp wastes were stored in closed plastic containers and collected in less than an hour. Public hospitals use standard safety boxes to store sharp wastes, while private hospitals use non-standard storages, such as carton boxes that can be easily damaged or torn out. In all hospitals, lack of proper and purpose-built waste storage areas was apparent.

Similar study in Addis Ababa conducted (Birhanu Desalew and Yohans Solomon, 2017) in fifty-three different hospitals shows that, in government hospital only two types color code labeling plastic buckets used such as yellow and black whereas in private hospital used uncovered plastic buckets of any type for on-site waste collection for all type of medical waste. Similar study in Gondar (Azage Muluken *et al.,* 2013) revealed that all surveyed HCFs didn't have appropriate and adequate color- coded containers and plastic bags for healthcare wastes collection. Two out of ten hospitals used safety boxes for contaminated sharp collection. Open plastic buckets and safety boxes were used to transport manually to the disposal site. Besides, in Addis Ababa hospital reported that there was no segregation of waste into infectious, pathological and pharmaceutical, and had no separate color-coding plastic buckets for the collection of infectious waste (Birhanu Desalew and Yohans Solomon, 2017).

According to Getachew Petros (2019) conducted in Durame general hospital and Shishicho primary hospital, there were no suitable isolated central storage sites for healthcare waste temporary storage in both hospitals. All departments of both hospitals temporarily stored all waste in open and sub standard bins for about12-24 hours. Sharp wastes were stored in standard safety box containers and placenta stored in closed plastic bins and collected in less than an hour. A fundamental issue that was highlighted through interview with personnel at the hospitals was that there were frequently insufficient waste containers to handle the volume of healthcare wastes generated. Much of the findings during observation were similar in both hospitals.

2.5.3. Collection and Transportation of Hospital Healthcare Waste

Proper and timely collection of medical wastes as well as proper transportation is better way used to bring the healthcare waste to the treatment and disposal sites. The Collection should be fixed and appropriate to the quantity of waste, but not more than a day (Esubalew Tesfahun, 2015). However, there was problem in doing so. Study done in Addis Abeba city indicated that in three hospitals, HCW materials were collected daily while the collection program was irregular in the rest hospitals.

In one hospital the waste was stored in temporary storage area up to one month before final disposal while in one other hospital stored for two weeks (Mesfin Debere *et al.,* 2011). Final disposal to an off-site area is done by outsourced disposal company trucks which come to the hospital once weekly and in all cases infectious waste is transported together with non-infectious waste (Katsume, 2018).

There was no structured collection and transportation system for general and hazardous waste in both private and public hospitals. Some used open plastic bins to collect and transport mixed wastes and other used open container and carton box. The waste from delivery, operation and intensive care units was collected in less than 2 hours (Samuel Fikadu and Wondemagegn Chernet, 2016). Similarly, mixed wastes were collected and transported in a carton or open plastic bins without labeled at the point of generation. This will also contribute to the risk of infections for healthcare providers, patients, visitors and the neighboring community. In general the means of transportation of healthcare waste in all surveyed HCFs was not in line with the WHO recommended standard (Azage Muluken *et al.,* 2013; Awodele *et al.,* 2016).

According to Esubalew Tesfahun (2015) contacted in Amhara region, there was no structured collection and transportation system for general and hazardous waste in both private and public hospitals. In four out of six public hospitals (67%), open plastic bins (capacity of 25 litters) were used to collect and transport mixed wastes, while one public hospitals (11.11%) used closed plastic container (capacity of 50 litters) and one public hospitals (11.11%) used both open container and carton box. Only sharps and pathological wastes were collected and transported separately.

Mixed waste was collected and transported in carton or open plastic bins in private hospitals. Almost in all private and public hospitals, healthcare waste was collected and transported to incineration facilities without using wheeled trolleys (leak-proof made with stainless steel) twice a day in the morning before 8:00 am and in the evening after 6:00 pm by cleaning personnel. The waste from delivery, operation and intensive care units was collected in less than 2 hours (Esubalew Tesfahun, 2015).

As Azeb Tayework study conducted in three different hospitals (BLSH, Y12MH and GMH), there was no structured collection and transportation system for general and hazardous waste in those hospitals. In two out of three hospitals used closed plastic container (capacity of 50 litters) were used to collect and transport mixed. Only sharps and pathological wastes were collected and transported separately. Mixed waste was collected and transported in carton or open plastic bins (Azeb Tayework, 2017).

Several methods were used for infectious and sharp waste treatment, depending on the type of waste material generated. These treatment methods include one of the following option or combination of option: steam sterilization, incineration, thermal inactivation, gas vapor sterilization, and chemical disinfection, sterilization by irradiation or electromagnetic radiation. After treatment the wastes or their ashes should disposed of by discharge into sanitary sewer systems (Azeb Tayework, 2017). The study conducted in developing countries reviled that the commonest method of healthcare waste treatment was done by poor design and construction incinerators have low combustion capacity (Israel Deneke *et al.,* 2011).

During healthcare waste management the unusable waste materials should preferably be treated to reduce their potential health or environmental hazard and volume, with remaining residues sent for land disposal to a suitably constructed site (Esubalew Tesfahun, 2015). Some HCFs had an attempt to treat infectious waste before dispose of using either barakina or alcohol (Azage Muluken *et al.,* 2015) and some institutions apply autoclaving for treatment of infectious and highly infectious waste generated in the laboratory (Chepngeno, 2015).

The hazardous waste is either treated or disposed of or left untreated. The general waste is also either treated or disposed off (Issam *et al.,* 2016). The needles and sharps were first autoclaved and then buried in pits after disinfection. The yellow bags sent to incinerator plant.

The Black bags were disposed of by the municipality as the general waste (Shalini *et al.*, 2013). Depending upon the type and nature of the waste material and the organisms in the waste, risk waste should be inactivated or rendered safe before final disposal by a suitable thermal, chemical, irradiation, incineration, or other treatment method, or by a combination of such methods, involving proper validation and monitoring procedures (Kumar *et al.*, 2013). All waste must be treated before it can be land filled. It is important that waste producers find better ways to manage their waste. Treatment is to reduce the amount of waste going to landfill and reduce the impact of waste when it is land filled (Ghasemi and Yusuff, 2016).

Current treatment strategies are directed towards reducing the amount of solid waste that needs to be landfilled, as well as recovering and utilizing the materials present in the discarded wastes as a resource to the largest possible extent.

Different methods are used for treatment of solid waste and the choice of proper method depends upon refuse characteristics, land area available and disposal cost they are as follows Incinerationdeposition Pyrolysis, gasification,Compaction,composting and land filling [USA environmental protection agency, 2009].

2.5.4. Disposal of Healthcare waste

Improper disposal of healthcare waste have several impacts to the environment (the air, water and soil), to healthcare workers and to the society at all (WHO, 2014). Therefore, the objectives of the safe disposal of a hazardous waste are to ensure that any adverse impact on the environment minimized, prevent hazardous substances leaching or moving into the environment in particular the ground and surface waters thus avoiding detrimental effects both in the short- and long-term to man and to the environment (Bredenhann *et al.*, 1998).

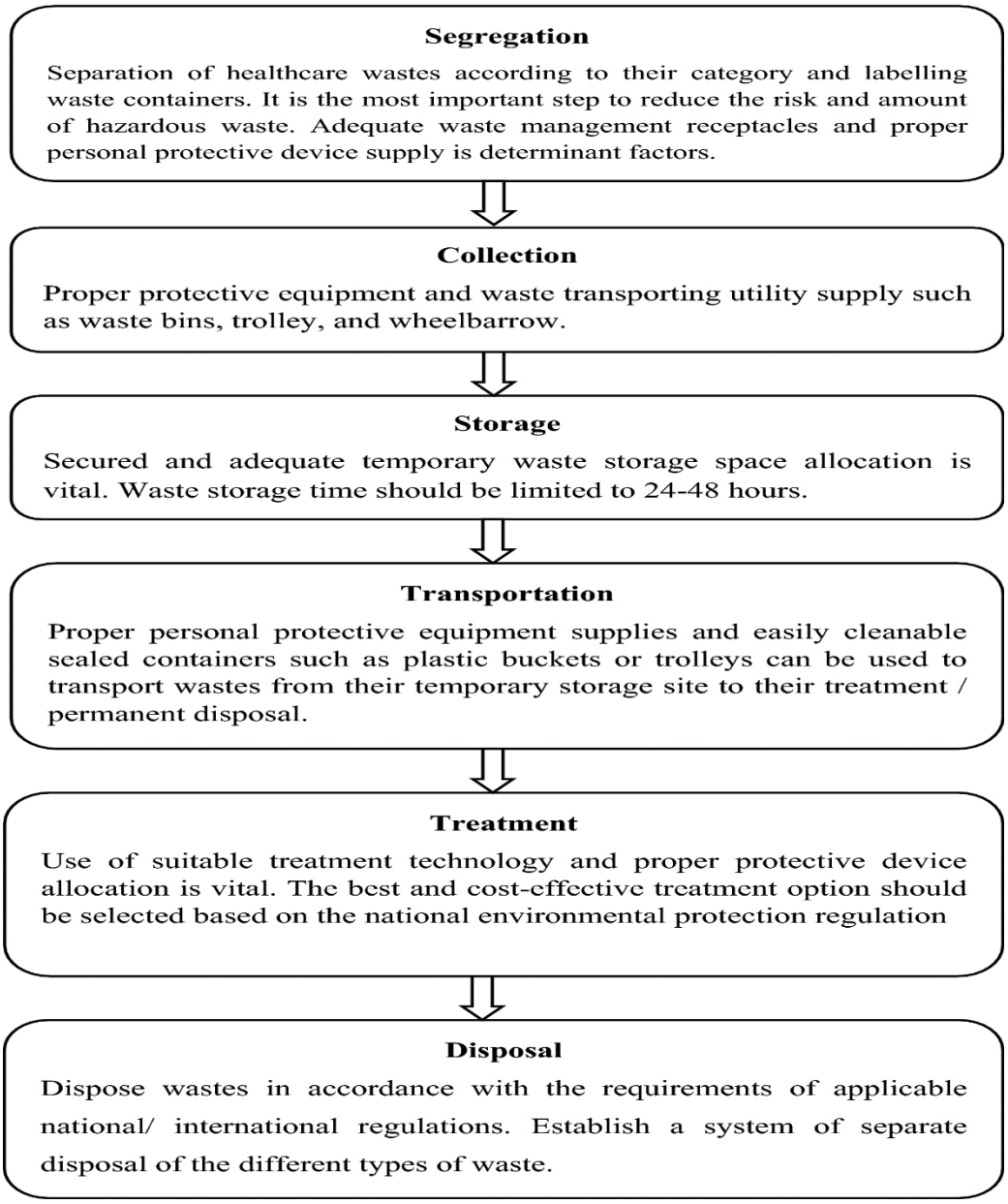

Figure 2 Healthcare waste management process

2.5.5. Incineration of Healthcare Wastes

Incineration is the burning of waste at high temperatures. It is to reduce organic & combustible waste to inorganic incombustible to reduce volume & weight that cannot be revealed, reused or disposed in outer land fields (Kalpanla *et al.,* 2016). The process removes hazardous materials, reduces the mass and volume of the waste and converts it into ash that is harmless. Incineration is suitable for pathological and infectious waste or sharp wastes (Shareefdeen,

2012). The advantage of incineration is that, apart from the residual ash which must be land filled, the waste is destroyed and the risk posed by the waste is minimized (Bredenhann *et al.,* 1998).

The drawbacks to modern incinerators include the large capital and operating costs. The waste should be less moistured as less than 30% and also combustible (Kalpanla *et al.,* 2016) As well incineration is suitable for wastes that are 60% combustible (Shareefdeen, 2012). However, different study indicated there is problem in using incinerators. The best available final disposal method of HCW is incineration using a single chamber incinerator built of brick. However, this type of incinerator is against the Stockholm Convention, since several problems have been reported with single chamber brick-made incinerators, including emission of toxic substances into the environment that are a risk to public health (Samuel Fikadu and Wendimagegn Chernetet, 2016, Gudeta Eli and Daniel Fitamo, 2018).

Also these incinerators are not proper in design and construction, and unable to burn waste completely; consequently they are not reducing waste volume significantly and produced high smoke emission (Esubalew Tesfahun *et al.,* 2015). Thus the use of low combustion single-chamber incinerators for the treatment of healthcare waste is against the Stockholm Convection on persistent organic pollutant (Esubalew Tesfahun, 2015). Open pit burning is also one of waste disposal methods used. Most HCFs use either on-site incinerator or a pit which are left open while waiting to accumulate enough waste to burn while HCFs at urban areas use off-site municipal disposal system.

This time window between storage and burning create good opportunity for animal and human scavengers leading to sharp injuries and exposure to hazardous wastes (Tadesse Alemayehu, 2015, Esubalew Tesfahun, 2015).

2.5.6. Land Filling of Healthcare Wastes

Land filling is a common method for the disposal of infectious healthcare waste. Hospitals and other HCFs typically contract out the transport of their generated wastes to certified healthcare waste transporters, who deliver healthcare waste to landfills approved for receipt of healthcare waste. The waste must be treated on-site by the waste generator or at a state approved healthcare waste treatment facility, prior to disposal in a permitted landfill. Open dumps are the most

common method of land disposal in developing countries. This is the least costly disposal option financially, but is one with the most negative impacts on public and environmental health (PATH, 2005).

During HCW, incineration significantly produced high smoke emission. The partial burned healthcare waste was disposed in an open pit. In addition to incinerators, all reviewed hospitals had an open hand dug pit in their backyard that was used for the direct dumping and open burning of healthcare wastes.

2.5.7. Compaction

The waste is compacted or compressed. It also breaks up large or fragile items of waste. This process is conspicuous in the feed at the back end of many garbage collection vehicles. Deposit refuse at bottom of slope for best compaction and control of blowing litter (Moeller, 2005).

2.5.8. Pyrolysis

Pyrolysis is defined as thermal degradation of waste in the absence of air to produce char, pyrolysis oil and syngas, e.g. the conversion of wood to charcoal also it is defined as destructive distillation of waste in the absence of oxygen. External source of heat is employed in this process. Because most organic substances are thermally unstable they can upon heating in an oxygen-free atmosphere be split through a combination of thermal cracking and condensation reactions into gaseous, liquid and solid fraction (moeller, 2005).

2.5.9. Gasification

Gasification is a process in which partial combustion of MSW is carried out in the presence of oxygen, but in lesser amount than that is required for complete combustion, to generate a combustible gas (fuel gas) rich in carbon monoxide and hydrogen e.g. the conversion of coal into town gas (Moeller, 2005).

2.5.10. Composting

Composting is the most responsible technical solution for many developing countries especially, where the climate is arid and the soil is in serious need of organic supplements. The composting process usually follows 2 basic steps which may be preceded or followed by pre-

or post- treatments (crushing, sorting, humidification, mixing with other waste, etc) (moeller, 2005).

2.5.11. Hospital Healthcare Waste Reuse and Recycling Practice

Accorging to Esubalew Tesfahun (2015) and Azeb Tayework (2017) studies, Healthcare waste recycling practice were totally absent in all study hospitals, except reusing in all studied hospital were collect separately, wash and sterilize (either thermally or chemically in accordance with the national infection prevention guidelines) surgical equipment's and other reusable items which are designed for reuse and are resistant to the sterilization or disinfection process. Pressurized materials such as cylinders were returned to the suppliers for refilling and reuse (Esubalew Tesfahun, 2015 and Azeb Tayework, 2017).

2.6. Impacts Associated With the Poor Management of HCSW

Improper MSW disposal and management causes all types of pollution: air, soil, and water. Indiscriminate dumping of wastes contaminates surface and ground water supplies [USA environmental protection agency, 2009]. In urban areas, MSW clogs drains, creating stagnant water for insect breeding and floods during rainy seasons. Uncontrolled burning of MSW and improper incineration contributes significantly to urban air pollution. Greenhouse gases are generated from the decomposition of organic wastes in landfills, and untreated leachate pollutes surrounding soil and water bodies. Health and safety issues also arise from improper MSWM. Insect and rodent vectors are attracted to the waste and can spread diseases such as cholera and dengue fever. Using water polluted by MSW for bathing, food irrigation and drinking water can also expose individuals to disease organisms and other contaminants (Goorah, *et al.*, 2009).

The U.S. Public Health Service identified 22 human diseases that are linked to improper MSWM [USA environmental protection agency, 2009]. Waste worker and pickers in developing countries are seldom protected from direct contact and injury, and the co-disposal of hazardous and medical wastes with MSW poses serious health threat. Exhaust fumes from waste collection vehicles, dust stemming from disposal practices and the open burning of waste also contribute to overall health problems. People know that poor sanitation affects their

health, especially in developing and low-income countries, where the people are the most willing to pay for environmental improvements (Moeller, 2005).

2.7. Impacts of Solid Waste on Human Health, Animals and Aquatics Life

There are potential risks to environment and health from improper handling of solid wastes. Direct health risks concern mainly the workers in this field, who need to be protected, as far as possible, from contact with wastes. There are also specific risks in handling wastes from hospitals and clinics. For the general public, the main risks to health are indirect and arise from the breeding of disease vectors, primarily flies and rats [USA environmental protection agency, 2009].

Uncontrolled hazardous wastes from industries mixing up with municipal wastes create potential risks to human health. Traffic accidents can result from toxic spilled wastes. There is specific danger of concentration of heavy metals in the food chain, a problem that illustrates the relationship between municipal solid wastes and liquid industrial effluents containing heavy metals discharged to a drainage/sewerage system and /or open dumping sites of municipal solid wastes and the wastes discharged thereby maintains a vicious cycle including these some other types of problem are as follows (Goorah *et al.*, 2009). Chemical poisoning through chemical inhalation

- Uncollected waste can obstruct the storm water runoff resulting in flood
- Low birth weight
- Cancer
- Congenital malformations
- Neurological disease
- Nausea and vomiting
- Mercury toxicity from eating fish with high levels of mercury
- Plastic found in oceans ingested by birds
- Resulted in high algal population in rivers and sea.
- Degrades water and soil quality

2.8. Impacts of Solid Waste on Environment

The decomposition of waste into constituent chemicals is a common source of local environmental pollution. This problem is especially acute in developing nations. Very few existing landfills in the world's poorest countries would meet environmental standards accepted in industrialized nations, and with limited budgets there are likely to be few sites rigorously evaluated prior to use in the future. The problem is again compounded by the issues associated with rapid urbanization (Moeller, 2005).

A major environmental concern is gas release by decomposing garbage. Methane is a by-product of the anaerobic respiration of bacteria, and these bacteria thrive in landfills with high amounts of moisture. Methane concentrations can reach up to 50% of the composition of landfill gas at maximum anaerobic decomposition (Cointreau-Levine, 1997). A second problem with these gasses is their contribution to the enhanced greenhouse gas effect and climate change (Moeller, 2005). Liquid leachate management varies throughout the landfills of the developing world. Leachate poses a threat to local surface and ground water systems. The use of dense clay deposits at the bottom of waste pits, coupled with plastic sheeting-type liners to prevent infiltration into the surrounding soil, is generally regarded as the optimum strategy to contain excess liquid. In this way, waste is encouraged to evaporate rather than infiltrate (Goorah *et al.,* 2009).

2.9. Hospital Healthcare Waste Management Guideline and Instructions

Ethiopian-MOH prepared the National Healthcare Waste Management Guideline in 2008. But none of the hospitals used this guideline. Only one public hospital (Debre Tabor hospital) had its own directives and written instructions to implement waste segregation. Standard operational manuals on healthcare waste management were absent in almost all hospitals. This study had also confirmed that none of the hospitals had well defined institutionalized healthcare waste management strategic plans and guidelines. According to WHO (2014) five principles are widely recognized as underlying the effective and controlled management of wastes and used by many countries when developing their policies, legislation and guidance:

The "polluter pays" principle implies that all producers of waste are legally and financially responsible for the safe and environmentally sound disposal of the waste they produce. This principle also attempts to assign liability to the party that causes damage.

The “precautionary” principle is a persuasive principle governing health and safety protection. Where there are threats of serious or irreversible damage to the environment, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation. The “duty of care” principle stipulates that any person handling or managing hazardous substances or wastes or related equipment is ethically responsible for using the utmost care in that task. The proximity principle recommends that treatment and disposal of hazardous waste take place at the closest possible location to its source to minimize the risks involved in its transport.

The “prior informed” consent principle as embodied in various international treaties is designed to protect public health and the environment from hazardous waste. It requires that affected communities and other stakeholders be apprised of the hazards and risks, and that their consent be obtained. In the context of healthcare waste, the principle could apply to the transport of waste and the sitting and operation of waste-treatment and disposal facilities (WHO, 2014).

2.10. Available Guidelines for Healthcare Waste Management in Ethiopia

- Infection Prevention Guidelines for Healthcare Facilities In Ethiopia.
- Environmental Pollution Control Proclamation No. 300/2002
- Proclamation No. 295/2002 Environmental Protection Organs Establishment Proclamation
- Proclamation No. 299/2002 Environmental Impact Assessment Proclamation

3. METHODS AND MATERIALS

3.1. Description of the Study Areas

This study was conducted in Wondo Genet Woreda, Sidama Regional State, Ethiopia. The woreda is situated between $7^0$13N and $38^0$37E latitude and 38.62^0E longitude. It was located 304 km from Addis Ababa (the capital city of Ethiopia) and 27 km from Hawassa, the Regional capital. The elevation of the Woreda varies from about 1200 meters above sea level along the shores of Lake Abaya to about 3200 m.a.s.l. at its westernmost point. The Woreda is bordered on the south by Shebedino and Melga woreda, on the west by Tulla sub city, on the northwest by Oromia, on the north by Oromia, and on the east by Melga woreda. The major town in Wondo Genet Woreda is Basha located 27 km from Hawassa, the Regional capital and 304 km from Addis Ababa. The study Woreda has thirteen (13) Kebeles and five Health Centers, one hospital and nine clinics. Wondo Genet Woreda is characterized by moderately hot temperature. Its elevation is 2,350 meter above sea level (Wondo Genet Wereda Statistical Report, 2022).

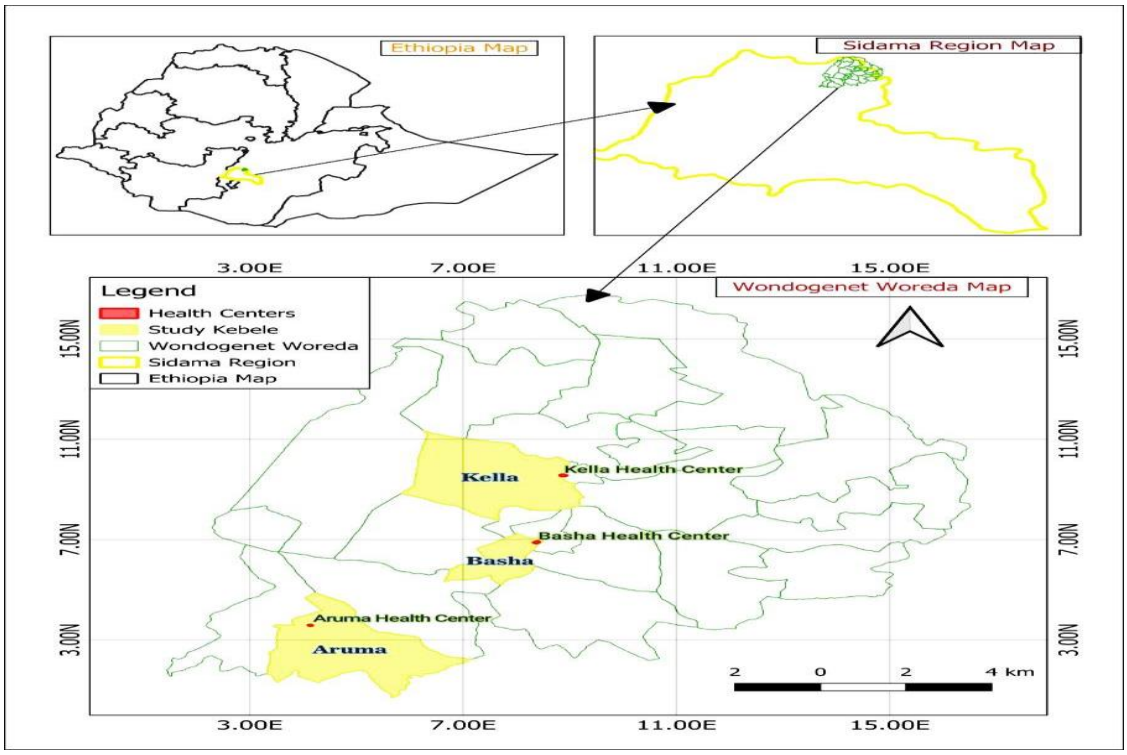

Figure 2: Map of study area (Drawn by: Selamu Bulado)

3.2. Geology and Soils

The three dominant soil types in the area are clay soil covering 40%, sandy soil 10% and loam soil 50% respectively (WGARDO, 2022). The underlying parent materials in the study area are of alkali trachytes and basalts, often overlain by volcanic ash deposits from the late tertiary period volcanic. The highland areas bordering the rift valley are characterized by moderately weathered dark-reddish brown soils with a clay-loam texture (Lemenih Mengistu, 2004). The soils at the lower elevation range of Wondo Genet are deep, loamy and relatively fertile Mollic Andosols (Lemenih Mengistu, 2004).

3.3. Climate

The rainfall and the temperature condition of the area was described based on the data collected from 2013-2022 by the National Meteorological Service Agency (NMSA) from Hawassa Station. The result of analysis of data from NMSA showed that the range of mean monthly minimum and maximum temperature of the study area are 10.2^{O}C and 30.1^{O}C in the month of December and February respectively. The hottest month is February with a maximum temperature of 30.1^{O}C and the coldest month is December with a minimum temperature of 10.2 ^{O}C. The agroecology of the Wereda has 23% humid and 73% sub-humid tropical climate and receives a mean annual rainfall of 1,163 mm per year and show bimodal type of rainy seasons. Short rain season is between March and May accounting for 28% (Belg or spring) of total rainfall, and long rain season between July and October accounting for more than 50% of the total rainfall (WGARDO, 2022).

3.4. Population

According to the Central Statistical Agency population projection data (CSA, 2019), Wondo Genet Woreda has a population of 156,710, of whom 79, 777 were male and 76,933 were female. The majority of the populations were Protestants, with 79.98% of the population reporting that belief, 8.04% practiced Ethiopian Orthodox Christianity, 4.69% were Muslim, 3.46% were Catholic, and 1.3% observed traditional religions (Wondo Genet Wereda Statistical Report, 2022). Different ethnic groups live in Wondo Genet Woreda. The majorities are Sidama, Oromo, Kembata, Wolayta, Amara and Hadiya. The Sidama language was spoken by most people (Wondo Genet Wereda Statistical Report, 2022).

3.5. Livestock

Livestock population is relatively high in Wondo Genet wereda. However, their productivity is not that much. The livestock resources of the wereda have not yet been exploited. Their products (milk, meat, egg, honey and others) and contribution to the regional and national economy is not that much significant due to poor management, inadequate and low-quality feed supply and prevalence of various animal diseases.

3.6. Healthcare status

There were five health centers in the Woreda namely, Kella HC, Aruma HC, Basha HC, Babo HC and Wosha Soyama healthy centers. In those five health centers of woreda there were 504 staff members (249 nurses, 78 lab technicians and 54 pharmacists, 62 cleaners, 35, guards and 26 other supportive staffs). According to the Wondo Genet Wereda Health Office Report 2022, the first ten major diseases in the area are, Malaria, Pneumonia, Intestinal parasite, Casteides, Upper respiratory tract infection, Skin infection, Diarrhea, Ear infection, Typhoid and Helminthes.

3.7. Study Design

Descriptive cross-sectional study design was used to assess the current practices of healthcare waste management systems, which included interviews, questionnaires, a checklist, and direct observation. The study used institution-based quantitative studies with descriptive and analytic components to address its specific goals of measuring the generation rate and physical composition of healthcare waste. From the last week of March to the first week of April, 2023, a qualitative Data description was made using mean, Standard Deviation (SD) and mean ±Standard Deviation (SD).

3.8. Study Populations and Sample Size Determination

The study population in this study was Wondo Genet Woreda Health Centers staff Members. There were five health centers in the Woreda namely, Kella HC, Aruma HC, Basha HC, Babo HC and Wosha Soyama healthy centers. Out of those five health centers in the Woreda, three health centers namely Kella health center, Aruma health center and Basha health center were purposely selected, because of the high flow of patients per day and amount of healthcare waste generation rate (pre-survey) assuming that the health centers within the Woreda have nearly similar environmental conditions, communities with comparable life styles and other variables.

Table 2: Some information about Wondo Genet Woreda health centers staff members (2023)

N^{o}	Name of the Health Center	Number of Health Professional	N^{o} of other Supportive Staffs	Total
1	Kella	48	24	72
2	Basha	91	28	119
3	Aruma	74	22	96
	Total	213	74	287

Source: Wondo Genet Woreda Health Office, (2023)

Out of total 504 populations of five healthcare centers of woreda, the study population was 287 (149 nurses, 38 lab technicians and 26 pharmacists, 49 cleaners, 15, guards and 10 other supportive staffs); those are taken from three selected health centers for this study. In each selected health centers, all staff members have equal chance to be included in sample size. A sample size (n) of respondents who participated in the study was determined using the formula developed by Pagoso *et al.* (1981) as follows:

$$n = N/ [1+ N (e^2)],$$

Where:

n = sample size,

N= the number of population and

e = represents error of estimation (margin of error), which depicts the acceptable error value.

The sample size is calculated as follows:

$$n = 287/ 1+ 287(0.05)^2 = 167$$

By adding 10% non-response rate, the final total sample size found to be 167 x 10% ≅ 17 then, 167 + 17 = 184 and n = 184. The final sample size was 184 which comprised 45 respondents from Kella health center, 78 from Basha health center and 61 from Aruma Health center, which was determined by way of proportional allocation. During data collection, all case teams or departments was included in the study.

Table 3: Proportional Allocation for determinations of the fraction of the sample between Healthcare Professionals and Supportive Staffs

Types of Profession	Health centers	**Population (N)**	**Total population**	**Sample Size (n)**	**Percentage sample size (%)**
Health Professionals	Basha	91	213	137	74.4
	Aruma	74			
	Kella	48			
Supportive Staffs	Basha	28	74	47	25.6
	Aruma	22			
	Kella	24			
Total		287		184	100

Source: Survey (2023)

3.9. Data Collection Tools

3.9.1. Questionnaires

In this study, questionnaire was employed as primary tool for collecting data from health centers managers and staff members. The questionnaire contains open ended and close ended items. The questionnaire was prepared in English language in order to easily collect the data and reliability. In addition to that, pre-test was conducted, in order to ensure the validity and reliability of the questionnaire. As a result of the information obtained from the pre-test, some modifications, corrections, and additions of words, phrases, and items in the questionnaire were made as much as possible.

For the survey on HCWM, a questionnaire was developed by referring to WHO assessment tool for country level documents (WHO, 2004). The questionnaire was created as an effective tool to assess the state of waste disposal in the health centers. Because all of the requirements for inclusion in the questionnaire were based on World Health Organization (WHO) recommendations. This questionnaire covered all important issues to examine the different aspects of Healthcare waste management. It was structured to generate the following data:

1. Availability of waste management plan

2. Use of proper color-coding system with recommended containers for sorting, collecting and transporting waste
3. Waste segregation practice
4. Waste disposal methods provided
5. Adequacy of the personal protective wear and cleaning equipment

3.9.2. Observational Checklists

Observational checklist was used to assess the management system in terms of segregation, collection, temporary storage, transportation, treatment and disposal of solid waste. It was used for assessing the healthcare waste management system in each health center, such as waste segregation, collection, temporary waste storage, transportation, treatment, and disposal. A data collection checklist was prepared in English. As with the case with Questionnaire Survey, Quantitative Measurements of the healthcare solid wastes, data was collected from three heath centers of Wondo Genet Woreda by using Observational checklists for a period of seven (7) consecutive days for each health center. On the first day, before the data collection was conducted, a brief explanation is given to the head of the medical director about the purpose of the study. Then, the HCW management system, such as waste segregation, collection, temporary waste storage, transportation, treatment, and disposal was assessed in each health center using observational checklists in the morning from 2 - 4 local time.

3.9.3. Key Informant Interview

Key Informant Interviews (KIIs): In addition to Questionnaire, Direct Observation, the researcher has used interview as another instrument of data collection. This instrument was vital to collect data that can't be obtained using questionnaire. Moreover, it provides a chance to respondents in order to express their views. In order to obtain qualitative information about assessing the healthcare solid waste management on selected health centers; the interview was administered on 12 Key Informants (1 head of respective departments (case teams) from each healthcare center, 3 experts on environmental health of healthcare centers, 3 environmental experts from Woreda's Environment Forest and Climate Change Office and 3 Coordinators of Cleaners of each health center) who were selected purposively based on their Profession, work experience, knowledge on healthcare solid waste management and educational background. The main questions involved KIIs were regarding segregation, collection, transportation, storage, treatment and disposal of healthcare waste management in the study area.

3.9.4. Field Measurement Using Weight Measurement Scale (Balance)

Weighing scale was used to quantify health centers' waste generation rate in each health center for seven consecutive days. To determine the waste generated with different physical composition like general, sharp, infectious, pharmacological and pathological waste with safety boxes and plastic bags of different colors and labeling are not well used according to WHO guidelines. But they were used self-prepared solid healthcare wastes collection boxes and bags.

To determine the amount of waste generated, plastic buckets of different colors were used according to the type of waste generated based on WHO guideline. Thus, black color for general waste, yellow marked for infectious, pathological waste and sharps, brown, marked for chemical and pharmaceutical wastes and red, marked for Radioactive and genotoxic waste and one safety box for sharp waste was distributed in different sections of the health center. The buckets, safety box and plastic bags were labeled to indicate the different categories of healthcare waste, date of collection and sample size. The actual data was collected for seven consecutive days with plastic bags which was kept inside in the buckets. Plastic bags were removed every morning and its weight is measured every day using weighing scale stared from 2:00 local time. All medically related departments (case teams) in the health centers were examined for the determination of healthcare waste generation.

Waste generation per day was determined by taking the fraction of the Total Waste produced over the study duration by the length of the study period (7 days) in kg $day^{-1/}$week. The solid waste generation can be computed by dividing the total weight of waste (in kg) generated per day/week with the number of patients in the health centers.

3.10. Determination of Healthcare Solid Waste Generation Amount and Rate

The generation rate of HCW was obtained by segregating and measuring the waste generates daily in the Health centers. The HCWs segregated into general wastes, infectious, sharps, pharmaceutical and pathological wastes. The waste segregation was done in accordance with World Health Organization (WHO) guidelines (WHO, 2014). The daily generation rate of waste is recording daily. The healthcare waste generation rate was determined on the basis of kg/patient/day or kg/week, as described by WHO guidelines. The percentage (%) of different

types of waste generation amount and its management was used to analyze healthcare Solid wastes management systems of the health centers. For the purpose of this study the researcher was used all the above mentioned parameters. The parameters developed for waste generation rates include: Waste generation rate per patient per day or Waste generation rate per day was defined as the total weight of waste (in kg) generated per day or total waste in kg per patient per day was calculated as: WPD = Total Waste in kg/day or The healthcare waste of each category: WPPD as waste collected per bed per day waste collected per patient per day for each category was determined as: WPPD = waste of each category in kg/patient/day.

3.11. Data Collection

First, a walk-through inspection of the health centers was done by the investigators in order to identify what type of waste generated in relation to the working section of the health center. Waste was collected and measured daily from Monday to Sunday consecutively, for seven days, to estimate the amount of the waste generated. To determine the magnitude of waste generated plastic buckets of different colors was used according to the type of waste generated based on WHO guideline. Thus, blue color for general waste, green color for pharmaceutical waste, red color for infectious waste and pathological waste and one safety box for sharp waste were distributed in different sections of the health center. The buckets, safety box and plastic bags were labeled to indicate the different categories of healthcare waste, date of collection and sample size. The actual data was collected for seven consecutive days with plastic bags which were kept inside in the buckets. Plastic bags were removed every morning and its weight was measured every day at 2:00 – 4:00 local time using weighing scale.

3.12. Data Analysis

To address the current practices of healthcare Solid waste management, data from interviews questionnaires and observation was analyzed by theme. Then, data was categorized and studied to understand relationships in the overall context of the study. The data was analyzed by using IBM SPSS statistical version 21. Pearson Correlation used to correlate the relationship between patient flow per day and quantities of healthcare solid waste generated from case teams. One-way ANOVA was applied to perceive variation in healthcare solid waste generation rate among three health centers. The analysis was performed separately for each of the three health centers; Data description was made using mean, Standard Deviation (SD). The data quality was

maintained by calibrating the instruments used for measurement. Finally results were presented in the form of tables and charts.

3.13. Data Quality Assurance

To minimize the possibility of obtaining biased information and variables, the questionnaire which was prepared in the English language was translated into local language, Sidamu Afoo, to make it easy to understand and administer for both interviewers and interviewees. The latter version was back translated to English language, to ensure its consistency. In order to make sure quality of data, structured and pre-tested questionnaire on about of the sample size by interviewers were used to collect information.

3.14. Ethical Considerations

The study was conducted after having an ethical clearance from the Biology Department, College of Biological Science, Hawassa University. Permission was obtained from Wondo Genet Woreda Health Office. Before performing the procedure, verbal and written consent is obtain from each health center, and issues of rights, privacy, and confidentiality are ensuring during the data collection period. They were volunteering to participate and they were informed on the research and its benefits. Respondents who participated in the study were voluntary and each respondent was asked to give verbal consent to participate and each participant was assured that the information provided was kept confidential.

4. RESULTS AND DISCUSSIONS

4.1. Demographic Characteristics of the Respondents

The background characteristics of respondents involved in this sub-topic were analyzed and interpreted as it is important to understand the profile of the respondents included in the study. Accordingly, in this section, healthcare professionals and support staff experts' gender, age, level of education, and work experience of the respondents have been assessed and the results were presented. From the total respondents, 112(60.9%) of study participants were males while 72(39.1%) were females. The majority 138(75%) of respondents were found the age between 31-45 years, the rest 34(18.5%) respondents were found the age between 21-30 years and 12(6.5%) respondents were found the age above 45 years. Accordingly, 92(50%) of participants has first degree, 54(29%) has diploma, 25(13.6%) of participants has certificate and 13(7%) of participants were masters holders (Table 4). The majority 148(80.4%) of participants were married, 32(17.4%) of participants were single (unmarried) and 4(2.2%) of participants were divorces (Table 4).

The majority 118(64.1%) of respondents were nurses and the rest 47(25.5%), 16(8.7%) and 3(1.6%) of respondents were supportive staff member and cleaners, pharmacists and top managers, respectively.

The majority 87(47.3%) of participants has work experience 10-15 years, the rest 73(39.7%), 17(9%), 5(2.7%) and 2(1%) of participants has work experience 6-10 years, 1-5 years, 16-20 years and above 21 years, respectively (Table 4).

Table 4: Demographic distribution of the sample size of selected health centers of Wondo Genet Woreda (2023)

Demographic Variable	Variable Category	Frequency (N)	Percent (%)
Gender	Male	112	60.9
	Female	72	39.1
	Total	184	100
Age	Below 20 years	-	-
	21-30 years	34	18.5
	31-45 years	138	75
	Above 45 years	12	6.5
	Total	184	100
Educational level	Below certificates	-	-
	Certificates	25	13.6
	Diploma	54	29
	Degree	92	50
	Masters and above	13	7
	Total	184	100
Marital status	Single	32	17.4
	Married	148	80.4
	Divorced	4	2.2
	Total	184	100
Position	Manager	3	1.6
	Doctors	-	-
	Nurse and others	118	64.1
	Pharmacist	16	8.7
	Supportive staff member and cleaners	47	25.5
	Total	184	100
Work Experience	1-5 years	17	9
	6-10 years	73	39.7
	10 -15 years	87	47.3
	16 -20 years	5	2.7
	Above 21	2	1
	Total	184	100

4.1.1. Socio-demographic Characteristics of KIs

A total of 12 KIs were participated in the study and among them (66.7%) were males and (33.3%) females. Majorities (83.3%) of KIs were felt within age range of 31-45 years and the rest (16.7%) of KIs were above 45 years, respectively (Table 5). The majority (50%) of KIs were had first degree whereas (25%) and (25%) were diploma and masters holders, respectively.

Majorities (66.7%) of KIs were married whereas (33.3%) were single (Table 4). The majority (41.6%) of KIs had 10-15 years' work experience. The rest (25%), (16.7%) and (16.7%) of KIs had 6-10, 1-5 and 16-20 years' work experiences (Table 5).

Table 5: Socio-demographic Characteristics of KIs (n =12)

Nº	Characteristics of the KIs	Category	Frequency (n)	Percentage (%)
	Sex of the KIs	Male	8	66.7
		Female	4	33.3
		Total	12	100
	Age group in year	21-30 years	-	-
		31-45 years	10	83.3
		Above 45 years	2	16.7
		Total	12	100
	Education level	Below certificates	-	-
		Certificates	-	-
		Diploma	3	25
		Degree	6	50
		Masters and above	3	25
		Total	12	100
	Marital status	Single	4	33.3
		Married	8	66.7
		Total	12	100
	Work experience	1-5 years	2	16.7
		6-10 years	3	25
		10 -15 years	5	41.6
		16 -20 years	2	16.7
		Above 21	-	-
		Total	12	100

4.2. Generation Rate of HCW from Each Department in the Selected Health Centers of Wondo Genet Woreda

Table 6, illustrates the total generation rate of healthcare wastes by type and amount within seven days of data collection time from different departments of selected health centers of Wondo Genet Woreda. The contribution of each department (case team) for all wastes were OPD (21.7%), delivery (18.5%), emergency(16.4%), MCH (15.1), laboratory(10.8%), pharmacy (9%), injection and dressing(5.1%), TB(2.3%) and VCT(2.1%) (Table 6).

Table 6: Types of total generated HCW from each department in the selected health centers of Wondo Genet

Name of HC	PF/week	Types of wastes and generation rate from different Departments in (kg/Week)										
		OPD	Pharmacy	Lab	Injection	MCH	TB	Delivery	VCT art	Emergeny	Total	**Mean± SD**
Basha	623	17.38	6.52	7.69	1.89	10.76	1.61	13.37	1.61	11.4	72.23	8.02±5.67
Aruma	579	14.1	6.1	7.1	1.83	9.7	1.5	14.8	1.5	11.4	68.04	7.6±4.67
Kella	519	10.3	4.6	6.1	6.1	8.6	1.2	7.2	1.0	8.6	50.8	5.6±4.07
Total	1721	41.78	17.22	20.89	9.82	29.06	4.31	35.37	4.11	31.4	191.07	
Weight %		21.7	9	10.8	5.1	15.1	2.3	18.5	2.1	16.4		

The mean daily healthcare waste generation rate was 8.02±5.67kg/day, 7.6±4.67 kg/day and 5.6±4.07 kg/day in Basha HC, Aruma HC and Kella HC respectively. This result was comparable with study conducted in Addis Ababa, Ethiopia, 2014, where the mean generation rate was 9.61±3.28kg/day, while it was higher than the studies conducted in West Gojjam Zone and Bench Maji Zone where the daily mean generation rate of healthcare waste was

1.79±0.54kg/day and 4.46±0.45kg/day respectively (Azage Muluken and Kumie Alemayehu, 2010; Meleko, *et al.*, 2018). This variation in the quantity of health care waste produced from different health centers could be due to inconstant proportion of patients treated on a day-care basis and or due the flexible practice of utilization of reusable items employed in health centers.

4.2.2. Healthcare Solid Waste Generation Rate Per Patient Flow Per Day

The mean daily HCW generation rate per patient flow per health center in studied health centers were 0.7±.0.03 kg/pat/day (Table 7). This result was comparable with the studies conducted in Nifas silk lafto sub-city health center where the mean healthcare waste per patient flow per day was 0.074±.016kg/pat/day (Biruk Birane, 2020). Similarly, studies conducted in Bench Maji Zone (Asrat Meleko and Tarekegn Tesfaye, 2018) and Adama, (Samuel Hayleeyesus and Wondimagegn Cherinete, 2016), reported similar results where the mean ranged from (0.0152-0.03kg/patient/day). This could be due to the type similarity in health service demand expressed by patients, which further determines the amount of waste generated. From studied health centers, there was no variation in daily HCW generation rate per patient flow per health center among three health centers. This could be due to similar environmental conditions, communities with similar life styles and relatively comparable number of patients visited health centers.

Table 7: Unit generation rate and healthcare waste generation per patient flow per day in the studied health centers of Wondo Genet Woreda

Name of HC	PF/week	PF/day	HCWG/kg/day	HCWG/PF/HC (kg/pat/day)
Kella	519	74	7.27	0.1
Aruma	579	83	9.72	0.11
Basha	623	89	10.32	0.12
Total	1721	246	27.31	0.33
Mean	574	82	9.1	0.11
SD	52.2	7.5	0.7	0.03

4.2.3. Estimated Quantity of HCW Generation Rate Per Year

The annual healthcare waste generation rate was estimated using the mean healthcare waste generation rate in kg per day multiplied by 365 days (by assuming the mean of healthcare waste

generation rate within seven consecutive days may represent the whole year). Thus, the estimated annual waste generation rate was 9,960.85Kg/year, of which general, infectious, sharp pharmaceuticals, and pathological wastes calculated to be generated within a year were recorded as 3,806.95kg/year, 2,080.5kg/year, 569.4kg/year, 722.7kg/year and 2,781.3kg/year respectively (Table 8). Furthermore, the annual total healthcare waste generation rate per patient per kilogram was calculated using similar formula and the obtained result was 13 kg/pat/year.

Table 8: Estimated quantity of HCW generation rate per day, week, month and year in selected Health Centers in Wondo Genet Woreda

Types of waste	**HCW(kg/day)**	**HCW(kg/week)**	**HCW(Kg/month)**	**HCW(kg/year)**
General	10.43	73	312.9	3,806.95
Infectious	5.7	39.96	171	2,080.5
Sharp waste	1.56	10.92	46.8	569.4
Pharmaceutical	1.98	13.88	59.4	722.7
Pathological	7.62	53.31	228.6	2,781.3
Total	27.3	191.07	819	9,963.85
Total HCW/pat/year (Kg/Year)			13	

4.2.4. Patient Flow in Studied Health Centers and Service Sections

The mean patient flow per day in health centers was 82±24.6 pat/day. More patients (623 in a week) were visited Basha health center and a smaller number of patients (519 patients in a week) were recorded from Kella health center. The number of patients recorded from Aruma health center during the study time was 579 patients per week. The result of this study was higher that results reported by Abera Hailemechael, (2023) the mean patient flow per day in health centers was 70.30±9.29pat/day and at OPD was 17.0±2.65pat/day.

4.2.5. Correlation between Quantity of HCW from Different Case Team and Patient Flow/Day

According to Table 9, the Pearson Correlation showed that there was a high degree positive relationship between observed number of patient flow and quantities of HCW generated from OPD case team ($r = 0.84$) ($p = 0.00$) in Wondo Genet Woreda in selected health centers. This result was similar with a finding obtained in Addis Ababa where almost all of assessed health

centers reported that the quantity of total health care waste per day generated from health centers was significantly increased as the number of patients increases (r = 1) (Mesfin Kote *et al*., 2011). Also, this result agreed with a study conducted by Komilis *et al*. (2012), there was a positive correlation between the total healthcare generation rates and the number of patients visiting health centers per day.

Table 9: The Pearson correlation of the quantity of HCW and patient flow per day

		PF/Day	OPD	Pharmacy	Lab	Injec	MCH	TB	Delivery	VCTart	Emergeny
PF/Day	R	1	.845**	.305	.283	-.399	.093	.224	.527*	.022	.027
	P value		.000	.178	.215	.073	.688	.328	.014	.923	.908

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

A one-way ANOVA was conducted to evaluate healthcare solid waste generation rate by type and amount from three selected health centers of Wondo Genet Woreda. The result of ANOVA indicated that there is no statistically significant difference ($p > 0.05$) in a quantity of solid wastes generated from three health centers except for general waste type ($p = 0.00$) (Table 10).

The post hoc test was conducted to identify general waste type generation rate among three healthy centers (Table 10). The result indicated that significantly large quantity of general healthcare waste was generated from Basha health center and lower quantity of general healthcare waste was recorded from Kella health center. Low quantity record of general healthcare waste from Kella health center could be due to relatively a smaller number of patients visited health center during study period. On other hand, Basha health center had relatively higher number of patient flow per week. This could be a reason for recoding highest quantity of general healthcare waste in Basha health center.

Table 10: Post hoc result of variation in quantity of general wastes among health centers

HC name	HC name	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Kella	Aruma	-.23571*	.05738	.002	-.3822	-.0893
	Basha	-.37714*	.05738	.000	-.5236	-.2307
Aruma	Kella	.23571*	.05738	.002	.0893	.3822
	Basha	-.14143	.05738	.0059	-.2879	.0050

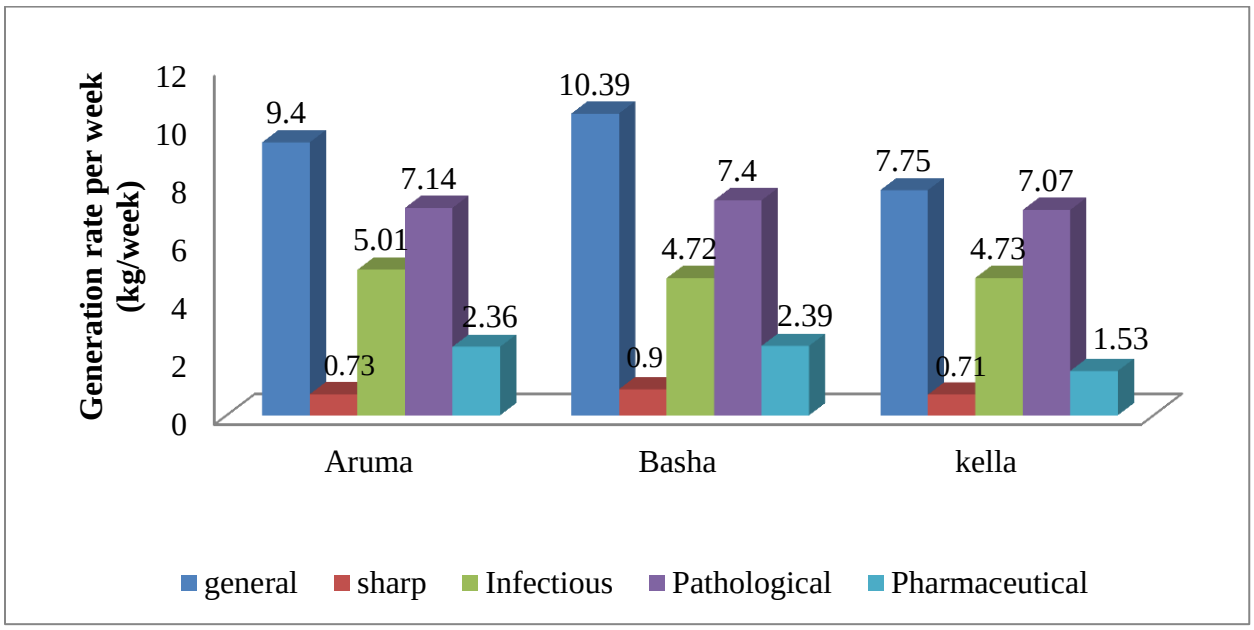

Figure 3: Distribution of healthcare waste in three health centers

4.3. Composition of Healthcare Solid Wastes

The departments (Case Teams) existed and identified under three health centers were OPD, Pharmacy, Lab, Injection, mother and child health (MCH), VCT, TB follow-up Unit, Delivery ward, and Emergency. The total number of patients in visited healthy centers during the study time (seven days) were 1,721, of which 623(36.2%) were recorded in Basha healthy center, 579(33.6%) were from Aruma and the rest 519 (30.2%) patients were recorded in Kella health center. Out of those patients visited healthy centers, about 87% were recorded from OPD case team of which 558(32.4%), 487(28.3%) and 452(26.3%) were recorded in Basha, Aruma and Kella healthy centers respectively in one week.

4.3.1. Composition of Total Generated HCW in the Selected Health Centers of Wondo Genet Woreda

The composition of HCW for all studied health centers 38.2% was general waste and 61.8% was hazardous wastes (20.9%, 5.7%, 7.3%, and 27.9%) were infectious, sharp, pharmaceutical and pathological waste respectively. The proportion of general and hazardous wastes for studied health centers was 38.2% and 61.8% respectively (Table 11). This result was relatively similar with a result obtained in study conducted by Tadese Kumei in Addis Ababa governmental health centers, which was 38% general waste and 62% hazardous waste (Tadesse Kumie, 2014). It was also similar with study conducted in health centers of Lafto sub-city, Addis Ababa, which was 27.4% general and 72.6% hazardous waste (Biruk Birhane, 2020). The result of general wastes of this study was lower but hazardous waste higher than a result obtained in health centers of West Gojjam Zone, Amhara Region, Ethiopia, was 52% general and 48% hazardous (Azage Muluken and Kumie Alemayehu, 2010) and in Bench Maji Zone, Ethiopia, was 57.9% general and 42.1% hazardous (Asirat Meleko and Tarekegn Tesfaye, 2018).

According to a WHO report, around 75- 90% of the healthcare wastes are actually nonhazardous or general wastes, and the remaining 10-25% is hazardous in nature (WHO, 2014). The results from those studied health centers indicted that the hazardous amount of waste was above the WHO recommendation. This high level of hazardous waste generation may be due to lack of proper management of healthcare solid waste from the point of generation up to dispose. In addition, the reduction (lack) of IPD in the selected health centers may lead to lower production of general waste, and therefore the proportion of hazardous HCW was high in comparison (Azage Muluken and Kumie Alemayehu, 2010; Asrat Meleko and Tarekegn Tesfaye, 2018). Observations during the study indicated that segregation practice of wastes in to different waste type was poor. So, it is possible to reduce the amount of hazardous wastes by applying segregation of wastes at the point of generation. By planning and applying proper segregation of wastes, it is possible to reduce public health risks and environmental pollution caused by hazardous wastes. The variation of result could be due to the lack of awareness on the segregation of waste at the point of waste generation in the studied health centers.

The analysis also found that the proportion of general and hazardous HCW generated from Basha health center was 38.1% and 61.2% respectively(Table 9) and from Aruma health center

was 39.8% and 60.2% respectively(table 6). Whereas, from Kella health center 36.2% and 63.8% was general and hazardous HCW respectively (Table 11).

Table 11: Types of total generated HCW in the selected health centers of Wondo Genet (2023)

Name of HC	Types of HC solid wastes in kg/week					
	General	Infectious	Sharp	Pharmaceutical	Pathological	Total hazardous
Basha	27.54	14.46	2.34	6.28	21.61	44.69
Aruma	27.06	13.8	2.48	4.4	20.3	40.98
Kella	18.4	11.7	6.1	3.2	11.4	32.4
Total(kg/week)	73	39.96	10.92	13.88	53.31	118.07
Weight %	38.2	20.9	5.7	7.3	27.9	61.8

4.4. Healthcare Solid Waste Management Practices in Health centers

Healthcare facilities need to address each component of the waste management practices. Each specific type of HCW requires specific proper handling and safe disposal practices. In particular, the hazardous content of HCW requires careful management since these wastes are hazardous in their nature. The role of sustainable waste management is to reduce the amount of waste that is discharging into the environment by reducing the amount of waste generated. Improper waste management and disposal practices causes threats to those living in nearby communities and the environment.

The major problems of healthcare waste management in all studied health centers were lack of commitment among the management team, that means less attention given to waste management, lack of HCWM facilities and low skills and knowledge on HCWM. And also Lack of necessary rules, regulations and instructions on different aspects of collections and disposal of waste; inability to use different designated color-coded bins and absence of team responsible for monitoring healthcare waste management practices.

4.4.1. Healthcare Solid Waste Collection Practice in Health Centers.

Based on the results obtained from observational check lists and general observation of researcher, there was no structured collection and transportation system for general and

hazardous waste in study health centers. In two out of three health centers used closed plastic container were used to collect and transport mixed. Only sharps and pathological wastes were collected and transported separately. Mixed waste was collected and transported in carton or open plastic buckets.

As the result obtained from interviews and observational check lists, Healthcare wastes generated in all health centers were collected on a daily basis and transported to the disposal area in the health centers compound. Healthcare wastes generated in all health centers were collected on a daily basis and transported to the disposal area in the health centers compound. This is in line with the study conducted in Addis Ababa (Tadesse Kumie, 2014) and Bench Maji Zone, Ethiopia (Asrat Meleko and Tekalegn Tesfaye, 2018). Some health centers used uncovered plastic buckets and others used covered plastic buckets for on-site waste collection and, when these buckets which are capable of measuring 10-20 litters filled, the waste handlers transfer the waste to large plastic buckets placed in the corridor and emptied smaller container and return back to be used again without washing and disinfection. This is similar with study done in Egypt (Omar and Nurshahida, 2012) where there were no facilities for washing and disinfection of healthcare waste containers and bins. All health centers used carton boxes, that can be easily damaged or turnout, for sharp waste collection.

A) Basha health center B) Kella health center C) Aruma health center

Figure 6: Waste collection plastic materials placed in corridor in studied health centers

Healthcare professionals and supportive staffs were inquired whether the HCWs were collected at point of generation or not. Accordingly, about (46%%) responded that HCWs have been collected at the point of generation and once the container filled, the wastes transferred to larger

container located in a corridor for temporary storage. Among the respondents about 49.5% responded that there were color code collections the wastes have been collected according to the color coding and labeling of waste collecting buckets. It is also clear that hazardous wastes require special attention to their effects. However, in this study it was observed that the waste collection containers filled more than their capacity which makes difficult to handle and transport the wastes to the site of disposal.

Table 1 Collection and transport of healthcare wastes in health centers

Statements	**Response of each Health Center**							
	Basha (n=78)		**Kella HC (n=45)**		**Aruma (n=61)**		**Total**	
	Yes (%)	**No (%)**	**Yes (%)**	**No (%)**	**Yes (%)**	**No (%)**	**Yes%**	**No%**
Are HCWs are collected at the point generation?	33(42.3)	45(57.7)	21(46.7)	24(53.3)	29(47.5)	32(52.5)	46%	54%
Is there sharp waste collector?	29(37.2)	49(62.8)	17(37.7)	28(62.3)	24(39.3)	37(60.7)	38%	62%
Are waste collectors sufficient in each HCT?	11(14.1)	67(85.9)	17(37.7)	28(62.3)	21(34.4)	40(65.6)	26.6%	73.4%
Is there color code collection?	32(41)	46(59)	35(77.8)	10(22.2)	24(39.3)	37(60.7)	49.5%	50.5%
Are waste collector bins overfilled?	43(55.1)	35(44.9)	35(77.8)	10(22.2)	31(50.8)	30(49.2)	59.2%	39.8%

4.4.2. Healthcare Solid Waste Storage Practice in Health centers

As result of observational check lists, there were no suitable isolated central storage sites for healthcare waste temporary storage in all health centers. All departments of studied health centers temporarily stored all wastes in open and sub-standard buckets for about 12-24 hours (Fig 6). Sharp wastes were stored in standard safety (carton) box containers and placenta stored in closed placenta pit. A fundamental issue that was highlighted through interview with personnel at the health centers was that there were frequently insufficient waste containers to handle the volume of healthcare wastes generated. Much of the findings during observation were similar in all health centers.

As presented in Table 13, the first item, which indicates, most (82.2%) of respondents responded that there was a temporary HCW storage area in the health centers and the rest (17.8%) of them responded there was no temporary HCW storage area in health centers. Respondents were asked if there are sufficient storage area inside health centers and if it is safe, most of them (95.9%) responded that there were no sufficient storage areas inside health centers and almost all (97.3%) responded storage places were not safe (Table 13). Similarly in this table, respondents were asked concerning the variation of storage area for types of waste in the health centers, the majority (58.9%) of them responded implies that there was no enough variation of storage area based on types of waste in the health centers.

Table 13: Solid healthcare waste storage practice in health centers

Statements	**Response of each Health Center**					
	Basha HC (n=78)		Kella HC (n=45)		Aruma HC (n=61)	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Is there temporary HCW storage area in health center?	70(84.9)	8(15.1)	35(74.5)	12(25.5)	55(87.0)	6(13.0)
Is there sufficient storage in health center?	14(7.5)	64(92.5)	2(4.3)	43(95.7)	-	61(100)
Is storage place safe?	-	78(100)	-	45(100)	4(8.7)	57(91.3)
Is storage place varying with type of HCW?	64(73.6)	14(26.4)	11(27.7)	34(72.3)	8(17.4)	53(82.6)

There were no suitable isolated central storage sites for healthcare waste temporary storage in all health centers. All case teams of all health centers temporarily stored all waste in open and substandard buckets for about 12-24 hours. This result is similarly with the study done in Gondar town Northwest Ethiopia (Azage Muluken, *et al*., 2013) and Shashemene town (Gudeta Elie and Daniel Fitamo, 2018). The result is in contrast with study done by different authors in different countries. For example: Egypt (Shouman, *et al.*, 2013), Ethiopia (Mesfin Kote Debere, *et al.*, 2011). A fundamental issue that was highlighted through interviewed with personnel at the health centers was that there are frequently insufficient waste containers to handle the volume of healthcare waste generated and this was assured during observation.

4.4.3. Healthcare Solid Waste Segregation Practice in Health Centers

Waste segregation is a key to efficient healthcare waste management. It involves the separation of different types of wastes at the point of generation, with specific requirements for handling, treatment and disposal (Azage Muluken, *et al.*, 2015).

Current study in Wondo Genet woreda health center found that in all three health centers, sharp wastes were deposited into puncture-proof safety boxes (carton box), infectious and pathological wastes were stored in yellow plastic buckets, general wastes were stored in black buckets and pharmaceutical wastes stored in brown buckets. There is no standard waste bin in all health centers instead they use plastic bucket. Based on categories of wastes, most sharp and pathological wastes such as placenta in all health centers were better segregated and hygienically collected at source of generation. Comparing to three health centers in Wondo Genet woreda, Basha health center was better than Aruma and Kella health centers in using safety boxes as some cases teams in Aruma and Kella health centers use cartoon boxes to store sharp wastes.

In all health centers, segregation at source was better than storage and disposal sites. Segregating waste at the disposal point is less practiced in all health centers, the situation being worse at Kella and Aruma health centers because at final disposal site both general and hazardous wastes disposed together in open pit till burning time.

As shown in Table 14, respondents were asked whether HCWs were segregated in each case team or not. Accordingly, majority (66%) of the respondents responded that HCWs were poorly segregated in each case team. 93% of them also responded that there were no sufficient waste

containers in their respective health center which may contribute to poorly segregations of wastes as all waste type kept within few containers until disposal period. As shown in Table 14, respondents were also inquired for the availability of effective segregation, majority 69.6 of the respondents replied that there was ineffective segregation of HCWs in health centers.

Generally, in all studied health centers, segregation of different categories of HCW was not sufficient. This result was similar with the study conducted in Addis Ababa, Ethiopia (Kumie, 2014), Bench Maji Zone, Ethiopia (Asrat Meleko and Tekalegn Tesfaye, 2018) where segregation of different categories of healthcare wastes was found to be insufficient.

A. Basha health center *B. Aruma health center* *C. Kella health center*
Figure 4: Healthcare solid waste segregation and storage practices in all health centers

Infectious wastes especially placentas and blood-stained cotton pads were kept in separate containers in the study health centers were disposed of without disinfection. This is contradicting with study conducted in Egypt that revealed infectious waste was first deposited into light blue bags for autoclave treatment before deposited into yellow bags for final disposal (Omar and Nurshahida, 2012). In all studied health centers, waste segregation was practiced partially; throwing wastes into any container nearby was common. Similar to study done in Kenya (Chepngeno,2015), Nigeria (Uwa, 2014) and South Africa (Abor, 2007). And also, in Amhara region (segregation was practiced partially; throwing wastes into any container nearby was common. Similar to study done in Kenya (Chepngeno, 2015), Nigeria (Uwa, 2014) and South Africa (Abor, 2007). And also, in Amhara region (Esubalew Tesfahun, 2015); in Addis Abeba, Ethiopia (Tadesse Kumie, 2014; Azeb Tayawork, 2016); in Addis Abeba, Ethiopia (Tadesse Kumie, 2014; Azeb Tayawork, 2016).

A. Basha health center B. Aruma health center C. Kella health center

Figere 5: Placenta pits in a, b&c (Basha, Aruma and Kella health center respectively)

The reasons for incomplete waste segregation in health centers could be lack of availability of labeled waste containers. The major problem with segregation practices was on health centers administrators who provide limited and substandard waste collection facilities and most of containers were old, lack of initial training of healthcare workers.

Table 14: Evaluation of solid HCW segregation practice in health centers

Statements	Response of each Health Center							
	Basha HC (n=78)		Kella HC (n=45)		Aruma HC (n=61)		Total	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes%	No%
Is Health care waste segregated in each case team?	36(46.2)	42(63.8	17(37.7)	28(62.3)	27(44.3)	34(55.7	44%	66%
Are waste bins sufficient in your health center?	6(7.7)	72(92.3	4(8.9)	41(91.1)	2(3.3)	5(96.7)	7%	93%
Is segregation of waste effective?	24(30.8)	54(69.2	17(37.7)	28(62.3)	14(22.9)	47(77.1	30.4%	69.6 %
Is segregation monitored regularly?	38(48.7)	42(53.3	21(46.7)	24(53.3)	29(47.5)	32(52.5	47.8%	52.2 %

4.4.4. Transportation Practices of Healthcare Solid Wastes in Health centers.

As the result of the interview done with key informants from each health centers and an observation made by the researcher, there were no wheeled transport containers or wheeled trolleys for transportation of wastes from storage site to disposal sites in the selected healthcare

centers. So that, the transportation process from the generation point to the disposal site was done manually by waste handlers using open plastic buckets and safety boxes in all health centers. This is similar with study conducted in Gondar town which reports healthcare wastes were transported manually to the backyard disposal site (Azaga Muluken *et al.,* 2013). This is dangerous for the waste transporter, other health centers community and to the environment since flow of wastes is obvious because the waste buckets were not covered and overfilled. Furthermore, the waste handlers were not fully equipped with personal protective equipment during healthcare waste collections and transportation including gloves, safety boots, face mask and other material in all studied health centers. This is not consistent with the recommended standard of WHO (2014) which requires the use of heavy-duty gloves, boots, face mask and apron. This put the waste handlers in danger of acquiring disease infection. Moreover, during transportation from the source to the incinerator the wastes have been mixed due to the use of single plastic material for transportation. This will also contribute to the risk of infections for healthcare providers, patients, visitors and the neighboring community as the wastes scattered on the surrounding treatment and disposal sites due to the use of sub-standard waste containers.

4.4.5. Treatment and Disposal Practices of Healthcare Solid Waste in Health Centers

As the result of the interview done with key informants from each health centers and an observation made by the researcher showed there were no practice of effective treatment and disposal of waste in the studied health centers. This result also agreed with the response of most Healthcare professionals and supportive staff who were asked the questionnaires. There are several treatment and disposal methods utilized in the management of infectious healthcare wastes in developing countries, such as autoclaves; microwave disinfection systems; chemical disinfections; incineration; and disposal on land (dump site, controlled landfill, pits, and sanitary landfill) (Diaz *et al.,* 2005). Out of these methods, local brick-made incinerator and open hand-dug pit were applied to treat HCWs in all studied health centers.

This may increase the risk of infection of healthcare professionals who work in laboratories and cleaners who manage the wastes. The local brick-made incinerator is used to burn sharps waste and dry hazardous wastes. The wet infectious wastes and other mixed types of waste were placed in a hand-dug open pit. The incinerator was less efficient in burning wastes because of the addition of large amounts HCWs. The partially burned healthcare wastes were disposed off in an

open hand-dug pit that was used for the direct dumping and open burning of healthcare wastes. Therefore, the current practices of healthcare waste treatment in health centers could expose the whole community to a high risk of health problems.

A. Basha Health center B. Kella Health center C. Aruma Health center

Figure 7: HCW treatment areas in a, b & c (Basha, Kella and Aruma health center respectively)

Open pits burning in all study health centers were one of the final disposal methods. Particularly, in Kella and Aruma health centers open pit burning was used for both general and hazardous wastes except sharps wastes. This result is similar with result from the study conducted in Gondar Town (Azage Muluken *et al.,* 2013). Burning waste containing plastic materials, blood bags and Intravenous (IV) fluid bags can release dangerous substances like dioxins, furans and other toxic pollutants in the surrounding communities. Particularly, Aruma health center has no incinerator therefore, they burn healthcare wastes in open area around the school. Open burning (uncontrolled incineration) of healthcare waste should be avoided in any case, because of risks to workers, not only from uncontrolled toxic gas emissions to the air, but as well from infectious wastes that are only partially burned. So, this is not safe for human health and the environment (WHO, 2005).

All facilities used local type incinerators made of brick. The incinerators didn't function properly and incomplete burning of waste was observed. They produce high smoke during waste incineration. This result is in line with the study done by (Samuel Fekadu Hayleeyesus and Wondemagegn Cherinete, 2016) in Adama city Ethiopia and (Gudeta Elie and Daniel Fitamo, 2018) in Shashemene town. However, this type of incinerator is against the Stockholm Convention, since several problems have been reported with single chamber brick-made

incinerators, including emission of toxic substances like polychlorinated dibenzo-p-dioxins and dibenzofurans, hexachlorobenzene and polychlorinated biphenyls are unintentionally formed and released from thermal processes involving organic matter and chlorine as a result of incomplete combustion or chemical reactions of healthcare wastes into the environment that are a risk to public health (WHO, 2005). It is also difficult to build modern incinerators due to the large capital and operating costs for modern technologies, the need for skilled labor to operate and maintain the system, the potential lack of local access to materials for incinerator construction (WHO, 2014). Open dumps burial or land filling is one the final waste disposal methods in all study health centers. This is the least costly disposal option financially, but is one with the most negative impacts on public and environmental health (WHO, 2005). However, the site of land filling generates air pollution and disease-causing germs (WHO, 2014). So an open dump burial or land fill is not a safe solution for treatment of healthcare waste.

4.5. Challenges of Healthcare Solid Waste Management Practices in Health Centers

4.5.1. Evaluation of Healthcare Occupational and Safety Issue in Health centers

Table 15, illustrates how healthcare workers and cleaners use safety devices and the vaccination they have been given. All the cleaners (supportive staff) and workers have been participated for the questionnaires under this issue. Out of them, about 82% of the respondents across all the sampled health centers use protective clothing when handling healthcare waste while about 18% do not use protective clothing as the health centers does not provide them standardized safety wearing for cleaning staff. As a result, about 19% responded that they did not wear heavy-duty gloves when dealing with healthcare waste whereas the remaining 81% replied they did use heavy duty glove during handling wastes and among them majority responded, they did use it more than once. This response indicates the gap in using the glove which may contributes the risk of infections for healthcare providers that using the same glove more than once. Regarding an injury resulted from handling healthcare waste, most (97.3%) of the respondents replied that there was no injury while the remaining 2.7 % of them responded there was injury. Regarding vaccination, almost all respondents (98.4%) responded that there was no vaccination ever taken before beginning the work in all health centers.

The finding of this research was similar to a study done in North West Ethiopia which reported the safety issue of the healthcare waste handler (Fentahun Mulgeta, 2000). The finding of this

research was different from the study done in Sidama Zone that reported the safety issue of the healthcare workers (Yosef Wondimagegn, 2004). The difference may be due to the difference in the level of awareness of the healthcare professionals and waste handlers. According to WHO (2002) guideline, management of HCW is an integral part of hospital hygiene and infection control. Infectious HCW contributes to the risk of nosocomial (of a disease originating in a Hospital or health centers) infections, putting the health of medical staff and patients at risk. Proper HCWM practices should, therefore, be strictly followed as part of a comprehensive and systematic approach to Health center hygiene and infection control.

Table 2: Healthcare occupational and safety issue in health centers

Statements	**Response of each Health Center**							
	Basha HC (n=78)		Kella HC (n=45)		Aruma HC (n=61)		Total	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes(%)	No(%)
Does the worker wear a special dress relating to waste?	66(84.6)	12(15.4)	41(91.1)	49(8.9)	44(72.1)	17(27.9)	82%	18%
Do they wear gloves?	30(38.5)	48(61.5)	20(44.4)	25(55.6)	29(47.5)	32(52.5)	42.9%	57.1%
Do they use the same gloves more than once?	60(76.9)	18(23.1)	35(77.8)	13(22.2)	57(93.4)	4(6.6)	19%	81%
Is there any injury related to healthcare waste?	2(2.6)	76(97.4)	-	45(100)	3(4.9)	58(95.1)	2.7%	97.3%
Is it registered?	1(1.3)	77(98.7)	-	45(100)	-	61(100)	0.5%	99.5%
Do waste handlers take vaccination before work?	-	78(100)	-	45(100)	3(4.9)	58(95.1)	1.6%	98.4%

4.5.2. Training Issues for the Staff Regarding Healthcare Solid Waste Management

With respect to training issue in the health centers, majority (92.9%) of the respondents agreed that waste handlers have knowledge about healthcare waste management processes as the training delivered to them whereas about 7.1% of the respondents said that they did not participated in any training regarding waste management in health center other than they had trained from colleges. Regarding to effective process of waste management, nearly all (91.9%) of the respondents said that waste handlers do not follow the effective process of waste management. These results reflect that there is the gap in knowledge about healthcare waste management and effective process of waste management in the studied health centers.

Relating to periodicity of training most respondents (99%) agree that there was no periodical training, whereas only 1% of respondents agreed that there was periodical training. This result indicates that the studied Health centers does not focus on healthcare waste handlers to create awareness for new coming cleaners and waste handlers to protect themselves from the risk of diseases associated with infection.

As the response of the interview done with key personnel from head of each health centers, there was a gap in the training issue of waste for the waste handler. Healthcare waste handling is a hazardous activity; thus, workers should be trained before starting work in handling wastes, and then it should be given regularly. Best practices in healthcare waste management require workers who receive continuous training (WHO, 2004). On the other hand, the absence of continued training and any operating guidelines on healthcare waste handling and management in health centers require close attention.

The finding of this research violates the Quality and Standard Authority of Ethiopia (QSAE) that prepared for working guidelines on handling and disposal of waste materials within healthcare facilities in 2004. It also not agrees with the Ministry of Health that prepared similar guidelines that could be practiced by all types of health facilities. The violation was due to Health centers level and economic level.

Table 3 Training issue for waste handlers in health centers

Statements	**Response of each Health Center**							
	Basha (n=78)		Kella(n=45)		Aruma (n=61)		Tota	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes	No
Does a waste handler know the effect of waste?	69(88.5)	9(11.5)	45(100)	-	57(93.4)	4(6.6)	92.9%	7.1%
Do they follow an effective waste management process?	4(5.1)	74(94.9)	2(4.4)	43(95.6)	9(14.8)	52(85.2)	8.1%	91.9%
Do they take training on the waste management process?	51(65.4)	27(34.6)	35(77.8)	10(22.2)	54(88.5)	7(11.5)	76%	24%
Is there periodic training?	2(2.6)	76(97.4)	-	45(100)	-	61(100)	1%	99%

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

The total healthcare solid waste generated from Basha, Aruma and Kella healthcare center was 10.32kg/day or 72.23kg/week, 9.72kg/day or 68.04kg/week, 7.27kg/day or 50.9kg/week respectively**.** The mean healthcare waste generation rate was 0.042Kg/patient/day and the mean daily healthcare waste generation rate in all studied health centers was 8.03±5.67kg/day. The percentage composition of hazardous healthcare waste generated from health centers was above the threshold set by the WHO. There is a lack of appropriate on-site waste handling, segregation, transportation, and disposal of HCW in the health centers. These improper healthcare waste management practices are mostly resulted from either ignorance of applying appropriate practices or due to lack of awareness of the proper healthcare waste management system.

Hazardous healthcare waste was mixed with the non- hazardous waste in storage area, during transportation and final disposal areas. Indiscriminate disposal of waste was practiced in the health centers and transportation of waste generated was done using plastic buckets. Overall, the waste management systems in the study health centers were poor and create a potential health risk as well as environmental pollution. Proper management of the healthcare wastes need to be promoted through proper training and providing of the necessary resources. Poor waste management was observed where both hazardous and non-hazardous waste was mixed up in waste plastic buckets. The results showed that there were insufficient waste collecting bins. It was observed that most waste collecting plastic buckets had no clear labels. Awareness of color codes, regular trainings on healthcare waste management, provision of adequate bins and ensuring clear labels on waste bins could significantly improve waste management within the health centers.

5.2. RECOMMENDATIONS

Based on the research findings, the researcher tried to put this recommendation with regard to the existing Healthcare waste management practice at Wondo Genet health centers.

- The health care management should be applied enforcement for the proper application of the principle of waste segregation, collection, storage, transportation, treatment and disposal practice based on WHO guidelines.
- The health centers should ensure proper waste management by providing adequate clearly labeled waste bins, proper temporary storage area, trolleys for waste transportation, suitable fenced and safe waste disposal areas and properly functioning and standard incinerators to ensure safe disposal of wastes to protect the environment and the public from risks.
- There should be continual training programs for all concerned health personnel to raise their awareness and change behavior towards proper HCW handling.
- Infection prevention and control committee should be strengthening to improve existing health care waste management problems.
- The supervisor assigned to monitor the overall activities of janitors should monitor those handlers on a regular basis or more frequently.
- The ministry of health: should apply enforcement for standard practices of health centers waste management in reference to the national guidelines and/or international guidelines.
- Current study was based on the data obtained within seven days of study, so that further studies should be conducted by the researchers to assess seasonal waste generation variation.

6. REFERENCES

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APPENDIX I

HAWASSA UNIVERSITY

School of Graduate Studies

College of Natural and Computational Science

Department of Biology

MSc in Ecotoxicology and Environmental Health

Data Collection Instruments

I. Questionnaire prepared for sample respondents

Dear respondents, this questionnaire is prepared for an academic purpose for the fulfillment of MSc degree in Ecotoxicology and Environmental Health in the department of Biology, Hawassa University. Specifically the objective of the study is to assess healthcare solid waste characterization and management practices in health centers of Wondo Genet Woreda, Sidama regional State, Ethiopia. Therefore, your response is very important for the success of the study because all information that you provide determines the analysis and conclusion of the research. Hence, you are kindly requested to give your response by selecting informed that your response is kept in confidential and you are not required to write your name.

I would like to thank you for your cooperation.

General Instructions:

- No need to write your name and put in the box(x) provided response
- Please fill the space provided for open-ended questions
- Data collection date: _____
- Health center name: _____
- Health facility code_____

Part I: Personal information of the respondents

1. Sex:
   - A) Male ☐ B) Female ☐
2. Age in years:
   - A) 18-25 ☐ C) Above 46 ☐
   - B) 26-45 ☐
3. Marital status: ☐
   - A) Single C) Divorced ☐
   - B) Married ☐ D) Widow ☐
4. Educational level:
   - A. Not attended formal ☐ C. 9-12 grade ☐
   - B. 1-8 grade ☐ D. Diploma ☐
   - E. Degree and above ☐
5. Position
   - A. Professional ☐
   - B. Supportive ☐

Part II: Evaluation of solid health care waste generation rate and its management system

The healthcare solid waste generation rate and its management practices are listed below. After you read each of the statements, evaluate them concerning your health centers and then put a tick mark (√) under the choices below. **(1=** represents **Yes;** and **2=** represents **No)**

S.N	Statements	Yes	No
	A. Healthcare waste segregation practice		
1	Is healthcare waste segregated in each case team?		
2	Are waste containers sufficient in each Health case team?		
3	Is segregation of waste effective?		
4	Is segregation monitored regularly?		
	B. Healthcare waste collection practice		

1	Are HCWs are collected at the point of generation?
2	Is there a sharp waste collector?
3	Are waste collectors sufficient in each Health case team?
4	Is there color code of the collection?
5	Is waste collector filled more than their capacity?
	C. Healthcare waste transportation practice
1	Is there safe transportation of HCWs?
2	Is there sufficient transporter in Health centre?
3	Is transportation done regularly?
4	Is waste transporter has lid?
	D. Healthcare waste storage practice
1	Is there temporary HCW storage Area in Health centre?
2	Is there sufficient storage in Health centre?
3	Is storage place safe?
4	Is storage area varying with types of healthcare waste?
	E. Healthcare waste disposal and treatment
1	Does Health centre have healthcare waste treatment equipment?
2	Is hazardous waste treat before disposing off?
3	Is there safe disposal?
4	Is there incinerator?
5	Is incinerator fenced?
	F. Occupational healthcare waste equipment and safety rule
1	Does worker wear special dress relating to waste?
2	Do they wear gloves?
3	Do they use the same gloves more than once?
4	Is there any injury related to healthcare waste?

5	Is it registered?
6	Do waste handlers take vaccination before work?
7	Is vaccination was periodical?
	G. Training issue of healthcare waste handling
1	Does a waste handler have knowledge on effect of waste?
2	Do they follow effective waste management process?
3	Do they take training on waste management process?
4	Is there periodically training?
5	Is it enough?

Part II. Key Informants' Interview Guiding Questions

This is an interview designed to gather information on the title **"To assess healthcare solid waste generation rate and its management system in selected health centers of Wondo Genet woreda, Sidama Regional State, Ethiopia."** The researcher selected a regarding bodies as key informants from each health centers. Genuine and complete responses by the interview are highly helpful to make the findings of the study reliable.

Thank You!

General Instructions:

- No need to write your name and put in the box(x) provided response
- Please fill the space provided for open-ended questions
- Data collection date: _____
- Health center name: _____
- Health facility code_____
- Position _____

A. Questions on generation rate and management practice of healthcare waste

1. Do healthcare waste generated segregate in their types and management practice in each case team of the Health center?

_____

_____

2. Are there written documents in healthcare waste generation rate per week?_____

If yes, How many Kg of waste generated?_____

3. Are there written documents on patient flow of health center?_____

3.1 Are there variations in weekly days?_____

3.2. How many beds does the facility has?_____

3.4. How many beds currently occupied?_____

3.5 How many outpatients visit each day on average? _____

4. Are healthcare waste management responsibilities included in the job description?_____

_____

_____

5. Is there effective collection of waste in each case team? _____

Is collection container sufficient?_____

6. Is there a special vehicle to transport medical waste and other to transport general waste from inside the health centers to storage or treatment outside the health center?

If the health center has no vehicle, by what mechanism the transport of waste takes place to the disposal and treatment place?_____

7. Is there storage place in the Health center?_____

Is it safe, clear and accessible to all?_____

8. Are hazardous wastes treated in Health center?_____

If yes, what are the methods used to treat it?_____

_____

9. Is there reuse and recycling of waste in the Health center?_____

If yes, what type of materials can be recycled?_____

10. Does Health center distribute safety equipment for healthcare waste management worker periodically?_____

_____

11. Does Health center give training for the new staff member in the management of healthcare waste?_____

If yes, is it periodical? is it enough?_____

12. Are there written documents specifying the Health center policy for the management of healthcare waste? _____

_____

_____

13. What are the main problems of healthcare waste management in the health center? Tell all?_____

Part III: Observational check list for assessing HCSWMP

1. For waste segregation and collection

S. No	Questions	Response code	
		1.Yes	0.No
1	Is there waste segregation at the generation point in the health		
2	Are there black bins containers for non-hazardous health care waste segregation?		
3	Are there yellow bins containers for hazardous health care waste segregation?		
4	Does the health center use another waste segregation option? If yes, specify: _____		
5	Are the wastes containers appropriately sealed?		
6	Does hazardous and non-hazardous health care waste collect on separate trolley?		
7	Does the health center have a clearly stated program to Collect health care waste from different departments?		
8	Is there a warning signal/signs/ on containers & places of the Collection of healthcare waste?		

2. For waste transportation and on-site healthcare waste storage

S. No	Questions	1.Yes	0.No
1	Does the health center have a separate place for storing wastes Temporarily?		

2	Is there a temporary waste storage bin having cover?		
3	Is there a temporary waste storage bin easily cleanable?		
4	Does the health center use plastic buckets and safety boxes to Transport HCW to the disposal site?		
	Manually		
	Open or unprotected		

3. For waste treatment and disposal:

S.	**Questions**	1.Yes	0.No
1	Does the health center treat healthcare waste before disposed of collection equipment		
2	Does the health centers use as a final disposal system?		
	Single chamber local built bricks incineration		
	Had functional incinerators		
	Without proper protection to the surrounding, worn-out Chimneys or no chimney, lack covers for waste feeding ashes removing doors.		
	Open-pit burning,		
	Small burial and placenta pit		

Part I: Seven consecutive day healthcare waste generation sheet by HC & Departments (kg/day)

Health Center Name---------- Code---------

Departments /Units/	Mond	Tuesd	Wednesd	Thursda	Frida	Saturda	Sunda	Total
OPD								
Pharmacy								
Laboratory								
Injection & Dressing								
MCH,FP & PI								

VCT &ART								
TB follow Unit								
Delivery Ward								
Emergency								
TOTAL								

Part II: Total healthcare waste generation registration sheet by HC & Departments (kg/day)

Name of HC	OPD	Pharmacy	Laboratory	Injection & Dressing	MCH, FP &EPI	VCT& ART	TB follow up	Delivery ward	Emergency	Total HW
Total										

Part III: Seven consecutive day healthcare waste generation sheet by HC & HCW type (kg/day)

Health Center Name---------- Code---------

Waste category	Monday	Tuesday	Wednes	Thurs	Frid	Satur	Sun	Total
General								
Sharp								
Infectious								
Pathological								
Pharmaceutical								
Total hazardous								
Total								

Part IV: Total healthcare waste generation registration sheet by HC &HCW type (kg/day)

Health	General	Sharp	Infectious	Pathological	Pharmaceutical	Total
TOTAL						

Part V: Seven consecutive day patient flow sheet by HC & Departments /Units/

Health Center Name---------- Code---------

Departments /Units/	Mon	Tues	Wednes	Thurs	Friday	Saturday	Sunday	Total
OPD								
Pharmacy								
Laboratory								
Injection &Dressing								
MCH, FP&EPI								
VCT &ART								
TB follow up Unit								
Delivery Ward								
Emergency								
TOTAL								

Part VI: Total patient flow sheet by HC& Departments /Units/

Name HC	OPD	pharmacy	laboratory	Injection and dressing	MCH,FP & EPI	VCT & ART	TB follow	Delivery ward	Emergency	Total
Total										

Part VII: Total number of beds by HC & Departments /Units/

Name of HC	OPD	pharmacy	Laboratory	Injection& Dressing	MCH, FP&EPI	VCT& ART	TB follow up	Delivery ward	Emergency	Total
Total										

APPENDIX II: SIDAAMU AFOO- VERSION

Hawaasa yuniversitiy

Masiterete xiinxallo gola

Kalaqamunna waaxote sayiinse

Bawuloojete rosi gola

MSc Ecotoxicology and Environmental

FayyimmateTaje gamba assinanni

uduunnicho

I. Xa'mo qixxaabbinohu doorantino dooramaanora Wondo genetete woradi xiinxallote doorantino fayyimmate uurrinsha giddo loossanno loosaasineraati.

Ayiiraddu dawaraasine, tini xa'mo qixxaabbinohu rosu hajora maastersete digire Ecotoxicology and Environmental Health aana baayoloojete rosi goli, Hawaasi yuniversitenniiti. Baxxino garinni tini xiinxallo xiinxalla hasidhinori fayyimmate uurrinshubba giddonni fultanno moolu ishini fulonna amandanni he'noonni rosicho Wondogenete woradi sase doorantino fayyimmate uurrinshubba giddo. Konni daafira, ate dawaro tinixiinxallo gumulamate lowontanni kaa'litanno korkaatuno wo'manti ati aatto/tta taje seerase agarinogarinni tantanne xiinxallote gumulshira hossanno. Ikkinohura ati tenne taje aatonke/aatanke gede doorroonniheha ikkanna ootto/tta teje Fojo woleho reqecci yitanokki gede su'makkiborreessitooti.

Umikki fajjora lowontanni asse galaxxeemmohe.

Xaphooma hajajo:

- Su'ma borreessa dihasiissaannonna dawarokki aanino malaatinni (x) xawisi.
- Eeggotena fano base heechuro borrotenni dawari.
- Taje wonshinoonni barra: _____
- Fayyimmate uurrinsha su'ma: _____

Gafa I: Meessaneete xawishsha

1. Koo/Tee:
   A) Koo ☐ B) Tee ☐
2. Diro deerra:
   A) 18-25 ☐ C) Above 46 ☐
   B) 26-45 ☐
3. Adhammete gara:
   A) Mine assirinokkiha/ta ☐ C) Gunnichu/te ☐
   B) Mine assirinoha/ta ☐ D) Tirinoha/ta ☐
4. Rosu Deerra:
   A. Certifikeete ☐ C. Dipolooma ☐
   B. Umi digire ☐ D. Maasterise ☐
5. Loosu qeecha:
   A. Dokitere ☐ C. Irkisaancho ☐
   D. Nerse ☐
6. Loosu rosicho:
   C. 1- 5 diro ☐ C. 11 – 15 ☐
   D. 6- 10- diro ☐

Gafa II: Fayyimmate uurrinshubba Moolunna du'namaanchu ishini fulote bikkanna amadooshshu hayyo keenate

Fayyimmate uurrinshubba Moolunna du'namaanchu ishini fulote bikkanna amadooshshu hayyo konni woroonni xawinsoonni. Worroonnire nabbawitto gedensaanni mitte mittenti xa;mubba yitannore hegersite umikki hedo wori. Hedokki woratto/tta woyiite (1 = Ee nna 2 = dee'ni yaate)

T.k	Xa'mo	Ee	Dee'ni
	A. Fayyimmate uurrinsha giddo ishine bandanni rosicho		
1	Uurrinshate giddo fulanno ishine fulanno basera bandanni?		
2	Ishinu fulanno basera fulanno ishine worranni contiinere ikkadote?		
3	Ishine bandanni amanyooti ikkadoho?		
4	Ishine bandanni amanyooti yanna yannatenni keennanni?		
	B. Fayyimmate uurrinsha giddo ishine corranni rosicho		
1	Fulanno ishini fulanno basera corranni?		
2	Quxamino uduunne corraanni uduunnichi no?		
3	ishinu fulanno basera corranni gari seerunniiti?		
4	Kuulunni bandoonni uduunnichi noo'ne?		
5	Uduunnuchoho bikkisara aleenni kuunsanni?		
	C. Fayyimmate uurrinsha giddo ishine hodhisate rosicho		
1	Co'ite hodhishshu amanyooti noo'ne?		
2	Uurrinsha'ne giddo ikkadu ishinu hodhishhi noo'ne?		
3	Yannasi agarre hodhinsanni?		
4	Ishine hunanni uduunnichi noo'ne?		
	D. Fayyimmate uurrinsha giddo ishine kuunsanni rosicho		
1	Fulanno ishine kuunsanni amanyooti noo'ne?		
2	Ishine kuunsannihu ikkadu base noo'ne?		
3	Basete co'ichimma agagntinote?		

4	Is storage area varying with types of healthcare waste?
	E. Fayyimmate uurrinsha giddo ishine hunanni rosicho
1	Uurrinshate giddo ishine hunanni base noo'ne?
2	Harfaamo ishine wirro horonsirate rosichi noo'ne?
3	Deerrasi agarirtino base noo'ne?
4	Ishine giirranni insinereetere noo'ne?
5	Insinereetere huxxantino?
	F. loosaasinete Fayyimmate agarooshshi uduunni shiqisho
1	Loosaasine uminsaha ikkino uduunni noo'ne?
2	Angate gaante wodhitanno?
3	Mitte angate govaante ganyite horonsidhanno?
4	Mannimmansa aana iillitinonsa jaddo no?
5	Borreessine amandoonni?
6	Loosaasine balaxxe kittiwaate qasidhanno?
7	Kitiwaate ganyine uunanni?

Gafa II: Afuu xa'mo lainohunni

Ayiiraddu massagaanchi, tini xa'mo qixxaabbinohu rosu hajora maastersete digire Ecotoxicologyand Environmental Health aana baayoloojete rosi goli, Hawaasi yuniversitenniiti. Baxxino garinni tini xiinxallo xiinxalla hasidhinori fayyimmate uurrinshubba giddonni fultanno moolu ishini fulonna amandanni he'noonni rosicho Wondogenete woradi sase doorantino fayyimmate uurrinshubba giddo. Konni daafira, ate dawaro tinixiinxallo gumulamate lowontanni kaa'litanno korkaatuno wo'manti ati aatto/tta taje seerase agarino garinni tantanne xiinxallote gumulshira hossanno.

Galaxxeemmo!

Xaphooma hajajo:

- Su'makki borreessitooti
- Fano basera xa'minoonni garinni wonshi
- Taje gamba assinoonni barra: _____
- Uurrinshate su'ma: _____
- Uurrinshate uuyiinoonni coodde_____
- Loosu qeecha _____

A. Fulanno ishini bikkanna amandanni hayyo

1. Mitte mittente dipaartimeentenni fulanno ishine bandanninna amandanni hayyo noo'ne?

_____

_____

2. lamala lamalate kiironni fulanno ishine borreessine amandanni hayyo noo'ne? _____ Ee yiittoro, me"e kg fushshinanni?_____

3. xiwamaano fultanno basenni borreessine amandoonni taje noo'ne? _____

3.1 Barru barrunni amandanni taje _____

3.2. meu algi noo'ne?_____

3.4. How many beds currently occupied?_____

3.5 How many outpatients visit each day on average? _____

4. Uurrinshate massagaanora uminsaha ikkitino yawo maati?_____

_____

5. ikkado amadooshshi noohe? _____

Ishine corranni uduunni ikkadoho?_____

6. ikkadu ishine hunanni uduunnichchi no one? Ishinu fulanno basenni kayiinse duunanni base geeshsha massanno uduuunnichi noo'ne?

_____

7. ishine kuunsanni base noo'ne?_____

Co'ichanna ikkadoho?_____

8. harfaamu ishini uurrinshate giddo hursate looso loonsanni?_____

Hiittenne hayyonni hursinanni? _____

9. wirro horonsi'nanni base noo'ne?_____

Hiikkonne uduunneeti wirro horote aana hosannohu?_____

10. Uurrinsha'ne loosaasinete fayyimmmansa agadhitanno uduunne uuyiitanno?_____

_____

11. moolu ishini amadooshshe lainohunni uurrinsha'ne la'annonsa bissara qajeelsha uuyiitanno?_____

Yannasi agadhinoho? ikkadoho?_____

12. Uurrinsa'ne giddo moola ishine amandanni hayyo xawissanno polisubba, lallawubbanna wodhubba

noo'ne? _____

Part III: Observational check list for assessing HCSWMP

1. For waste segregation and collection

S. No	Questions	Response code	
		1.Yes	0.No
1	Is there waste segregation at the generation point in the health		
2	Are there black bins containers for non-hazardous health care waste segregation?		
3	Are there yellow bins containers for hazardous health care waste segregation?		
4	Does the health center use another waste segregation option? If yes, specify: _____		
5	Are the wastes containers appropriately sealed?		
6	Does hazardous and non-hazardous health care waste collect on separate trolley?		
7	Does the health center have a clearly stated program to Collect health care waste from different departments?		
8	Is there a warning signal/signs/ on containers & places of the Collection of healthcare waste?		

APPENDIX IV

Some photographs during field observation in the selected health centers

Figure 8: Mixed healthcare solid wastes in the dumping site in health center

Figure 9: Interview with Environmental protection expert in Basha health center

Figure 10: Interview with Environmental protection expert in Basha health center

Figure 11: healthcare Solid waste collection bins in the selected health centers