SCHOOL OF PUBLIC HEALTH, COLLEGE OF HEALTH SCIENCES,

UNIVERSITY OF GHANA, LEGON

A STUDY OF SOLID MEDICAL WASTE AT THE COMMUNITY LEVEL: GENERATION AND COLLECTION IN HOUSEHOLDS, AMONG TRADITIONAL BIRTH ATTENDANTS AND CHEMICAL SHOP VENDORS, AND IMPACTS ON HEALTH

BY

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THIS THESIS IS SUBMITTED TO THE DEPARTMENT OF BIOLOGICAL, ENVIRONMENTAL & OCCUPATIONAL HEALTH SCIENCES, UNIVERSITY OF GHANA, LEGON, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN PUBLIC HEALTH

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DECLARATION

I hereby declare that this thesis is the product of my original independent research conducted in the Greater Accra Region under the supervision of Professor Julius N. Fobil and Dr. Gabriel Gulis. I affirm that this work has neither been published nor submitted in whole or in part to any institution for any academic award. All references made to other researchers' works have been duly acknowledged.

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ABSTRACT

Background: Solid waste generated from activities involving health protection, medical diagnosis and treatment, known as solid medical waste (SMW), is increasing in households due to home based care, treatment of chronic diseases, shortened lengths of hospital stay, and home management of illnesses such as malaria. The hazardous properties of SMW require specific management to minimize potential harm to human health and the environment, which is often undertaken in healthcare facilities. However, little is known about the characteristics and management of SMW from non-traditional settings in the community.

Objective: To investigate the management of solid medical waste in a district in the Greater Accra Region of Ghana, focusing on households, traditional birth attendants (TBAs) and chemical shop vendors (CSVs).

Methods: A descriptive, exploratory, mixed methods study, comprising a 3-staged study design was conducted in Ga South Municipal Assembly. The first stage explored collection, disposal, and harm from SMW in 600 households using questionnaires followed by interviews with private waste contractors and focus group discussions (FGDs) with adult members of households. In the second stage, household solid waste (HSW) was collected in dry and wet seasons from 60 households and manually segregated to obtain the SMW components. These were weighed and percentage composition calculated. The third stage explored stakeholder perspectives regarding segregation of SMW at source as a management option, using FGDs. Seasonal differences and relationships with SMW generation were evaluated, while qualitative data were analyzed using a thematic approach.

Results: Household production and per capita generation of SMW were 7.26 x 10^{-3}kg/household/day and 1.77 x 10^{-3}kg/person/day respectively. Medicinal waste and sharp waste comprised 98% and 2% of SMW respectively. Daily per capita generation of SMW was significantly higher in the wet season than in the dry season ($z = 3.129$, $p = 0.002$). Harm due to SMW was reported by 4.8% of households and mostly involved sharps. Barriers to segregation of SMW at source included lack of community education, storage facilities and logistics, time consumption and cost.

Conclusion: Although the quantity of SMW in HSW is low, its composition, largely of medicinal waste, and a smaller proportion of sharps conferred on it some hazardous properties. Community education and logistic support for segregation at source might improve SMW management in the community.

DEDICATION

First, this work is dedicated to God, the first and unequalled environmental expert, in Whose magnanimity I was blessed with this fellowship. Secondly, it is dedicated to others in the following order: the study participants, their administrative and health authorities; my family; my mentors, prayer and academic peers, and the medical students whose report motivated this research.

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DEFINITION OF TERMS

Most of the operational definitions used in this research were adapted from Glossary of Environment Statistics, a United Nations publication (Division, Economic, & Analysis, 1997), and modified using either researcher's additions or additions from Environmental Protection Agency, Ghana (EPA, 2002a), (Rushton, 2003), (Demirbas, 2011), (Igbinomwanhia, 2011), (Christensen, Scharff, & Hjelmar, 2011) and Encyclopedia of Environmental Health Vol. 2 (Kulkarni, Crespo, & Afonso, 2011).

Acid rain: is a form of precipitation with increased acidity due to uptake of acid pollutants in the air.

Air pollution: refers to the presence of poorly dispersed pollutants in the air which interfere with human health and/or produce harmful effects in the environment.

Attenuation: is a process by which compounds are reduced in concentration over time through adsorption, degradation, dilution or any other transformation.

Contaminant: any physical, chemical, biologic or radiologic substance that has an adverse effect on environmental media (air, water, land or biota).

Contamination: is the process by which (a) contaminant(s) spread from one place to another.

Dioxin: a synthetic organic material of the chlorinated hydrocarbon class; known to be carcinogenic. It is a persistent trace organic pollutant which can be transported over long distances in the atmosphere. Often abbreviated PCDD meaning polychlorinated dibenzo-*p*-dioxin.

Disposal option: implies available methods used to eliminate the specified waste stream from the household such as discarding in a household bin for ultimate collection, burying in a pit, burning etc.

Disposal practice: refers to the way(s) in which a household routinely eliminates the specified waste stream.

Emission: discharge of pollutants into the atmosphere from stationary or mobile sources.

Greenhouse gases: Carbon dioxide, nitrous oxide, methane, ozone, and chlorofluorohydrocarbons that occur naturally or result from anthropogenic activities and contribute to warming of the earth's atmosphere by allowing sunlight to pass through but preventing the counterbalancing loss of heat radiation.

Harm: injury or damage to the health of people and/or the environment.

Hazard: refers to the intrinsic potential of a substance to cause harm.

Household solid waste: is solid waste material usually generated in residential premises.

Hazardous waste: is waste that possesses toxic, infectious, radioactive or inflammable properties and pose a substantial actual or potential risk to human health, other living organisms and the environment.

Household hazardous waste: hazardous waste that occurs in a household or residential premises.

Landfill: A landfill is a physical facility in surface soil designed for disposal of solid waste in a manner that protects the environment from contamination. It should have a liner system, a cover system, management systems for leachate and gas, monitoring

systems for surface water, ground water and disposed material. It should be appropriately sited and have restricted access.

Land disposal: refers to waste disposal at landfills.

Leachate: is liquid from a landfill or disposal site that results from water trickling through waste often dissolving pollutants and can infiltrate the soil, surface or ground water.

Municipal solid waste: consists of waste produced by households and similar waste from commerce, offices and public institutions often disposed by or on behalf of the municipal authorities through its waste management system. It includes food waste, garden waste and yard trimmings, paper and cardboard, plastics, metal, glass, textiles, leather and miscellaneous items.

Offensive waste: refers to waste containing body fluids, often from healthy persons but cause offense to those who in contact with it. Due to the uncertainty regarding a person's infection status at the time of disposal, for precautionary reasons it is assumed to be potentially infective and used as such in the text.

Open dump: refers to uncovered ground site used for the disposal of waste without environmental control.

Pathogen: is a microorganism capable of causing disease in other organisms.

Persistence: refers to the length of time that a compound is able to remain in the environment after it has been introduced.

Pollution: refers to the presence of substances in environmental media whose nature, location or quantity produces undesirable environmental effects.

Pollutant: is a substance that is present in concentrations that may harm organisms or exceed environmental quality standards.

Scavenging: manual sorting of solid waste and removal of material intended for further use.

Segregation: is a process which involves a systematic separation of the different waste streams according to properties, the type of treatment and final disposal option applied.

Solid waste: refers to material which is useless to and discarded by the generator, which has low liquid content.

Storage: refers to the isolation of waste with the intent that it will be retrieved for processing and disposal at a later time.

Surface water: refers to all water naturally open to the atmosphere including streams, rivers, lakes, and the sea.

Toxicity: implies the ability of a substance to cause poisonous effects resulting in severe biological harm or death following exposure to or contamination with that substance.

Treatment: refers to operations intended to minimize health hazards and damage to the environment by altering the characteristics of the waste. This is distinct from the application of the word in healthcare where it is used for therapeutic purposes.

Waste: refers to anything that is discarded by an individual, household or organization. A product's material value is often determined by its owner, and in the context of waste, it is often of marginal or no value and therefore discarded.

Waste stream analysis: is a systematic approach to obtain and analyze data on one or more waste streams or sub-streams.

Waste survey: is a statistical study of a sample of the population which involves obtaining information on specific characteristics that may be related to waste such as age, income, household size etc.

LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
CANSI	Community acquired needle stick injury
CI	Confidence interval
CHPS	Community based health planning and services
CSV	Chemical shop vendor
ED	Emergency department
EHSD	Environmental Health and Sanitation Department
FGD	Focus group discussion
GSMA	Ga South Municipal Assembly
HBV	Hepatitis B virus
HCV	Hepatitis C virus
HIV	Human Immunodeficiency virus
HCW	Healthcare worker
HSW	Household solid waste
iqr	Interquartile range
MOH	Ministry of Health
MPCU	Municipal Planning Coordinating Unit
MSW	Municipal solid waste
MTDP	Medium Term Development Plan
PEP	Post exposure prophylaxis
s. d.	Standard deviation
SMW	Solid medical waste
TBA	Traditional birth attendant
WHO	World Health Organization
WMD	Waste Management Department

CHAPTER ONE

1 INTRODUCTION

1.1 Background

The health care industry generates waste which is generally termed healthcare waste (HCW). HCW may be in solid, liquid or gaseous forms and contains pathogens, toxic heavy metals and chemicals (WHO, 2014a). Although the healthcare industry is the traditional source of HCW, non-traditional sources include household and community settings where limited healthcare activities occur. HCW from non-traditional sources does not differ in composition and properties from that generated in the traditional healthcare facilities except that it is generally not regulated and does not undergo similar treatment in the non-traditional settings before disposal (Yordanova, Angelova, Kyoseva, & Dombalov, 2014). This study focused on the solid component of healthcare waste called solid medical waste (SMW), arising from typical non-traditional settings in households and in the community.

SMW constitutes 0.1% of the mixed municipal waste stream (Yordanova, Angelova, Kyoseva, & Dombalov, 2014). Although it is generated in small quantities, it is the character of the waste; in terms of its ability to transmit infectious pathogens and its toxicity - that attract public sensitivity and makes it a concern to health authorities. SMW includes, but is not limited to, discarded medicines, blood soaked bandages, hypodermic needles and syringes, lancets and insulin pens. Hypodermic needles and other sharps in the waste stream can cause physical injury and have the potential to transmit infections when contaminated with infected body fluids. Outdated and unused medicines are often

discarded in household bins with household waste which ultimately ends up in landfills (Tong, Peake, & Braund, 2011). Active pharmaceutical ingredients from these discarded medicines are then discharged into the landfills (Kummerer, 2009).

Healthcare activities are increasing in the households due to promotion of home based care (Phorano, Nthomang, & Ngwenya, 2005; Kang'ethe, 2008), the requirement for care and treatment of chronic diseases in aging populations (Weisfeld & Lustig, 2015), shortened lengths of hospital stay (Oyewole, Sapp, Wilson, & Oyewole, 2014), and home management of illnesses such as malaria (Chinbuah *et al.*, 2012). SMW generated from healthcare activities in households and other settings in the community adds on to the existing difficulties with institutional management of HCW faced by municipal and health authorities in most African countries (Udofia, Fobil, & Gulis, 2015). While there is growing awareness about SMW because of the associated hazards, its management has not received priority attention in developing countries. Much less attention has been accorded to SMW from households and the community.

The present research conducted waste stream analyses to provide empirical data on the quantity and composition of SMW in households; identify disposal options used by households, traditional birth attendants and chemical shop vendors; determine the proportion of households reporting harm from SMW and explore the views household members about source segregation as a management option.

In Ghana, key stakeholders in waste management at the national level are the Environmental Protection Agency (EPA) and the Ministry of Local Government and Rural Development (MLGRD). EPA functions under the auspices of the Ministry of Environment, Science, Technology and Innovation (MESTI) and has regulatory

responsibilities. MLGRD provides administrative oversight in policy implementation to the Metropolitan, Municipal and District Assemblies (MMDAs), which discharge their waste management responsibilities of waste collection and sanitary disposal through their Waste Management Departments (WMDs). The Environmental Health and Sanitation Departments (EHSD) collaborate with EPA and other regulatory agencies to enforce and monitor compliance with environmental standards. Additionally, they provide continuous public education regarding environmental protection and monitor the impact of waste management activities in the Municipal Assembly (MLGRD, 2010; Puopiel, 2010). The regulations regarding the management of medical waste are non-specific and subsumed in several regulations addressing environmental sanitation and municipal solid waste management namely: Constitution of the Republic of Ghana,1992; Environmental Protection Agency Act, 1994 (Act 490), Environmental Assessment Regulations, 1999 (LI 1652), Local Government Act, 1993 (Act 462), National Building Regulations, 1996 (LI 1630), Town and Country Planning Ordinances, 1944 (Cap 84), Vaccination Ordinance (Cap 76), Quarantine Ordinance (Cap 77), Mosquito Ordinance (Cap 75), Infectious Disease Ordinance, Food and Drugs Law 305b (1992), Mortuaries and Funeral Facilities Act, 1988 (Act 563), The Criminal Code, 1960 (Act 29) (as cited in EPA, 2002b; MOH, 2006). The Ministry of Health (MOH) published guidelines for management of waste in healthcare facilities in 2006. These guidelines are based on recommendations by World Health Organization (WHO) and can be applied to other healthcare settings including those belonging to alternative healthcare providers (MOH, 2006). In September 2011, the Abidjan-Lagos Corridor Organization (ALCO) published a simplified manual to serve as a regional reference document for the management of SMW across 5 ECOWAS member countries namely Cote d'Ivoire, Ghana, Togo, Benin and Nigeria. The

manual recognizes the individual/household level as one of the 5 levels of intervention in healthcare waste management (ALCO, 2011). However, none of the two aforementioned documents directly addresses the management of SMW in households.

The Municipal Assembly engages private waste management companies in a contractual agreement based on users' willingness and capacity to pay. To ensure adequate coverage and avoid duplicity of services, districts are divided into zones which are allotted to the service providers. Institutions and individuals are expected to make arrangements for waste collection with service providers assigned to their zone. Waste management activities are expected to be conducted in a manner that would not adversely affect others in the community (MLGRD, 2010). There are currently no systems for collection of SMW or any hazardous waste from households in Ghana. Landfills remain the only management option for HSW. As there is no source segregation taking place on a wide scale in households, co-disposal of SMW with HSW remains the norm. No studies have been identified that directly addressed the management of SMW in households in Ghana, except for one study which investigated a type of SMW (pharmaceutical waste) (Sasu, Kummerer, & Kranert, 2012).

1.2 Problem Statement

According to the Environmental Sanitation Policy (Revised 2010) of the Ministry of Local Government and Rural Development in Ghana, infectious or medical waste from hospitals or clinics is designated as hazardous waste which implies such waste must be treated accordingly. No mention is made of similar waste generated from households. This can be attributed in part to healthcare facilities being the traditional setting in which SMW are produced. Challenges with management of SMW have been widely reported

from healthcare facilities and therefore waste from healthcare facilities has engaged public attention.

In developing countries, travel distance and indirect costs of hospital care may compel some households to undertake limited healthcare activities at home. This generates SMW which is often discarded at the discretion of the households in the absence of local guidelines or regulations. Studies in various countries indicate that SMW in households comprise of lancets, needles and syringes, unwanted medication and wound dressings among others. Community-acquired needle stick injuries and potential transmission of Hepatitis B are the most frequently reported consequences of SMW. In Ghana, the high prevalence of Hepatitis B, existence of scavengers, proliferation of open refuse dumps accessible to young children and stray animals are factors which potentially enhance human exposure to these consequences. In recognition of the potential for injury, some safety measures have been applied elsewhere. In the United States, sharp collection for households is available in most states. In Sweden, take back programs enable citizens to return unwanted medication through pharmacies and only 1% of waste is landfilled. However, similar management options do not exist in Ghana where virtually all household waste is landfilled.

Between handling in the household and final disposal at the landfill, the presence of SMW in the household waste stream portends potential hazards to members of the household, waste workers without adequate protection, unsupervised young children and unsuspecting public. With increasing life expectancy and a shift towards chronic diseases demanding a shared responsibility for care in households, management of SMW will become increasingly important given its hazardous properties. As the present treatment options for SMW cannot be safely undertaken in households, the focus will shift towards

segregation at source, safe storage and transport of SMW from households. In this regard, the quantity and composition of SMW is critical to determine storage and transport capacity, but there is a paucity of information regarding SMW in households in Ghana. This research addresses the quantity, composition and management of SMW in the community, and fills a gap hitherto unaddressed in waste management research in Ghana.

1.3 Aims, Objectives and Hypothesis

1.3.1 Aim of research

The aim of the research is to investigate, characterize the component materials and determine the impact SMW generation and collection at the community level; focusing on households, traditional birth attendants (TBAs) and chemical shop vendors (CSVs) as points of generation.

1.3.2 Research Objectives

The research has the following objectives:

1. To characterize solid medical waste in households in Ga South Municipal Assembly.
2. To describe disposal options for solid medical waste from household and community sources in the study area.
3. To estimate the relative proportion of household members reporting harm due to solid medical waste at household and community levels.
4. To ascertain stakeholder views regarding segregation at source as a potential management option at the community level.

1.3.3 Research Questions

Questions this research addressed were the following:

1. What are the proportions of the component materials in solid medical waste from households?

2. What are the disposal practices in respect of SMW in households and in the communities?

3. What is the prevalence of injuries/harm due to SMW originating from households?

4. What factors facilitate and/or serve as barriers to segregation of SMW at both household and community levels?

CHAPTER TWO

2 LITERATURE REVIEW

Much of what is known about SMW and its management is derived from hospital surveys. Therefore this chapter first presents the knowledge about SMW and its management in healthcare facilities and then describes what is known about SMW in the community. Pathogens, environmental and health hazards associated with SMW are also addressed.

Three main electronic databases were used for the review of relevant literature: Pubmed, Google Scholar and ScienceDirect. A more detailed search was conducted on solid medical waste management in African countries using additional databases namely: Web of Science, EMBASE, Scopus, Proquest and African Journals Online. The search terms were: 'medical waste' OR 'biomedical waste' OR 'clinical waste' OR 'hospital waste' OR 'hazardous waste' OR 'healthcare waste' AND 'Africa'. The search was repeated replacing 'Africa' with names of individual countries from two World Bank websites (www.worldbank.org/en/region/mena and www.worldbank.org/en/region/afr), with the addition of Mauritius. The period under review spanned 1997 to October, 2014. Additional searches were conducted for Ghana and Madagascar on Google. Articles included in the final review were those written in English, or had an abstract in English if written in another language; those that described waste management activities in relation to solid medical waste and the study was conducted in an African country. Articles excluded were those which did not meet these criteria, articles on liquid medical waste management and veterinary services.

2.1 Definitions associated with solid medical waste

SMW is all material discarded in solid state from healthcare activities involving human beings or animals, research or testing of biologicals (Congress, 1998; WHO, 1992; Burke, 1994; Badni & Dharmashree, 2011). The majority of definitions appear to accept the following as components of SMW: culture, stocks of infectious agents and biologicals, pathological waste, blood and blood products, sharps and solid waste contaminated with effluents from healthcare activities.

Healthcare waste comprises both hazardous and non-hazardous waste related to medical procedures in various settings including health care facilities, research centres, laboratories and includes similar waste generated in the course of health care activities undertaken in the home (WHO, 2014a). Medical waste is a component of healthcare waste generated from activities involving health protection, medical diagnosis, treatment and scientific research (Rutala & Mayhall, 1992; Klangsin & Harding, 1998; Marinkovic N, 2008). Infective or infectious wastes are considered a sub-set of medical waste which can potentially transmit an infectious disease (Rutala & Mayhall, 1992). This term was synonymous with the term 'regulated medical waste' (Burke, 1994). Regulated waste refers to the aforementioned type of waste which was required by law to be tracked in the US. This was the preferred term by the US Congress as the possibility of transmission from such was considered remote. Interpretations also differ according to countries: in Austria 'infectious waste' is used for waste associated with limited contagious diseases such as anthrax and tuberculosis, while in Greece all waste generated from patient care is considered 'infectious'(Mahnik & Horinek, 2008). Some definitions exclude SMW generated from a household, a farm operation or other agricultural ventures, elderly people's home or home health care agency such as defined in the Michigan Medical

Wastes Regulatory Act of 1990 (MWRA) in the United States (DEQ, 1997) , while others are less specific. In this research, SMW as defined was applied to waste from healthcare activities in the specified setting (households, TBA homes and chemical vendor shops).

2.2 Classification of solid medical waste

The World Health Organization (WHO) has classified all waste generated from healthcare facilities into nine categories (Table 1). This excludes general waste which is non-hazardous and similar to domestic waste (WHO 2014a). All other categories of waste are considered hazardous and require some measure of pre-treatment before final disposal.

Table 2.1 Categories of medical waste

Waste category	Examples within the waste category
Infectious waste	Laboratory cultures, waste from isolation wards, wastes from the production of biologicals, discarded live and attenuated vaccines, swabs, dressings, examination gloves, other materials and equipment in contact with infected patients' body fluids, excreta
Pathological waste	Human tissues, body fluids, removed body parts, fetuses
Sharps waste	Needles, scalpels, blades, broken glass and vials, syringes with or without attached needles, needles with attached tubing such as infusion or blood giving sets, lancets, nails, saw
Pharmaceutical waste	Pharmaceuticals that are expired or no longer required; vaccines, items contaminated by or containing pharmaceuticals such as bottles, boxes
Genotoxic waste	Waste containing genotoxic drugs mainly used in cancer therapy, genotoxic chemicals
Chemical waste	Waste containing chemical substances, laboratory reagents, film developer, disinfectants that are expired or no longer needed, solvents, cleaning materials
Waste with heavy metal content	Batteries, broken thermometers, blood pressure gauges, dental amalgam
Waste containing pressurized containers	Gas cylinders, gas cartridges, aerosol cans
Radioactive waste	Unused liquids from radiotherapy or laboratory research – contrast media, contaminated glass ware packaging, or absorbent paper, urine or excreta from patients tested or treated with unsealed radionuclides; sealed sources

Adapted from: (Prüss, Giroult, & Rushbrook, 1999; Manga, Forton, Mofor, & Woodard, 2011; Debnath & Mitra, 2014)

Official guidance in the United Kingdom (UK) recognizes three hazardous categories: infectious waste, medicinal waste and chemical waste, while waste contaminated with non-infectious body fluids is regarded as offensive waste (Cooper, 2011). The reference document adopted for management of healthcare waste in Ghana by Abidjan-Lagos Corridor Organization (ALCO) recognizes the categories described by WHO and merges them into three categories for segregation namely, regular/household related waste (black), infectious sharp (off-white safety boxes) and non-sharp (yellow) waste and non-infectious hazardous waste (brown) (ALCO, 2011). Box 2.1 shows the relevant categories in the UK and the equivalent category in the classification used in the ALCO reference manual. In the study, the term 'solid medical waste' was restricted to the combination of medicinal waste and sharp waste. Offensive waste was reported separately. In this study, it was assumed that offensive waste was potentially infectious because infections can be unrecognized or undiagnosed (Blenkharn, 2011), individuals could be in the incubation period of an infectious disease, and the possibility that storage conditions can potentially enhance the microbial burden in the waste (Saini, Das, Kapil, Nagarajan, & Sarma, 2004).

Box 2.1 Classification of solid medical waste in the study

UK Category	ALCO category	Description	Examples
Medicinal waste	Non-infectious hazardous waste	Expired, unwanted or left over medicines which were discarded. It also includes containers contaminated with residue/contents of pharmaceuticals and drug vials.	Syrup bottles, blister packs with residue/content, drug vials, loose tablets
Sharps waste	Infectious sharp waste	Items that cause cuts or puncture wounds which have been discarded.	Needles, syringes with needles attached, broken glass ampoules, blades, shaving sticks
Offensive waste	Non-sharp waste (potentially infectious)	Discarded items which have come in contact with body fluid, although not known to be infectious but causes offense to those who come into contact with it.	Plaster, soiled tissue, condoms, sanitary pads, diapers

2.3 Characteristics of solid medical waste and preferred treatment options

The physical characteristics of SMW such as composition, moisture, and heating values are useful parameters in selecting appropriate treatment technology, while bulk density provides estimates of equipment capacity and landfill size. Sharp waste consists of items that can penetrate/pierce the skin and cause injury. Items include knives, blades and hypodermic needles, broken glass vials, and infusion sets. Bulk density reported for sharps in healthcare waste (HCW) was 429kg/m^3, while moisture content is reportedly low, 0-1%. Due to their low heating value of 0-30kcal/kg, they will require mixing with other waste which have a high heating value if destined for incineration (WHO, 2014a). WHO recommends that all discarded sharps be treated as though they were potentially infectious waste (WHO, 2014a). Among the components of non-sharp waste, pharmaceutical waste includes expired, unwanted, and contaminated pharmaceutical

products, vaccine vials and receptacles containing or contaminated with residue. Genotoxic waste has properties which are capable of inducing mutations, birth defects or cancers. Cytotoxic drugs are capable of limiting cell growth and replication. Apart from the drugs in these categories, all materials that come into contact with the drugs as well as patients' secretions containing these drugs are considered genotoxic or cytotoxic respectively. These waste categories are considered unsuitable for landfills due to their hazardous nature and require high temperature incineration (WHO, 2014d). In Ecuador, medicines were reported to have a moisture content of 64% and a bulk density of 959kg/m^3 (Diaz, Eggerth, Enkhtsetseg, & Savage, 2008). Non-hazardous medicines can be encapsulated and buried in landfills, undergo high temperature incineration or returned to the supplier. Intravenous fluids containing salt, glucose and amino acids and cough syrups can be diluted and discharged to a sewer (WHO, 2014d). Cotton absorbents, gauze, pads are reported to have a moisture content not exceeding 30% with a heating value up to 6700kcal/kg and are therefore suitable for incineration. Human anatomical waste has a low heating value of 400-2000kcal/kg and a high moisture content of 70-90%. This type of waste cannot be incinerated in large amounts due to the high moisture content. In some countries anatomical waste is buried or burnt in crematoria in accordance with socio-cultural and religious beliefs (WHO, 2014d). Most plastics such as syringes, have a low moisture content with a high heating value of up to 11000kcal/kg (WHO, 2014a). These can be shred and incinerated provided they do not contain poly vinyl chloride.

2.4 Sources of solid medical waste

According to WHO, examples of major sources of healthcare waste (HCW), of which SMW is a component, include hospitals, health centres, clinics, research centres, mortuaries, blood banks and biomedical laboratories (WHO, 2014a). These produce large quantities of SMW comprising nearly all types of SMW. Minor sources typically have sharp waste (mainly needles), but other types of SMW are uncommon. Minor sources include but are not limited to physician offices, dental clinics, psychiatric hospitals, cosmetic parlors, illicit drug users' homes, funeral homes and home treatment. Sources of SMW are grouped into major and minor sources based on the quantity of healthcare waste generated (WHO, 2014a). In the United States, corresponding categories were termed large and small generators with the threshold quantity being 50 pounds of SMW per month (Grau, 1997; Janagi, Shah, & Maheshwari, 2015). Large generators of SMW were those that generated more than the threshold value. They were required to officially register as generators of SMW and use approved carriers/receivers for treatment and disposal (Liss *et al.*, 1990).

2.5 Management of solid medical waste

This refers to the activities, whether administrative or operational involved in the handling, storage, treatment, transportation and disposal of SMW (Odigie & Siminialayi, 2009). The processes and standard requirements in the health facility are elaborate compared to the less well defined disposal practices in respect of SMW that occurs in the community.

2.5.1 Healthcare facilities

2.5.1.1 Waste generation

Survey data have shown that the total waste quantities generated from a hospital in developed countries is 2 to 7 times that in developing countries owing largely to a heavy dependence on disposable materials (Shinee, Gombojav, Nishimura, Hamajima, & Ito, 2008). Factors associated with medical waste generation in healthcare facilities include: scale of the medical facility (type of facility and number of beds), level of specialization, patient load, level of instrumentation, use of disposal devices, existing regulations and waste management practices (Prüss *et al.*, 1999). Medical waste generation in Africa has been estimated at 282, 447 tons/year from nearly 70,000 healthcare facilities with individual countries producing between 157 and 79,000kg/year (Udofia & Nriagu, 2013). Actual waste surveys can provide more reliable estimates of waste generation, but where this is not possible, WHO recommends generation factors for estimation of the total health care waste (general and hazardous). These are: 0.1 kg/patient per day for primary health care clinic; 1 kg/bed/day for small district hospital; 2 kg/bed/day for general hospital; and 4 kg/bed/day for tertiary level or major teaching hospital, where 10% - 25% may be regarded as hazardous (Prüss *et al.*, 1999). In most healthcare facilities in Africa hazardous waste accounts for between 20% - 72% of the total waste stream, comparably higher than rates reported in advanced countries.

2.5.1.2 Segregation of solid medical waste

Segregation is an important step which helps to reduce the volume of waste treated as infectious waste according to definition. It involves a systematic separation of SMW into categories (Badni & Dharmashree, 2011). The receptacles and bin liners used to collect the different categories of SMW are given color codes for easy identification (Liss *et al.*,

1990). In Ghana, the color coding used for segregation is that prescribed by ALCO: yellow denotes infectious waste; black denotes general waste; and brown denotes pharmaceutical waste (ALCO, 2011). Color coded waste bags, called bin liners, are placed in waste receptacles which should have pedal operated covers (Mastorakis, Bulucea, Oprea, & Dondon, 2011). The bags and receptacles must be labeled boldly with the biohazard symbol to indicate the hazardous nature of the waste (WHO, 2005). Receptacles for sharps should be rigid, leak proof, puncture resistant containers and placed at points of generation for easy disposal (WHO, 2014d). To prevent accidental loss of contents, the lids should be secure and receptacles removed when they are three-quarters full. Occasionally improvised containers may also be used in resource constrained settings (Christiansen & Bisbjerg, 2011). Some types of SMW have been collected separately for recycling such as intravenous bottles (Christiansen & Bisbjerg, 2011).

2.5.1.3 Collection and transport

Collection involves removal of SMW from the generation points at the services areas and on-site transportation to temporary storage points within the premises. Packaging used for collection and on-site transport should have the appropriate color code and symbols and be clearly labeled to indicate the source, type of waste and date generated. Improvised packaging with plastic bins, strong plastic sacks, multiple layer paper sacks lined with plastic or wax-treated cardboard boxes can be used, but should have clear labels (Christiansen & Bisbjerg, 2011). Bagged SMW should not be tampered with and transport routes within facility premises should minimize passage through wards and sterile areas (WHO, 2005, 2014d). Closed trolleys which are separately colored for hazardous and non-hazardous waste, easy to clean, load and unload, and have blunt edges to avoid

damage the waste bags are recommended for on-site transport (Mastorakis *et al.*, 2011; WHO, 2014d). Collection from points of generation should be undertaken according to generation rates. New bags can be stored within the service unit and should immediately replace collected bags.

2.5.1.4 Temporary storage area

A health facility should have a temporary storage area demarcated for hazardous and non-hazardous waste. It should be sited close to the treatment facility, if one exists on-site and avoid food preparation areas. The size of the storage area will be determined by waste generation rate and frequency of collection (WHO, 2014d). To prevent scavenging of medical items, access must be limited to authorized personnel. The storage area should have adequate water for sanitizing the area, adequate drainage and an impervious floor. Good ventilation, lighting and adequate access for off-site transportation are essential. It should be locked when not in use and secured from insects, rodents and stray animals. To avoid putrefaction and stench, stored waste should be removed within 24 hours to treatment points on-site or off-site. Off –site transport should be in standard, enclosed, back loading vehicles (WHO, 2014d).

2.5.1.5 Treatment and final disposal of solid medical waste

In advanced countries, the common methods used for SMW treatment and final disposal include steam sterilization, autoclaving, dry heat, microwaves and incineration (Tudor, Townend, Cheeseman, & Edgar, 2009; Patwary, O'Hare, & Sarker, 2011).The most popular treatment is incineration in developing countries is incineration. It involves a combustion process resulting in the transformation of waste into unrecognizable residue such as ash and gases. The ash is then disposed in a sanitary landfill (Lee, Ellenbecker, & Moure-Ersaso, 2004; Demirbas, 2011). It prevents putrefaction; sterilizes pathological, infectious and sharp wastes; reduces the volume and mass of the waste and recovers heat energy from the combustion process. Methods other than incineration are referred to as alternative treatment technologies. It is expected that such treatment should render waste safe for commitment to the environment (Tudor *et al.*, 2009). In infectious waste, it should be able to reduce the infectious organisms present in the waste to a level that does not require additional precautions to protect an exposed worker or public against infection; pathological waste should not be recognizable; it should alter their original shape or form of clinical waste making it unusable; and destroy the chemical composition of pharmaceutical waste. The solid residue from alternative treatment technologies can be sent to MSW landfills (Tudor *et al.*, 2009). Additionally, in African countries, open burning, burial and open dumping have been reported in countries such as Cameroun, Nigeria, Ethiopia and Zambia (Nkhuwa, Kafula, & Ahmed, 2008; Abah & Ohimain, 2011; Manga *et al.*, 2011; Debere, Gelaye, Alamdo, & Trifa, 2013).

2.5.1.6 Handling and protection for waste workers

The health hazards posed by SMW require safety measures and personal protection to be applied during handling of SMW. According to WHO, the most effective personal protective equipment (PPE) include gloves to limit exposure to potentially infectious body fluids and chemicals (this includes heavy duty gloves for waste workers); face masks to protect from aerosols and particulates from incineration or other forms of burning; thick sole boots to offer protection against sharps waste and coveralls (and aprons) to cover the body (WHO, 2014b). Access to handwashing facilities with soap and water, and alcohol rubs or hand sanitizers are also important for hand hygiene and help prevent the transfer of microbes from contact with SMW.

2.5.2 Households and community

2.5.2.1 Waste composition

Studies on SMW in households and the community are scanty in published literature compared to studies conducted in healthcare facilities. Fewer studies have looked at the entire stream of SMW (Cussiol, Rocha, & Lange, 2006; Alves *et al.*, 2012), while other focus on components of SMW such as pharmaceutical waste (Sasu *et al.*, 2012; Ojeda-Benitez, Aguilar-Virgen, Taboada-Gonzalez, & Cruz-Sotelo, 2013). A study conducted in Brazil showed that SMW generated from home care over a five month period comprised of syringes (38.1%), needles (36.5%), lancets (28.5%) and plaster (31.7%), with a greater number of procedures performed by the individual and/or caregiver (Alves *et al.*, 2012). Only 10% of respondents segregated sharps waste for disposal, while potentially infective waste was not segregated at all (Alves *et al.*, 2012). Cussiol et al. (2006) found that household infectious waste recovered was twice the total amount of general waste and SMW from healthcare facilities (Cussiol *et al.*, 2006). Sharps were

mostly razor blades and made up 0.02% of the collected waste. Non-sharps were toilet paper, diapers and sanitary pads accounting for 5.47% of the wet weight.

Among the components of solid medical waste, pharmaceutical waste is the most commonly reported type of SMW often reported (Delgado, Ojeda-Benitez, & Marquez-Benavides, 2007; Sasu *et al.*, 2012; Ojeda-Benitez *et al.*, 2013). Other items reported in households include insulin needles and syringes, lancets (sharps), cotton swabs, bandages, disposable diapers, examination gloves (potentially infectious waste), parenteral tubing and infusion bags (general plastic waste) and contaminated medication cups from chemotherapy (chemical waste) (Olowokure, Duggal, & Armitage, 2003; Oyewole *et al.*, 2014; Majumdar, Sahoo, Roy & Kamalanthan, 2015). Although anatomical waste is not typically produced from minor sources, placenta is an example of anatomical waste found in areas where home births exist. In some institutional births, the placenta may be returned to patients for burial in keeping with socio-cultural and religious beliefs (Manga *et al.*, 2011).

Sanitary products such as sanitary pads, baby diapers and incontinence pads that originate from healthy individuals are typically considered household waste. However, if they originate from infected persons and are considered to pose a risk to healthy persons, then these are treated as SMW. For instance echoviruses and polioviruses have been recovered from soiled diapers in household waste (Collins & Kennedy, 1992). Since the poliovirus can be transmitted through orofaecal contact, such waste can be deemed to pose a potential health risk and treated as SMW in the circumstance. In some studies, toilet paper, tampons, diapers, wipes and bandages were considered potentially infectious waste because they contain blood, secretions and exudates (Cussiol *et al.*, 2006; Chaves *et al.*, 2013).

2.5.2.2 Disposal practices

Kang'ethe (2008) investigated SMW in a home care program in Botswana and reported that 73% of participants knew people who were secretly burying SMW. This clandestine practice was due to the challenging cost of transporting SMW to the clinics as well as stigma from family and community. The practice was common among the poor who could not afford paraffin to burn the waste and did not have toilets (Kang'ethe, 2008). In another study in Botswana, 41% of respondents in a home based care program reported disposal of human and solid waste materials from caring for persons living with HIV in the bush (Phorano *et al.*, 2005). In this study, participants were concerned about used gloves and condoms which children often played with because they had the semblance of balloons. This was complicated by uncollected waste at household pits and refuse collection points. Households were unable to burn refuse due to lack of firewood and the District Council lacked the capacity to collect the waste from collection points regularly (Phorano *et al.*, 2005). In Kenya, 6% of 13,673 survey participants aged 15-64 years admitted to having seen a needle or syringe near their home or community in the past year indicating inappropriate disposal (Kimani *et al.*, 2014).

The household bin appears to be the major receptacle for various types of SMW. In a facility based study in South Africa, 88% of diabetics discarded used needles directly into household bins (Govender & Ross, 2012). A multi-country study among diabetics indicated that 72.6% of patients performed injections at home, discarding needles, syringes and lancets in the household bin in 46.9% to 52.2% of cases. The use of specific containers was reported in less than 10% of cases (Bouhanick, Hadjadj, & Weekers, 2000). Unlike the US and UK, some countries including the Philippines and Ghana do not have regulations regarding the handling and disposal of sharps in the community

(Quiwa & Jimeno, 2014). The situation is no different with unwanted medication. In Serbia, 85.6% of urban and 74.5% of rural respondents discarded unused medications in the household bin (Kusturica, Sabo, Tomic, Horvat, & Šolak, 2012). Similarly, 75% of respondents in a study in Ghana (Sasu *et al.*, 2012), 76.5% of respondents in a study in Kuwait (Abahussain, Ball, & Matowe, 2006) and all respondents in a study in Nigeria (Auta, Omale, Shalkur, & Abiodun, 2011) dispose of medicines in household bins. Similar disposal practices have also been reported in UK, Lithuania, Malta and Ireland (Bound & Voulvoulis, 2005; Kruopienė & Dvarionienė, 2007).

Backyard burning of trash containing SMW (pharmaceutical waste) has been reported in country side areas of Lithuania and Ghana (Tong *et al.*, 2011; Sasu *et al.*, 2012). In contrast, Sweden has used a take-back system since 1971 where unused medicines are returned through pharmacies to appropriate channels for incineration and final disposal at designated landfills (Persson, Sabelstrom, & Gunnarsson, 2009; Tong *et al.*, 2009). In England, if the waste is deemed to pose a potential health risk, its ultimate disposal is determined by the producer of the waste. If it is generated from a healthcare provider, then the provider is held accountable for its disposal. However, if the patient generated it through self-administered treatment, then the patient becomes responsible for the waste. The patient is expected to segregate it from household waste, seal and label it prior to collection. The local authority has a duty to arrange for collection and disposal of the patient's waste through an authorized waste carrier and inappropriate disposal attracts prosecution (Griffith & Tengnah, 2006).

2.6 Pathogens in solid medical waste

In community settings, exposure to SMW can occur in the household and outside the household. Therefore, the survival of pathogens present in SMW under environmental conditions portends a threat to human health. This is because, unlike in healthcare settings, the handling of SMW both within and outside the household is often undertaken without adequate protection. Studies have reported the presence of pathogens in SMW namely: *Pseudomonas spp.*, *Lactobacillus spp.*, *Staphylococcus spp.*, *Micrococcus spp.*, *Propionibacterium acnes*, *Corynebacterium diptheriae*, *Escherichia coli*, respiratory syncytial virus (RSV), noroviruses and hepatitis viruses (Collins & Kennedy, 1992; Nascimento, Januzzi, Leonel, Silva, & Diniz, 2009; Vieira *et al.*, 2009; Babanyara, Ibrahim, Garba, Bogoro, & Abubakar, 2013; Bultman, Fisher, & Pappagianis, 2013; Hossain *et al.*, 2013). Although viruses may not survive as long as bacteria in SMW (Park *et al.*, 2009), once in the soil, it may be protected from inactivation (Bultman *et al.*, 2013). Viruses survive longer when clustered together, in cooler, wetter, pH neutral soils and these conditions can be found close to the water table. Survival periods from 11 to 180 days in soils have been reported (Bultman *et al.*, 2013). Furthermore, potential desorption of the viruses back into water can occur during heavy rains. Human pathogenic viruses with protective coatings can maintain infectivity in the environment for up to 6 months (Bultman *et al.*, 2013). In hospital settings, the microbial burden in SMW is not considered to be high because they frequently contain antiseptics which do not provide a favorable environment (Blenkharn, 2011). This excludes pathogenic cultures and excreta from infected patients.

On the other hand, in households, SMW is mixed with household waste which has a high microbial burden. A study by Kalnowsky found that household waste was 10 to 100,000

times more contaminated by microbes than SMW and it also contained common nosocomial pathogens such as *Klebsiella* species, *Pseudomonas aeruginosa*, *Enterobacter* species, *Proteus* species and group D streptococci (Kalnowski, Wiegand, & Rüden, 1983; Rutala & Mayhall, 1992). Another study also confirmed that household waste was more commonly contaminated with fecal bacteria (Möse & Reinthaler, 1985; Rutala & Mayhall, 1992). Although household refuse contains more bacteria than SMW, the latter has a wider range of pathogens and risk of infection is greater (Blenkharn, 2011). A report by Collins and Kennedy (1992) described studies on SMW and household waste. In one of the studies, 2% of blood-stained waste in households was reported to be positive for hepatitis viruses (Collins & Kennedy, 1992).This suggests that under favorable environmental conditions, a mixed waste stream containing SMW and household waste constitutes a potential hazard to human and animal health. Some of the pathogens associated with medical waste are shown in Table 2.

Table 2.2 Human pathogens associated with solid medical waste

Pathogens	Disease	Gateway(s)	Characteristics and soil survival time
Clostridium tetani	Tetanus	Spores can enter a wound contaminated with soil, dust, faeces.	Spores are resistant to heat, most antiseptics and chemical agents.
Escherichia coli*	Diarrhoea	Faecoral	Can survive for months in cool, dark nutrient rich soils.
Enterococcus faecalis*	Urinary tract infections, meningitis, wound infections, bacteraemia	Faecoral, often transmitted by hands and fomites	High adaptability, exhibit remarkable resistance to antibiotics.
Pseudomonas* aeruginosa	Osteomyelitis, cellulitis, folliculitis, otitis externa, pneumonia	Ingestion from vegetables; penetrates through breaks in the skin, colonizes hospitalized patients, contaminates wet surfaces and solutions.	Lives in water and soil, can grow between 20°C and 43°C. Survives environmental stresses without a host for >40 days; may survive in some antiseptic solutions.
Mycobacterium tuberculosis*	Tuberculosis	Inhalation of airborne infectious droplet nuclei from prolonged close contact with an infected person, rarely through mucous membrane or non-intact skin.	Resistant to drying and to chemicals. Survives within and outside human host. Resistance to drying facilitates airborne transmission, optimum growth at 37°C, grows slowly.
Salmonella spp.*	Diarrhoea, typhoid fever, paratyphoid fever	Faecoral	Survives in soil for many months in favorable conditions up to 6 weeks
Staphylococcus aureus*	Cellulitis, abscess, sepsis, pneumonia, osteomyelitis, toxic shock syndrome	Colonizes skin and mucosal surfaces, may penetrate through cuts, wounds, insect bites, burns and associated skin diseases	Can survive for long periods on dry, inanimate objects; relatively heat resistant. Survives in almost any environment with a human host.

Pathogens	Disease	Gateway(s)	Characteristics and soil survival time
Streptococcus pyogenes*	Pharyngitis, impetigo, pyoderma, acute glomerulonephritis, rheumatic fever	Person to person spread by respiratory droplets and direct contact via cuts, bites, and abrasions	Frequent in tropical climates, infections can be sub-clinical or asymptomatic.
Hepatitis B	Viral hepatitis, chronic hepatitis, hepatocellular carcinoma	Mucous membrane and non-intact skin exposure to infected human blood and body fluids	Persistent in dry air, can survive for up to 12 months; viable for 10 hours at 60°C, survives exposure to some antiseptics and 70% ethanol.
Hepatitis C	Viral hepatitis	Needle sticks, cuts from sharp objects, blood splashed on mucous membranes	Can survive for up to 5 weeks in the environment: for up to 8 months in needle syringes at room temperature
HIV	Acquired Immunodeficiency syndrome	Mucous membrane and non-intact skin exposure to infected human blood and body fluids, needle sticks	Inactivated at 56°C, survives for up to 15 minutes exposed to 70% alcohol, 3-7 days at ambient temperature

Sources: (Russell & Nash, 2002; Thompson, Boughton, & Dore, 2003; ICRC, 2011; WHO, 2014c) **Identified in solid medical waste samples (Saini et al., 2004; Park et al., 2009; Hossain et al., 2013)*

2.7 Environmental hazards of solid medical waste

Both the disposal and treatment of SMW pose challenges to the environment. Surface disposal of SMW in open refuse dumps constitutes an environmental nuisance. Wind draughts blow litter around the vicinity of the dump and attracts rodents, insects and stray animals (Nemathaga, Maringa, & Chimuka, 2008). Stench also arises from putrefaction of organic waste. To prevent these, the dumps are burnt periodically, which in itself

constitutes a hazard to neighbouring communities because of exposure to contaminants in inhaled smoke during the burning process.

The treatment of SMW in rudimentary incinerators lacking air pollution control equipment generates smoke which contributes to air pollution. Among the emitted air pollutants, of greatest concern are dioxins and furans. Dioxins are persistent organic pollutants (POPs) which can be carried long distances from the emission source and deposited in soil, surface water and food sources resulting in environmental pollution (Hossain, Santhanam, Norulaini, & Omar, 2011). High concentrations of these toxic emissions are generated as a result of frequent start up and shut downs during incineration; poor combustion control and differences in the waste feed composition (Shareefdeen, 2012). In addition, greenhouse gases such as carbon dioxide and nitrogen oxides; steam, and halogenic acids are generated which contribute to air pollution, global warming and acid rain (Prüss *et al.*, 1999).

Studies have shown that exhaust gases and bottom ash from incineration of SMW may contain viable microorganisms and heavy metals (Blenkharn & Oakland, 1989; Dugenest, Casabianca, & Grenier-Loustalot, 1999; Singh & Prakash, 2007; Hossain *et al.*, 2011). Many of the heavy metals are toxic at low concentration while some may bio-accumulate and persist in the environment (Singh & Prakash, 2007). Manfredi and Christensen (2009) demonstrated that up to 98.7 – 99.9% of heavy metals from a SMW landfill were still present when modeled for a 100-year period and compared with the original content of the waste (Manfredi & Christensen, 2009).

In some developing countries, SMW is dumped in open spaces or landfilled with or without treatment (Longe & Williams, 2006; Nkhuwa *et al.*, 2008; Debere *et al.*, 2013).

As waste accumulates, moisture percolates through the landfill, and carries with it dissolved and suspended materials generating leachate (EPA, 2002c; Christensen *et al.*, 2011; Keelson, 2014). Microbes including *Staphylococcus aureus, Enterococcus spp, Salmonella spp*., and other enterobacteriaceae have been reported in leachate several weeks following the deposit of SMW in landfills (Blenkharn, 2006). Consequently, SMW is restricted in landfills in many countries except it has been disinfected from infectious organisms (Hossain *et al.*, 2011). Evidence shows that most bacterial and viral pathogens are eliminated from wastes and leachates in the first 8-12 weeks after disposal in the landfill, but repeated deposits perpetuates their presence in leachate (Blenkharn, 2011). Dissolved minerals, salts and halogenated organic compounds have also been reported in leachate (Slack, Gronow and Voulvoulis, 2005; Hossain et al. 2011). For instance, polycyclic aromatic hydrocarbons, heavy metals and nutrients have been reported in leachate samples from abandoned dump sites at Oblogo in Ga South Municipality, Ghana (Keelson, 2014).

In a landfill, methane is one of the gases produced from anerobic decomposition of waste. It is less easily broken down and a potent greenhouse gas (Hossain *et al.*, 2011). Leakage of gas into the environment can lead to fire explosions, odours and damage to the vegetation. Most of the gas is generated within the first 30 years of disposal (Christensen *et al.*, 2011). In well-engineered landfills, top covers, gas wells, flares and engines/turbines are used to control gas and recover energy. This expensive technology is not widely available in most developing countries.

Environmental hazards associated with pharmaceuticals in SMW include destruction of bacteria necessary for sewage treatment, adverse effects on aquatic and terrestrial life and air pollution when medicines are burnt at low temperature (Vellinga *et al.*, 2014; Vogler

S., 2014). For example, springtails (*Folsomia candida*) play a role in natural decomposition processes in soil and recycling of nutrients. A dose-dependent reduction in survival and reproduction was reported following a 4-week exposure to diclofenac, a commonly used non-steroidal anti-inflammatory analgesic (Chen, den Braver, van Gestel, van Straalen, & Roelofs, 2015).

2.8 Health hazards of solid medical waste

Sharp inflicted injuries are the most commonly cited in published literature. These create a portal of entry for human pathogens, especially blood borne viruses. A recent analysis of 21 studies on community acquired needle stick injuries (CANSIs) and their outcome(s) has been reported by Osowicki and Curtis (2014). They document six cases of blood borne virus transmission attributed to CANSIs in Spain, Australia and Georgia. Among these cases was a 4 year old child infected from a needle discarded by a neighbor co-infected with HBV and HIV (García-Algar & Vall, 1997). The other five cases were in adults. In three of the five adult cases, cleaning staff were involved and in one case a patient's relative. All patients developed hepatitis. Among the 3 adults who developed HCV, HCV antibody was detected from 3 months post exposure. No cases of HIV transmission were documented (Osowiki & Curtis, 2014). In most of the infected cases, delayed or absent immunoprophylaxis appears to have enhanced vulnerability. In developing countries, those who are most at risk of percutaneous injury from sharps include scavengers and informal waste carriers who often work with minimal or no protection (Figure 1), exposing them to injury at the extremities (Blenkharn & Odd, 2008; Oteng-Ababio, 2014).

A female scavenger at an open dump site working with bare hands

An informal waste carrier emptying waste with bare hands

Figure 2.1 Persons at risk of percutaneous injury

Some studies reporting needlestick injuries in the community are summarized in Table 3. In some of these studies, injuries were sustained while handling trash (Wyatt, Robertson, & Scobie, 1994; Papenburg *et al.*, 2008). In Russia, small pox in a group of children was linked to inactivated vaccines discarded in the environment. Eight children who were exposed to inactivated smallpox vaccine vials in a playground, were hospitalized later with high fever (39°C - 40°C) and skin eruptions (Salkin & Kennedy, 2001). A study in Japan showed that 34% of municipalities reported accidents from collection and transportation of SMW generated in home health care, most of which were needle sticks (Miyazaki, Imatoh, & Une, 2007).

Individuals with chronic conditions such as diabetes mellitus generate sharp waste which is often discarded in household bins. In a study in South Staffordshire, England, 30% of diabetic patients discarded lancets directly into the bin, while 12% discarded needles directly (Olowokure, Duggal, & Armitage, 2003). In Mauritius, 79% of 85 persons who used diabetic lancets, discarded them in the household bin (Subratty & Nathire, 2005). Pathogenic viruses like HBV or HCV can be recovered from nearly 4.7% of discarded

needles owing to their ability to survive for several weeks (Blenkharn, 2011). The healthcare costs for needlestick injuries strains household finances. The median cost of an emergency department evaluation and treatment for a community acquired needlestick in the United States was estimated at $575, ranging from $415 (without physician consultation) to $3371. This was higher if a referral was made to an infectious disease physician (Jason, 2013).

The release of dioxins from uncontrolled combustion of high chlorine content waste poses a significant threat to public health as dioxins are known carcinogens (specifically TCDD) and has been linked with prenatal mortality, immunosuppression, neurotoxicity, reproductive disorders, liver damage, chloracne, and hyperpigmentation. It is also lethal to wildlife even in small doses. Being lipophilic, it accumulates in animal fat and can be consumed through the food chain (Kulkarni *et al.*, 2011; Schecter, Colacino, & Birnbaum, 2011). Many disposable plastics and sanitary products are made from chlorinated products. Medical devices, tubing and some plastic consumer products often contain endocrine disrupting chemicals (EDCs) which are organic compounds which interfere with the natural balance of the hormonal system resulting in endocrine abnormalities (Bain, 2010). Exposure in humans has been associated with abnormalities in reproductive health, thyroid function, obesity and diabetes mellitus. EDCs have also been associated with breast and prostate cancer (Majumdar, Sahoo, Roy, & Kamalanathan, 2015).

Toxic chemicals and heavy metals in SMW deposited in landfills can be absorbed through the food chain and consumed by humans. Heavy metal toxicity can lead to kidney damage, skeletal damage, prostate cancer (cadmium); tremor, restlessness, sleep disturbance, depression, personality changes, kidney and lung damage paresthesia and numbness in the extremities, coordination difficulties, constricted visual field, death

(mercury) (Järup, 2003). Cadmium commonly occurs in polyvinylchloride products and rechargeable nickel-cadmium batteries. Mercury has been used in thermometers, for treatment of syphilis, as diuretics and amalgam used for tooth filling. A recent study of water quality in an unsaturated zone near a dumpsite in Ghana which received untreated industrial and hospital wastes demonstrated high concentrations of organic and trace metals indicating a possible threat to ground water quality (Denutsui *et al.*, 2012). Although these were not directly attributed to SMW, its contribution in mixed waste streams cannot be disregarded.

Waste and leachate is one of the known ways that active pharmaceutical compounds enter the environment (Tong *et al.*, 2011). Although concentrations of individual compounds are often below levels considered harmful to human health or to have detectable impact in the environment, concerns exist about the impact of chronic, low level exposure to pharmaceuticals in the environment. Yet another area of concern is the interaction between traces of multiple pharmaceuticals (Vellinga *et al.*, 2014). If there is no collection of leachate, then it may contaminate surface and ground water through run-off or percolation through soil. Antibiotics that gain entry into the environment induce selection pressure for resistant bacteria which can be introduced to exposed persons and animals (Larsson, 2014). This often results in drug resistant community acquired infections which are both difficult and expensive to treat. A study in Brazil demonstrated antibiotic resistance in Staphylococcal strains recovered from leachate of HCW in an untreated sanitary landfill. Resistance was demonstrated to penicillin, erythromycin, azithromycin and oxacillin often used as conventional antibiotic therapy (Nascimento, da Silva, Ferreira-Machado, & Diniz, 2015). In landfills where co-disposal of SMW and HSW occur, one can expect a similar phenomenon since pharmaceuticals are common in

household waste. Furthermore, medicines in whole dosage forms or with intact packaging may be retrieved from recently disposed SMW at refuse dumps and diverted for resale to unsuspecting public by scavengers.

Table 2.3 Studies on injury from solid medical waste in the community

Authors	Country	Study design	Study units	Key findings
(O'Leary & Green, 2003)	Australia	Retrospective analysis	120 non-HCW case notes at ED (16 cleaners inclusive)	25 children (21%) were <16 years, median age was 6 years. 68% cases from exposure to discarded syringes (located in toilets) 7/16 cleaners injured while cleaning toilets. 4/24 non-accidental cases were children who stabbed playmates with used needles. Majority of patients received prophylaxis and referred. 6-months post exposure serology was negative for HBV, HCV and HIV (n=10).
(de Waal, Rabie, Bester, & Cotton, 2006)	South Africa	Longitudinal study	54 children at ED	Exposure to needles and syringes dumped in soccer field 23 (43%) children played with discarded needles giving injections and threw needles at each other. Baseline serology: all HIV (-); 6 patients (11%) were HBsAg (+) 81% given HIV PEP; no sero-conversion to HBV, HCV and HIV occurred at 6 months
(Jason, 2013)	United States	Retrospective analysis	51 CA-NSI records treated at US ED (2001-2008)	Annual rate of 0.7 per 100, 000 US citizens Estimated maximum annual medical cost of ED-treated CA-NSIs was $9.8 million or $0.03 per citizen. 56% of CA-NSIs occurred in women; insulin syringes involved in 17% of CA-NSIs. Those aged <10 years had a rate of 1.3 per 100, 000 US citizens. 3records noted injury occurred while emptying a garbage bag or handling a plastic bag; other places were hotel room, beach, park and alley. In one record the needle belonged to a neighbor.
(Wyatt *et al.*, 1994)	UK	Retrospective analysis	64 children at 2 EDs between 1987-1992	A rate of 1 in 1600 new attendances. Mean age 6years 10 children (16%) had sustained needlestick injuries pretending to be intravenous drug users. Only 1 case involved the dustbin at home. 36 children received HBV protection, none received HIV PEP. None of the 3 children were followed up sero-converted.

Table 2.3 contd.

Authors	Country	Study design	Study units	Key findings
(Slinger, Mackenzie, & Tepper, 2000)	Canada	Retrospective analysis	116 case records of children at EDs 1991-1996	19.3 CA-NSIs per year; 73% male; median age 6.6 years Parks were the most common site of injury (21%) and yards adjacent to the child's home or another home. Outdoor injuries were more common in children aged 5+years HBV protection given in 78% of cases; none received HIV PEP. Follow up results were available for HIV (42%), HBV (38%) and HCV (18%). None tested (+).
(Papenburg *et al.*, 2008)	Canada	Retrospective analysis and prospective study	274 children at 2 hospitals 1988-2006 and 1995-2006	64.2% males; median age was 7.9 years Most injuries occurred in streets (29%) and parks (24%). 213 (78%) received HBV protection; 69 (25%) completed HIV PEP. Serology was performed for HIV 189 (69%), HBV 167 (61%) and HCV 159 (58%). None tested (+).
(Butsashvili, Kamkamidze, Kajaia, Kandelaki, & Zhorzholadze, 2011)	Georgia	Retrospective analysis	Medical records, 2002-2007: 46 eligible cases	25 (54%) were children with accidental exposure in the street/yard 8 (15%) participants stepped on a needle at the sea shore. 3 adults were injured from handling trash. No case of HIV or HCV was documented. One case was HBV (+). She was not vaccinated against HBV and refused vaccination after injury.
(Res & Bowden, 2011)	Australia	Case report	1 cleaner Period not indicated	History of previous Hepatitis B vaccination, but details uncertain. Baseline serology for HIV, Hepatitis B (surface antigen and surface antibody) and Hepatitis C were all negative. Delayed 1st dose of Hepatitis B vaccination till day 46 (+) for Hep. B surface antigen and 'e' antigen by day 63 Hep. B surface antibody and 'e' antibody detected by day 225 Antibodies to HIV and Hepatitis C not detected.

Table 2.3 contd.

Authors	Country	Study design	Study units	Key findings
(Russell & Nash, 2002)	Australia	Prospective study	50 children	64% males; median age was 6.9 years No sero-conversions to HIV, HBV or HCV at 3 months follow up. No HIV PEP was given. HBV vaccine was given to 41 (82%); none immune cases (HBV) were 42 (84%). Injuries were sustained in a park (30%), in the street (18%), at the beach (6%) at the beach and in a car park (5%).
(Makwana & Riordan, 2005)	UK	Prospective study	53 children referred to paediatric infectious disease clinic 1995-2003	63% male; median age 8.4 years Most common mechanism of injury was playing with a needle found in a public place. At home, injury was caused by needles used use for testing measuring blood sugar. Twenty five patients had HBV vaccine and post exposure serology at 6 months. None tested (+) to HBV, HCV and HIV. 28 (53%) lost to follow up.
(Celenza *et al.*, 2011)	Australia	Retrospective analysis	96 ED CANSI records in 2 tertiary hospitals, 2001-2005: 39 eligible cases	53.9% males; median age 31 years Occurred mostly in security personnel (25.6%) and cleaners (23.1%). 31 were non-immune to HBV; only 4 received PEP. Of the 27 who had baseline HIV serology, all tested (-) to HIV; 6 received HIV PEP. Location of injury described for 36 cases: 19 (52.8%) in public places – street, hospital grounds, hotels/shops, park, and public transport. 17 cases did not occur in public places, of these 41.2% occurred while emptying bins.

HCW=healthcare worker, ED= Emergency Department, HBV=Hepatitis B infection, HCV=Hepatitis C infection, HIV=Human Immunodeficiency Virus infection, PEP=post exposure prophylaxis

CHAPTER THREE

3 METHODS

3.1 Background to the study area

3.1.1 District Profile

Ga South Municipal Assembly (GSMA) was created in 2009 from the former Ga district which comprised of what is now known as Ga South and Ga West District Assemblies in south western Accra (Figure 2). There are over 500 demographic enumeration areas (EAs) including 35 urban towns and hundreds of satellite communities and hamlets occupying a land area of approximately 413.76 km^2 (MPCU Draft Profile, MTDP). According to the Ghana Statistical Services, Ga South Municipality has a population of 411,377 including 201, 222 males. There are 100,701 households with an average household size of 4 (GSS, 2014, unpublished document).

The municipal assembly is 90% urban having towns with populations between 5,000 and 20,000. The predominant ethnic group is the Ga ethnic group, followed by Akan and Ewes. However, Twi is widely spoken. Majority of the settlements southwards are unplanned high density residential areas clustering close to commerce and industries along the main Mallam-Kasoa highway. Estate development and commerce are gradually displacing the earlier agro-based economy. Apart from the highway and a rehabilitated trunk road along Krobitey, most of the roads are unpaved.

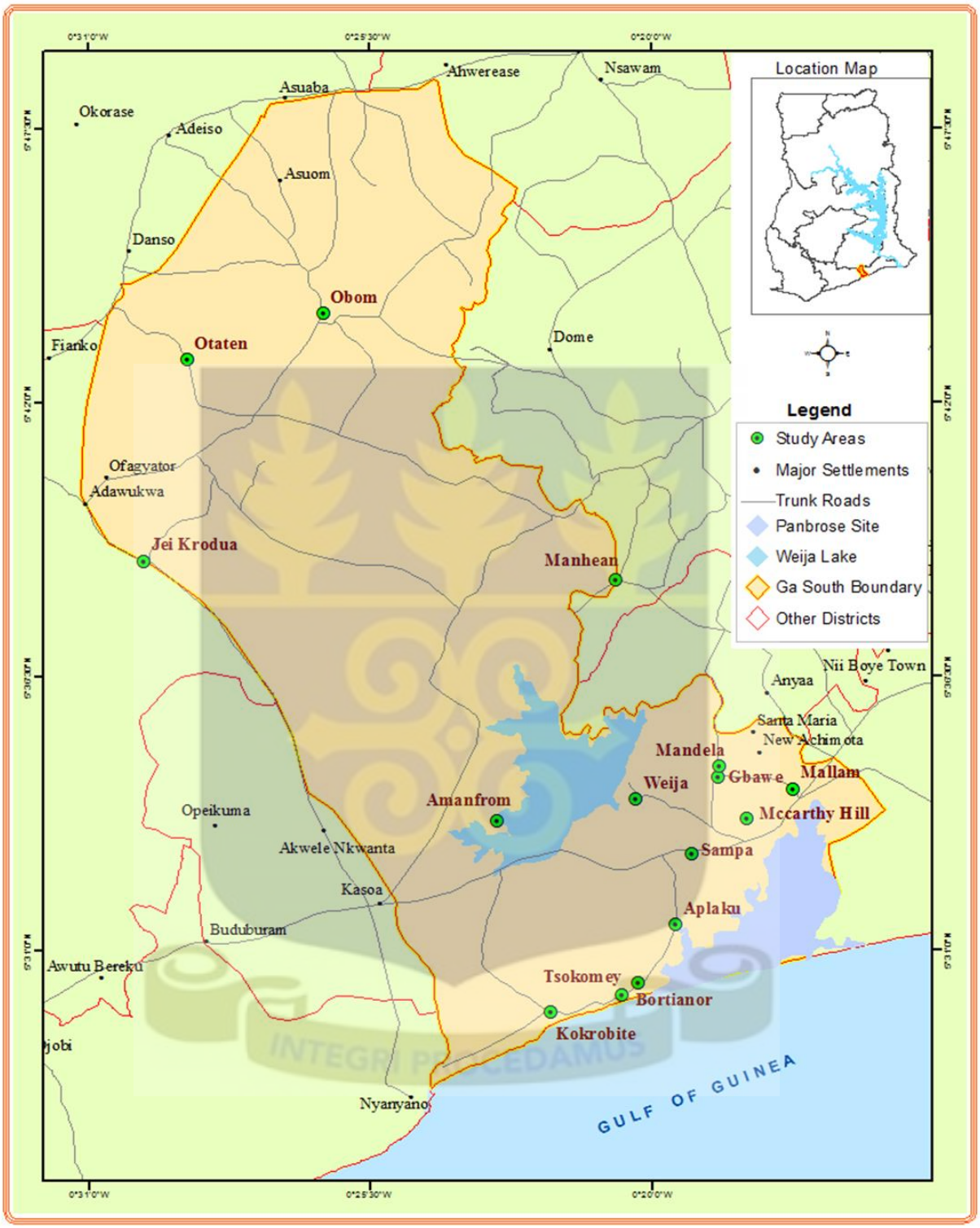


Figure 3.1 Map of Ga South Municipal Assembly

Source: Ghana Statistical Services, 2014

3.1.2 Status of solid waste management in Ga South Municipal Assembly

The estimated total daily waste generation in GSMA is 19,425kg or 19.425 tonnes based on a per capita generation of 0.4kg/capita/day (Ga South Municipal First Quarter Report on Waste Management, 2014, unpublished document). Six private waste companies were contracted by the Municipal Assembly to provide door to door refuse collection according to allotted zones. Households were registered and provided bins by the respective contractors at an average rate of GHC5 ($1.65). Collection services were provided weekly at rates set by the Assembly. A maximum limit of GHC 20 ($6.6) was set for refuse collection at residential premises and GHC25 ($8.3) for commercial premises. In addition, one of the contractors was assigned to collect waste from the centralized containers provided to indigenous poorly planned residential areas around Mallam Junction (3), McCarthy Down (1), Gbawe (3), Weija/Oblogo (4), Amanfrom (2), and Galilea (3). Those who use the centralized bins were expected to pay subsidized rates ranging from 20-50 pesewas ($0.06 – $0.16) which also generates revenue for the Municipal Assembly.

Challenges with solid waste management in the municipal included unplanned areas, slow adoption of the door to door waste collection system, poor road network, flooding and poor surface accessibility, littering and indiscriminate dumping of refuse (MPCU Draft Profile, MTDP). Aside from designated dump sites at Abokobi, Kpone and Adjenkotoku, illegal refuse heaps exist within the community notably at Bortianor, Tsokomey junction and Oshiyie. At the time of writing only one site at Kpone, Tema was functional; the other sites had been sealed off. However, a new scientifically engineered landfill site was introduced at Sonitra Pit, Bulemin which includes a recycling plant as part of a resource recovery system. Measures have also been taken to reclaim old landfill sites in the

municipal (at Mallam, Oblogo and Sabah). GSMA has benefitted from externally funded projects on waste management. Under the Second Urban Environmental Sanitation Project, four major old refuse dump sites within the municipality were capped (funded by the World Bank), while the Ghana Netherlands WASH project supported the capping of the Sarbah landfill site.

3.1.3 Study participants

The participant groups selected as sources of SMW in the community were the following:

Traditional birth attendants (TBAs) and chemical shop vendors (CSVs) play supportive roles in healthcare. A TBA has been described as a person who assists a woman with pregnancy, childbirth, and newborn care and who acquired her skills herself or by working with other TBAs (WHO, 1992). TBAs have been associated with maternity care, particularly in rural areas of countries including Indonesia, Tanzania, Zambia and Ghana (Titaley, Hunter, Dibley, & Heywood, 2010; Phiri, Fylkesnes, Ruano, & Moland, 2014; Aborigo, Allotey, & Reidpath, 2015; Mahiti, Kiwara, Mbekenga, Hurtig, & Goicolea, 2015). Currently, the continuum of care approach recognizes their role in supportive care for pregnant women and conduct of normal deliveries, but not in handling complications (Mahiti *et al.*, 2015). They handle placentae which is anatomical waste.

Chemical shop vendors are persons licensed by the Pharmacy Council to sell over the counter medicines. They have a minimum level of secondary education and are a first point of contact for healthcare in many communities. Their shops outnumber pharmacies five to one in Ghana and are preferred for their shorter waiting times, longer business hours, friendly disposition and availability of commodities (Letbetkin E., 2014). They are occasionally coopted into health programs due to their accessibility to the public and have

been used successfully under the Mobilized Against Malaria program to increase the use of artemisinin-combined therapy and appropriate referral of malaria cases in Ghana (Letbetkin E., 2014).They generate pharmaceutical waste.

TBAs and CSVs were purposively selected with the criteria that the individual had a minimum age of 18 years and either owned and/or worked in a chemical shop within the study area in the case of a CSV, or offered supportive pregnancy care and normal delivery services in a community within the study area in the case of a TBA.

Households are one of the minor sources of SMW in the community (WHO, 2014a). As more healthcare activities are undertaken in the household, members of the family play additional roles of caregiving which generates SMW (Kang'ethe, 2008). On the other hand, where care is provided by a healthcare practitioner, household members can play a supportive role and may share the responsibility of discarding some of SMW generated if it is not retrieved by the practitioner. In the study, an eligible household was defined as a group of persons who may or may not be related to one another but live together, share common housekeeping arrangements and consented to participate in the study and there is at least one adult aged 18 or older, who was informed about the household or had been resident for at least one month prior to the study period.

In Ghana, private enterprises now collect more than 60% of solid waste in most places (Oduro-Kwarteng & van Dijk, 2013). Service provision in form of house to house collection and centralized container services is offered by accredited private waste service providers through contractual agreement with a municipal assembly (Obirih-Opareh & Post, 2002). In order to complement information from households on waste collection, key informants at five accredited service providers were interviewed. Contact was

facilitated by the GSMA Waste Management Department. The informants were either directly involved with operations in their companies or conversant with them.

3.2 Study design and organization

3.2.1 Quantitative methods

3.2.1.1 Waste stream analysis

3.2.1.1.1 Sample size and selection of households

Similar to previous studies, the household was the sampling unit (Qu *et al.*, 2009; Salam, Hossain, Das, Wahab, & Hossain, 2012; Monney, Tiimub, & Bagah, 2013). Igbinomwanhia (2011) suggests a minimum of 50 sampling units (households) per 500 households, giving a ratio of 1:10 (Igbinomwanhia, 2011). Therefore, sixty households were selected from a sampling frame of 600 households involved in a questionnaire survey conducted earlier. The sampling frame comprised of twenty households each in 30 enumeration areas. From these, two out of twenty households in each enumeration area were selected by ballot to participate in the household waste stream analysis. Therefore, sixty households were selected from a sampling frame of the 600 households involved in a questionnaire survey conducted earlier. The database comprised of 30 enumeration areas each with a list of twenty households. From these, two out of twenty households in each enumeration area were selected by ballot to participate in the household waste stream analysis. Once a household was selected, a member of the household was informed about the selection of the household for waste collection and waste stream analysis.

3.2.1.1.2 Labelling and distribution of household bin bags and bins

Identification numbers were assigned to the households using their location (given two digit numbers from 01-30) and their serial numbers in an electronic database (a two digit number from 01-20 in each location). For instance, the third household in the first location was assigned '01/03'. The numbers were used to label black household bin bags with dimensions: 725 x 975mm or 29" x 39" and an 80-litre plastic household bin which were distributed one week prior to waste collection. Each selected household received one bin and two bin bags and a household member was informed about the time of waste collection (between 6am to 8am). Households were requested to store their waste (as routinely done) in the bin bags and receptacles provided and keep them covered to prevent stray animals from tampering with the waste.

3.2.1.1.3 Household waste collection

Data collection took place in 2 phases that lasted five weeks: two weeks in October, 2014 (wet season); and three weeks from December, 2014 to January, 2015 (dry season). A door to door collection was conducted in the sample households (Figure 3.2). A pilot waste stream analysis conducted in nine households (excluded from sample population) indicated that daily collection of household waste did not yield meaningful quantities of SMW; therefore household waste was collected weekly. Each bagged waste represented a week's collection of waste for a household. New bin bags were provided during waste collection for the following week's collection. Retrieved bin bags with content were transported from the households to a location appointed for waste segregation.

3.2.1.1.4 Manual sorting of household waste

To compute the amount of solid waste generated in a household daily the unsorted contents of the bagged waste was weighed. The weight of the container was deducted

from the measurement to obtain the weight of unsorted household waste. Where the waste exceeded the volume of the container, successive weights were added to obtain the total weight of the waste. Manual segregation was undertaken by field staff to obtain the percentage composition of specific waste fractions in household waste. This was carried out on a table measuring 4 metres by 2 metres, overlaid with a plastic wire mesh on a clean plastic sheet. The waste fractions of interest, namely medicinal waste, sharp waste and offensive waste, were manually sorted and placed into smaller receptacles (a 10-litre plastic container for heavier offensive waste and a 1.5–litre container for smaller items (medicinal waste, sharps, bandages, cotton wool), each with pre-determined weights (Figure 3.3). After the hand-segregated items were removed, the wire mesh and plastic sheet was checked for loose tablets and blades which were added to the corresponding waste fractions and weighed. The waste measurements for each waste fraction was estimated on the basis of wet waste (w/w) in kilograms (kg). Bin weights were deducted from the measured weight of the components. Each measured weight represented the amount of the respective waste fraction (medicinal waste, sharp waste and offensive waste) collected from a household in one week. This procedure was repeated for all the waste bags collected each day. Equipment used during the waste stream analysis has been listed in Appendix 11.

3.2.1.1.5 Weighing and recording

All measurements were taken and recorded using a scale GBK 120 with a precision of 0.005kg (Adam Equipment Company, 2013) for total household solid waste and a digital scale with a capacity of 5kg and a precision of 0.001kg was used for household SMW. At the onset of the survey both scales were checked against standard weights of 5 Newtons (0.5099 kilograms). Thereafter, both scales were standardized between measurements.

An electronic database was created to contain records of all wet waste measurements from the waste stream analysis using the Statistical Package for Social Sciences (SPSS) version 22. The variables in the electronic database are listed below:

i. HSW weight measurements for each week (HSW1, HSW2 etc.)
ii. Medicinal waste weight measurements for each week (Medicinal1, Medicinal2, etc.)
iii. Sharp waste weight measurements for each week (Sharp1, Sharp2, etc.)
iv. SMW weight measurements for each week (the sum of ii. and iii. for each household labelled TSMW1, TSMW2 etc.)
v. Offensive waste weight measurements for each week (OFW1, OFW2, etc.)

The numbers following each label in parenthesis denotes the week in which the waste fraction was collected. Therefore 'Medicinal1' denotes the weight measurement of medicinal waste collected in the first week. The same applied to other waste fractions.

3.2.1.2 Waste survey

A waste survey was conducted using a 32-item questionnaire (Appendix 7) to examine socio-demographic characteristics and health related factors associated with generation of SMW. The questionnaires were administered to one respondent in all the households involved in the waste stream analysis. As the waste surveys (October, 2014 and January, 2015) and the household questionnaire survey (mid-April to June, 2014) took place at different times, an eligible respondent was selected from those present in the household during the waste survey. BaSocio-demographic characteristics investigated included household income and educational status. Earlier studies on household waste have noted that characteristics such as family and household size (Sajauddin, Huda, & Hoque, 2008;

Qu *et al.*, 2009; Salam *et al.*, 2012), educational status (Qu *et al.*, 2009; Monavari, Omrani, Karbassi, & Raof, 2012) and household income (Dangi, Urynowicz, Gerow, & Thapa, 2008; Sajauddin *et al.*, 2008; Qu *et al.*, 2009; Monavari *et al.*, 2012; Salam *et al.*, 2012) influence household waste generation. The number of bedrooms was obtained to compute room occupancy from household size. Since SMW is a component of HSW, these factors were also assumed to be relevant for SMW (Gu *et al.*, 2014). Health related factors investigated: the presence of medical complaints (present/absent), presence of children aged below 5 years in household (yes/no) and National Health Insurance Scheme (NHIS) membership status (registered/not registered). These factors were assumed to influence generation of SMW by facilitating access to (NHIS) or creating a need for (medical complaints, children aged under five years) healthcare services (Taffa & Chepngeno, 2005; Nonvignon *et al.*, 2010; Brugiavini & Pace, 2011; Blanchet, Fink, & Osei-Akoto, 2012). Health service utilization, on outpatient basis, often results in prescriptions which are administered in the household provided that the regimen does not require admission or directly observed treatment at the health facility. These left over medicines when discarded contribute to SMW, apart from waste materials from medical procedures conducted and from self-medication within the household (Subratty & Nathire, 2005; Miyazaki *et al.*, 2007; Oyewole, Sapp, Wilson, & Oyewole, 2014). Therefore these variables and the corresponding data were added to the electronic database containing the wet waste weight measurements from households.

3.2.1.3 Household questionnaire survey on disposal options and harm from SMW

To address objectives 2 and 3, we conducted a cross sectional study to investigate disposal options and harm associated with SMW in households. As the previous studies that reported harm associated with SMW in the study area were unavailable, we based the

sample size on the following assumptions: (i) a sample size that would allow for maximum variability in the outcome (proportion of households reporting harm associated with SMW), (ii) the need to allow for under-reporting, (iii) to ensure the inclusion of households that generate SMW and (iv) practical considerations (available funds, transport, logistics, team capacity). Based on these assumptions, a sample of six hundred households was computed using the expression, $n=Z^2\alpha pq/L^2$ where the proportion of households reporting harm due to SMW, *p* was assumed to be 50% (Watson, 2001), allowable error, *L* was 5%, *q* being *1-p*, and *Zα* being the standard normal deviate with a value of 1.96 (Dohoo, Martin, & Stryhn, 2012). A minimum sample of 384 households was required to achieve the objectives. Allowing for a non-response rate of 54% based on a previous study, this was rounded up to 600 households (Haiduven & Ferrol, 2004). In the first stage of sampling, systematic sampling with probability proportional to estimated size was used to select 30 enumeration areas from a list of enumeration areas for GSMA provided by Ghana Statistical Services (GSS). This was aimed at achieveing a reasonable coverage of the study area taking into consideration the heterogenous nature of household waste and related household practices. In the second stage of sampling, the aim was to select 20 households in each enumeration area. To achieve this a central location in each enumeration area was identified with assistance from an officer from the Public Health Department of the Municipal Assembly, from which a random direction was selected by one of the field staff spinning a bottle. Given the large size of the enumeration areas, the first household was selected by ballot from the first 20 households in the directional line. Subsequent households were selected by proximity and eligibility criteria. In each household, one eligible respondent was selected for the interview. Where

there were more than two eligible respondents in a household, the respondent for the interview was selected by ballot.

Data collection lasted from mid-April to the end of June 2014. Questionnaires were administered by trained field staff, often in the local dialect, after obtaining informed consent from the head of the household or a representative. Questionnaire administration took place during the day, mainly in the evenings (4pm – 6pm) when families were at home and lasted an average of 30 minutes for each respondent. The questionnaire was designed based on research objectives and field tested in five households in English and the local dialect for clarity and consistency of meaning. It was also used to test the potential responses to the questionnaire. Minor adjustments were made based on feedback (for the detailed questionnaire, see Appendix 4). In summary, it contained 4 sets of questions pertaining to:

i. Socio-demographic characteristics (16 items)
ii. Health system contact and waste disposal options for SMW (24 items)
iii. Exposure/accidents from solid medical waste (9 items)
iv. Health conditions and nuisance associated with SMW (6 items)

Respondents were asked the waste disposal options for the following: medicines, sharps, blood soaked items, soiled items and disposables. SMW comprised of sharps and medicines. Waste considered as offensive (and potentially infectious) was divided into 'blood soaked items', 'soiled items' and 'disposable items' for easier understanding of the respondents. 'Blood soaked items' included sanitary waste and items visibly stained with blood. 'Soiled items' were items like wound dressings, plaster or articles contaminated with pus. 'Disposable items' generally referred to condoms, diapers and incontinence pads, and pregnancy test kits. Options for disposal included: 'In the toilet or

sink', 'Give out to other people', 'Drop them in the dustbin (wrapped/in container)', 'Drop them in the dustbin (not wrapped/in container)', 'Bury them', 'Burn them', 'Drop them in any bin by the road side', 'Discarded in a pit latrine', 'Discarded in a nearby bush' and 'Others'.

There were three open ended questions. The first of these required the respondent to list diseases or conditions associated with SMW. The second question required the diseases to be listed in order of importance from the most to the least important. The last of the questions required respondents to list of SMW considered a problem in the community. Apart from questions requiring numbers (household size, number of children, number of people harmed at home and in the community), the rest of the questions were close ended questions. Regarding harm from SMW, the respondent was also required to state what item was involved, what harm was done and in the community, where the event of harm occurred.

Household waste collection for waste stream analysis

Double bagging household waste for transportation to sorting venue.

A practical demonstration of manual waste sorting with one of the field staff.

Identification of types of solid medical waste manually sorted from household waste

Manual sorting of household waste

Manual sorting of household waste

Figure 3.2 Waste collection and sorting for composition analysis

3.2.2 Qualitative data collection (Interviews and FGDs)

3.2.2.1 Interviews with waste management companies in the municipality

Informal interviews were conducted with key informants at five private waste companies purposively selected on the basis of service provision within the study area. Verbal consent to conduct the interviews was facilitated through the Waste Management Department of the GSMA. The responsible officer from the GSMA also accompanied the researcher during the interviews with each key informant. Information was obtained regarding waste collection in the municipal assembly, as well as their views about separate collection of SMW. Informants were allowed to discuss freely and occasionally the researcher probed for clarity or details. The subject of SMW was introduced and informants were asked if and how a separate collection could be undertaken. All discussions were recorded as field notes. Before concluding each interview, the key points were summarized and shared with the informant for affirmation. A phone interview was held with a management staff of one company to obtain information regarding the status of a prospective waste treatment plant for SMW in Accra metropolis.

3.2.2.2 Interviews with TBAs and CSVs

Face to face interviews were held with 3 TBAs and 3 CSVs in September, 2014. Questionnaires and field notes were used to document information regarding service provision and disposal practices related to SMW generated from services provided. CSVs were interviewed early in the day before commencing business and when clients were not in the shop. TBAs were interviewed in their personal homes early in the morning by field staff. Each interview lasted 30 minutes on the average.

In January 2015, 7 TBAs and 5 CSVs were interviewed individually using questionnaires prior to participation in FGDs (see section 3.4.3.2). Two of 5 CSVs contacted during field visits were interviewed in their shops by the PI when they indicated that they would be unable to attend the FGD, the others were interviewed at the venue for the FGDs. Two separate, but similarly worded questionnaires (Appendix 5 and Appendix 6) were used to interview the CSVs and TBAs. Consent forms were administered prior to the interviews.

3.2.2.3 Poster development

A poster was conceptualized (by the researcher) and designed with assistance from the Health Promotion Unit of the Ministry of Health and field tested. A hand bill was also adapted and developed as a potential template for the reading public. The poster was given to trained field staff to share with four community members and record their interpretation of the poster without explaining it to them and their comments after explaining it to them. The comments were recorded and reviewed by the researcher. As a second step, the researcher presented the poster to key stakeholders at the Ministry of Health, Ghana Health Service, and peers at the University of Ghana School of Medicine and Dentistry. The comments led to modification of the poster. It was used during the FGDs to improve participants' understanding of SMW by making reference to the pictures.

3.2.2.4 Focus group discussions with members of households

To address objective 2, 2 FGDs were conducted with gender based groups comprising 9 male and 5 female household members. The sample size was based on an acceptable range of 3 – 12 participants (Tracy, 2013). Participants were originally selected by extending invitations to adult household members (one male and one female) during the household survey, in randomly selected locations. The date and venue were fixed in agreement with the potential participants, after obtaining informed consent. Reminders were made by

phone calls in the week preceding the FGDs. However, some of the invited persons did not turn up and other participants were mobilized from the communities around the municipal hospital. Informed consent and participant data were obtained prior to the discussions.

Discussions were led by a moderator who could speak local dialects (Ga, Twi) and English. Each discussion began with an introduction of the research team, and setting ground rules. The FGDs were held on the same day and lasted 90 and 75 minutes for males and females respectively. A structured FGD guide was used which was similarly worded for both groups (see Appendix 8). The FGDs were audio-taped and notes were taken by two field workers (one in each group). Being the preferred language of communication, the discussions were conducted in the local dialects (Ga, Twi) by a medical practitioner and a trained field staff with the PI in attendance. Important, non-verbal behaviour of participants were noted and issues were clarified when required.

3.2.2.5 Focus group discussions on segregation of solid medical waste at source

To address research objective 4, a total of 4 focus group discussions were held with 7 TBAs, 3 CSVs and 15 members of households (comprising 1 group of male and 1 group of female members of households). The FGDs for TBAs and CSVs held in January, 2015 while the FGDs for householders held in February, 2015. A purposive selection of participants was undertaken based on selection criteria for TBAs and CSVs. Recruitment of TBAs was facilitated by health center staff in a sub-district where TBAs were reported to still function actively, while 8 CSVs were invited at random during one of the field visits in the study area by the researcher. Household members were persons aged 20 years or older who resided within the study area, preferably married or responsible for their households.

Each focus group started with an introduction of the researcher and field staff, the topic for discussion, general rules for participation. The focus group guides have been included as Appendix 9 and Appendix 10. Participants at the FGDs were provided with posters to facilitate discussion about types of SMW and potential segregation at source, adapting the discussion to the context of each group (Figure 3.3). Discussions took place in both English and local dialects assisted by field staff, technical staff and participants with the PI probing participants on issues that required further clarification. Observations were made of the group dynamics, and how participants achieved convergence or divergence of views. The discussions were audiotaped by the PI and discussion notes were written by two field staff.

A focus group discussion with TBAs. A midwife (standing, left) assists with translation.

A focus group discussion with male householders.

Explaining solid medical waste and segregation at source to the TBAs.

A traditional birth attendant studies the poster.

Focus group discussion with female members of households.

Field staff during one of the training sessions.

Figure 3.3 Some of the focus group discussions and training session for field staff

3.3 Data Management and Analysis

Initial data management included visual scrutiny of the spreadsheet for missing data and outliers. Histograms were used to visualize continuous variables. Outliers were cross checked against the questionnaires, and corrected, where applicable. Variables derived from weight measurements of the waste fractions, such as generation rates or otherwise grouped from existing variables are discussed under the relevant sections.

Earlier studies on waste composition studies have demonstrated a relationship between household income and household waste generated (Dangi *et al.*, 2008; Sajauddin *et al.*, 2008; Qu *et al.*, 2009; Monavari *et al.*, 2012; Alias, Manaf, Ho Abdullah, & Nyuk Onn, 2014). Similarly, earlier studies in Ghana have shown that waste generation rates vary according to socioeconomic groups (Asase, 2011; Monney *et al.*, 2013). Based on this relationship, households are often selected from socioeconomic strata based on income levels (Delgado, Ojeda-Benitez, *et al.*, 2007; Monavari *et al.*, 2012) or a combination of factors (Monney *et al.*, 2013; Miezah, Obiri-Danso, Kádár, Fei-Baffoe, & Mensah, 2015). However, fieldwork in the present study revealed that households' income levels were not homogenous within the study areas. Therefore, household income levels were obtained from households that participated in the waste stream analysis and arbitrarily assigned three income groups (low, middle and high) using the ranges of values shown in Box. 3.1. Statistics of waste generation and relevant analysis were based on these groups as well as the overall sample.

Box 3.1 Distribution of households by income group

Description	Interpretation	No. of households (%)
≤ GHC 200 ($ 52.63)	Proxy for low income group	29 (48.3)
GHC 201 – 300 ($ 52.89 – $78.95)	Proxy for middle income group	16 (26.7)
>GHC 300 ($78.95)	Proxy for high income group	15 (25.0)

Amounts under description were determined by dividing the sum of monthly household income into 3 groups; values in parenthesis were obtained using the prevailing exchange rate USD 1: GHC 3.8.

3.3.1 Objective 1: Waste characterization of solid medical waste in households in Ga South Municipal Assembly – analytic procedures

First, the background characteristics of households in the sample population were presented as frequencies and percentages generated with statistical software, Statistical Package for Social Sciences (SPSS version 22). Next the waste generation rates of the specific waste fractions (medicinal waste, sharps waste, offensive waste, SMW) were computed using formulae described below. Finally, factors affecting SMW generation were evaluated.

All measurements were based on wet waste measurements of the specific fractions in kilograms. Waste generation rates and percentage composition of specific fractions in household waste were computed below in nos. 1 - 3:

1. Household daily waste generation rate (kg/hh/day) =

$$\frac{\text{Waste weight of all samples collected within a specified period}}{\text{Number of days in the specified period*}}$$

*For the survey period, the denominator was 35 days, for the wet and dry seasons, 14 days and 21 days were used respectively.

2. Per capita daily generation rate (kg/person/day) =

$$\frac{\text{Household daily waste generation rate}}{\text{Average household size}}$$

(Average household size = the average of the household sizes obtained in the wet and dry seasons)

3. Percentage weight of specific waste fractions was computed in two steps:

a. Percentage composition of each waste fraction in household (mixed) waste was derived as adapted from (Alias *et al.*, 2014; Miezah *et al.*, 2015):

$$\frac{\text{Weight of the separated waste fraction}}{\text{Total amount of household waste sampled}} \times 100$$

b. The percentage composition for each waste fraction (medicinal waste, sharps waste, offensive waste, SMW) was determined for each survey week, summed for all 5 weeks and then averaged to obtain percentage weight.

The descriptive statistics for SMW generation rates (per household and per capita) included mean (± s. d.), median (iqr), minimum and maximum values, and coefficients of skewness and kurtosis. SMW generation rates (response variable) were not normally distributed as visually evident by histograms, and confirmed by Shapiro-Wilk normality test. In this test, a p-value less than 0.05 indicates a non-normal distribution (Komilis, Fouki, & Papadopoulos, 2012). An earlier study also found SMW generation rates were non-normally distributed and highly skewed towards high values (Komilis *et al.*, 2012). The waste generation rates and other statistical analysis were computed with a statistical software, Stata version 14.0. Statistical significance for all tests was set at $p<0.05$.

Explanatory variables

National Health Insurance Scheme (NHIS) membership: NHIS has been shown to enhance utilization of formal health services for illness and access to prescriptions (Taffa & Chepngeno, 2005; Nonvignon *et al.*, 2010; Brugiavini & Pace, 2011; Blanchet *et al.*, 2012).

Under-fives (Children aged below five years)**:** Healthcare seeking is more common among younger children (Taffa & Chepngeno, 2005). Children aged under five years have a higher fever prevalence compared to older children and adults and a higher proportion will be treated in formal services (Abokyi *et al.*, 2015), while in another study more than half of the fever cases were first managed with home remedies and chemical shop vendors (Nonvignon *et al.*, 2010). Irrespective of the source of healthcare, medicines are often administered at home. Left over or expired medicines and related supplies in the household are ultimately discarded, contributing to the household waste stream. Furthermore, consumption expenditure patterns in households with children differ from those without children and may influence the pattern of solid waste generation (Johnstone & Labonne, 2004).

Education: Regarding the influence of education, one study demonstrated a positive relationship between education and waste generation (Sajauddin *et al.*, 2008), while others have reported a negative relationship (Qu *et al.*, 2009; Oribe-Garcia, Kamara-Esteban, Martin, Macarulla-Arenaza, & Alonso-Vicario, 2015). Education was also shown to have the largest impact among the grouped factors influencing generation of household hazardous waste in a study in China (Gu *et al.*, 2014).

Family type: This has been shown to influence household waste generation (Ojeda-Benítez, Armijo-de Vega, & Marquez-Montenegro, 2008).

Type of house: This has been reported to affect waste composition (den Boer, Jędrczak, Kowalski, Kulczycka, & Szpadt, 2010; Edjabou *et al.*, 2015).

Room occupancy: Room occupancy was used as an index for overcrowding and computed as household size divided by the number of bedrooms. Where room occupancy exceeded 2 persons per room, it was deemed to be overcrowded. Overcrowding has been associated with higher rates of infection transmission especially respiratory tract infections, tuberculosis, meningococcal disease and poor mental health (Krieger & Higgins, 2002; Howden-Chapman, 2004; Arku, Luginaah, Mkandawire, Baiden, & Asiedu, 2011). While these conditions in themselves may not directly contribute to SMW generation, it was assumed that they could contribute indirectly because the management of these associated conditions requires prescribed medicines, some of which can be taken on an outpatient basis. When these medicines and their containers are discarded at home (either on completion or left over from stopping the medicines following symptom relief or side effects), they can contribute to the SMW stream in the household.

Medical complaints: The presence of medical complaints generates the demand for healthcare. Among other options of healthcare, visits to the healthcare facilities, pharmacies and chemical shops are often accompanied by prescriptions. When medications are bought, introduced into the household and not completely consumed for various reasons (expiry, change of regimen, non-compliance), some of these are likely to join the household waste stream, if they are not kept or passed on to other household members.

Household size and household income: Both factors have been reported to influence waste generation in earlier studies (Ojeda-Benitez et al., 2008; Oberlin, 2013a; Alias et

al., 2014). It was assumed that since SMW was a component of household waste, household size and income would also influence SMW.

Given the small sample size of households participating in the waste stream analysis (n = 60 households) and the non-normal data, statistically significant variation in SMW generation was evaluated using non-parametric tests. Non-parametric tests use ranks of data for comparison rather than original data and are appropriate for non-normally distributed data (Komilis *et al.*, 2012). The tests are listed below:

1. Kruskal-Wallis H test: It is the non-parametric analogue of a one-way analysis of variance (ANOVA). This test compares two or more groups of ordinal or quantitative data when the sample data violate the assumptions of normality. In this case the SMW generation rates were compared between income groups. The null hypothesis assumes that the samples come from identical populations. The test does not require equal sized samples. A p-value <0.05 indicates significant variation between groups. It is reported using the test statistic, *H*, and the p-value (its significance value).

2. Wilcoxon signed rank test: This is the non-parametric analogue of the repeated measures t-test. It compares two-sample paired data (e.g. per capita generation rates of SMW in the wet season and dry season) by computing the differences of the paired observations and testing if the median of the differences equals zero. It does not assume normality. A p-value <0.05 indicates significant variation in per capita generation of SMW. This test was conducted for per capita generation rates for medicinal waste, sharps waste, offensive waste and SMW.

Earlier studies have demonstrated no seasonal variation in composition and generation of household waste (Ketibuah, Asase, Yusif, Mensah, & Fischer, 2004; Asase, 2011), and

in waste quantity and composition of household waste (Fobil, Carboo, & Armah, 2005). However, it was evaluated in the present study because certain disease conditions demonstrate seasonal variation. Examples include clinical malaria, anaemia and respiratory tract infections which are more common in the rainy season (Ehrhardt *et al.*, 2006; Kwofie *et al.*, 2012), typhoidal Salmonellosis which peaks with local rainfall patterns (Labi, Obeng-Nkrumah, Addison, & Donkor, 2014), and rotavirus infection which peaks in the dry season (Mwenda *et al.*, 2010), similar to meningococcal meningitis infections (Greenwood, 2006). Disease conditions such as these give rise to medical complaints, necessitating medical treatment and eventual generation of SMW. Furthermore, some studies have reported that seasonal variation influences waste generation (Alhumoud, Altawash, & Aljallal, 2007; Gómez, Meneses, Ballinas, & Castells, 2009; Thanh, Matsui, & Fujiwara, 2010).

3. Kendall's tau is a non-parametric measure of the correlation among ranked data. The correlation coefficient takes any value between plus one and minus one, with a positive correlation signifying that the ranks of both variables are increasing in the same direction. A negative correlation signifies the ranks of the variables are increasing in the opposite direction. The test is less sensitive to error and p-values are more accurate for small sample sizes. Therefore it is deemed a better estimate of correlation than Spearman's statistic (another non-parametric correlation test) and one can generalize more accurately with the test. In the present study it was used to investigate possible associations between SMW generation rates (per household and per capita) and continuous variables such as household income and household size. The null hypothesis is that there is no association between the variables. Statistical significance is assumed when p-value <0.05.

4. Wilcoxon Rank sum test: This is the non-parametric analogue of the independent t-test. It is used to test differences between two conditions in which the participants are different. The null hypothesis states that the two groups have equal mean ranks. A p-value less than 0.05 indicates that the two groups are significantly different. It is reported using the test statistic, *W*, and the p-value (its significance value). For instance, the median quantities of SMW generated were compared between households that reported medical complaints and households that did not report medical complaints. Apart from medical complaints, other variables tested were NHIS status, education, under-fives, type of house and room occupancy. The variables with significantly different groups were further subjected to regression analysis.

5. Regression analysis is a method of predicting an outcome variable (Y_i) from one or more predictor variables (X_i). The subscript denotes the values corresponding to i^{th} respondent. The relationship between the variables is assumed to be linear. It is defined by its gradient or slope often denoted by β_1, and the point at which the slope crosses the y-axis (vertical axis) often represented as β_0 and known as the intercept. The parameters, β_1 and β_0 are referred to as regression coefficients. The model which depicts the relationship also contains an error term which is the difference between the predicted values of the model and the observed values. The following expression is often used to depict the model: $Y_i = (\beta_0 + \beta_1 X_i) + \varepsilon_i$. Here, the regression coefficient (β_1) represents the change in Y_i following a unit change in X_i. Two types of regression analysis were used in this study:

a. Ordinary least squares regression: This models the mean of a response variable (in this case, household SMW generated) recorded on an interval scale as a linear function of one or more appropriately coded categorical explanatory variables (in this case, household

characteristics e.g. type of house, room occupancy, medical complaints). It demonstrates the average change in the response variable associated with a unit change in the explanatory variable, holding constant other explanatory variables in the model. R^2 is a measure that indicates the percentage of the variation in the response variable that is shared by the explanatory variable.

b. Quantile regression: This models the relationship between the explanatory variable, X_i (i.e. household characteristics) and the conditional quantiles of the response variable, Y_i (household generation of SMW). The distribution of the response variable is described in quantiles (percentiles). Therefore the regression coefficient, which represents the change in the response variable produced by a unit change in the explanatory variables, is dependent on the quantiles selected. The p-values generated support the hypothesis that the computed coefficient equals zero and a value of 0.05 or less represents a statistically significant effect.

Most regression applications estimate the rate of change in the mean of the response variable distribution, as in ordinary least squares (OLS) regression (Cade & Noon, 2003). However, weight measurements of SMW in the present study had an unequal variation, most likely due to a complex web of factors which cannot be entirely accounted for in statistical models. This heterogeneous variation suggested multiple rates of change throughout the distribution of these measurements (Cade & Noon, 2003). Quantile regression estimates these multiple rates of change which would be missed by an OLS regression model, which focuses on changes in the mean obscuring the true picture of the relationship. Furthermore, quantile estimators have been reported as robust to outliers in a distribution and useful for non-normal distributions as found in the SMW weight measurements (Hennings & Katchova, 2005).

In the present study, it was assumed that each explanatory variable (household or respondent characteristic) exhibited different rates of change in the quantity of household SMW, at specified quantiles, when other factors were held constant. Each explanatory variable (household characteristic) was a categorical variable with two levels assigned '1' or '0' according to the variable definitions in Box 3.2.

Box 3.2 Variable definition for quantile regression

Variable name	**Study definition**
kphhdSMW	Household SMW generated per day in kilograms (response variable)
NHIS	National Health Insurance Scheme membership, 1 if registered, 0 if otherwise
MedicalCmplt	Medical complaints, 1 if present (reported), 0 if otherwise
Education	Educational background, 1 if secondary or higher, 0 if otherwise
Underfive	Children aged below five years, 1 if present, 0 if absent
housetype	Type of house, 1 if compound house, 0 if flat/other
occupCat2	Room occupancy (categorized), 1 if > 2 person per room, 0 if ≤ 2 person(s) per room

The quantile regression model and its terms were:

$$Y = \alpha + \sum_i \beta_i X_i + \varepsilon,$$

where Y is the household generation of SMW in kg/household/day, α is a constant term, β_i represents the regression coefficient for *i*th household or respondent characteristic, X_i, and the residual error term is represented by ε (Zietz, Zietz, & Sirmans, 2008). The commands, 'reg' and 'sqreg', in Stata version 14.0 (StataCorp College Station, USA)

were executed to perform OLS and quantile regression analysis respectively. The probability values (p-values) were presented for the hypothesis that the computed regression coefficient is equal to zero. A p-value less than 0.05 implies that it is highly unlikely that the difference in SMW generation (represented by the regression coefficient for the characteristic) was due to chance.

Field observations

Descriptive narratives of waste categories and examples of waste materials sorted during the waste stream analysis were provided. A table was created which included SMW waste category (medicinal waste, sharps waste), drug formulation for medicinal waste (tablets/capsule with blister packs, dispensing envelopes with residue or full content, syrup bottles with residue or full content, vials, infusion bag) and therapeutic categories. Photographs of some examples were tabulated along with a photograph taken at an uncapped landfill in the study area. A separate table showing photographs of some examples of offensive waste were included as an appendix. The full listing of findings from participating households during the waste stream analysis are listed in the appendix.

3.3.2 Objective 2: Disposal options for solid medical waste from household and community sources

Characteristics of households were presented as frequencies and percentages**.** The patterns of storage receptacles for SMW (bucket with or without lid, sack/cellophane bag, standard waste bins, basket/basin/carton, others), its methods of collection from the household (communal collection bins, pick up by refuse trucks, dumped in nearby bush or gutter, burnt or buried on site), person responsible for conveyance to the disposal point

(children, adolescent, adults) and the method of disposal of placenta from childbirth (buried, discarded in a pit latrine, others) were all described by frequency and percentage of the participating households. All disposal options were converted into a modified dichotomous variable with two levels, namely 'Dustbin' and 'Burn or bury/Others'. The proportion of households using either of the options was presented for each waste category of interest (medicinal waste, sharps waste, offensive waste – soiled items, blood soaked items, and disposables).

Interviews with key informants at the private waste management companies

The highlights of each interview with the key informants were shared with the informants at the conclusion of each interview for affirmation or clarification at the venue. Thereafter, the full interview notes were carefully studied by the researcher, and the main findings in each interview summarized under two broad themes: household waste collection and SMW segregation. The summaries were compared across interview notes and highlights to identify common sub-themes and/or differences. Key findings on household waste collection were presented in a table according to the waste companies represented, and further discussed in narrative form.

3.3.3 Objective 3: Estimation of the relative proportion of household members reporting harm due to solid medical waste at household and community levels

Households that reported harm associated with SMW (accidental poisoning, piercing injury/needlestick, foreign body in the nose/ear, fire or explosion, others) had three options namely, 'yes', 'no' and 'not sure'. The latter two options were combined so that a modified dichotomous variable was created with two levels (yes/no).

Multiple responses to open ended questions ('Diseases associated with SMW' and 'Items constituting a problem in the community') were presented as frequencies and percentages of the households. To demonstrate the importance of a response, it was ranked according the percentage of all responses, as well as the percentage of respondents contributing to that response. The analysis was based on the first three responses as the majority of respondents listed three options out of five responses permitted in the questionnaire.

3.3.4 Objective 4: Stakeholder views about segregation of solid medical waste at source as a potential management option at community level

The data addressing this objective comprised of interview notes with the key informants of private waste management companies (the same described under objective 2), audio recordings and written notes from FGDs with TBAs and CSVs. The theme was discussed alongside other themes on disposal of SMW (objective 2) and harm associated with SMW (objective 3). Therefore the analytic procedures described hereafter apply to objectives 2, 3 and 4.

All audio recordings from the FGDs were transcribed and translated into English by the moderator. Data immersion, then manual coding and data reduction into themes and sub-themes were done by the researcher using iterative analysis. In this approach, the researcher was guided both by reviewed literature and context specific data. The FGDs conducted with members of households, TBAs and CSVs had three themes: disposal of SMW (objective 2), harm associated with SMW (objective 3) and segregation of SMW at source as a potential management option in the community (objective 4). One theme emerged from the discussions was also added: gender roles in waste management. The latter appeared to influence the practical considerations regarding segregation of SMW at source. Data from interviews with TBAs and CSVs were integrated with corresponding data from FGDs where relevant. The findings generated on the separate collection of SMW by key informants of the private waste management companies were integrated with findings on the same theme from the FGDs with other study participants. The final output was reviewed by the moderator and field staff for validation. Descriptive narratives and illustrative quotes from the data have been used to complement quantitative results.

A full variable list for the study is presented in the box below (Box 3.3) according to the study objectives.

Box 3.3 Study variables listed according to research objectives

Research objective	Research method	Variables	Definition	Indicators for measuring them
1. Quantify and characterize SMW from households	a. Waste stream analysis with quantitative measurements	Daily household generation rate of HSW	Quantity of HSW generated daily per household	Kg/hh/day
		Daily per capita generation rate	Quantity of HSW generated daily per person	Kg/person/day
		Percentage composition in household waste (All variables repeated for medicinal waste, sharps waste, offensive waste, SMW)	Percentage of waste fraction in HSW	(%) in HSW
	b. Background characteristics from waste survey	Sociodemographic characteristics	Highest level of education of respondent	None/basic Secondary/higher
			Type of house	Compound house Flat/Other
			Family type	Single family Extended family
			Household income	High income Middle income Low income
			Average household size	Household size in wet and dry seasons averaged per household

Box 3.3 contd.

Research objective	Research method	Variables	Definition	Indicators for measuring them
1. Quantify and characterize SMW from households (contd.)	b. Background characteristics from waste survey (contd.)	Health related characteristics	National Health Insurance Scheme membership	No Yes
			Children aged below 5 years	No Yes
			Medical complaints	No Yes
			Room occupancy	≤2 persons/room >2 persons/room
	c. Qualitative (descriptive)	Category	Sub-stream of SMW	Medicinal waste Sharps waste
		Description	Drug formulation	Blister packet, dispensing envelope with residue
				Blister packet, dispensing envelope with content (Capsules, tablets)
				Syrup bottles with residue
				Syrup bottles with content
				Others with residue
				Vials
				Infusion bags

Box 3.3 contd.

Research objective	Research method	Variables	Definition	Indicators for measuring them
1. Quantify and characterize SMW from households (contd.)	c. Qualitative (descriptive)	Therapeutic categories	Antimalarial Analgesic/anti-inflammatory agent Antibiotic Antihypertensive Others	Specific drug in each category Included antidiabetics, anti-helminthics, multivitamins, antacids, antifungal drugs
2. Describe disposal options for SMW in from community	a. Household questionnaire survey (quantitative)	Storage of SMW ('nature of bin in the home')	Percentage respondents who use various receptacles for temporary storage of SMW	(% respondents by receptacle type) Cellophane bag Bucket with/out lid Sack/bag Basin/basket/carton Standard bin Other
		Disposal options	Percentage respondents whose households discard SMW by specified options	(% respondents) Dustbin Burn/burial/others Not applicable
		Waste collection	Methods by which household waste containing SMW is removed from the dwelling	(% respondents by method of removal) Bury in a pit Burn in the compound Carry to a communal bin Pick up by refuse truck Dump in a nearby bush Other

Box 3.3 contd.

Research objective	Research method	Variables	Definition	Indicators for measuring them
2. Describe disposal options for SMW in from community (contd.)	a. Household questionnaire survey (quantitative)	Conveyance to disposal point	Responsible person who conveys SMW in household waste to the point of final disposal	(% respondents by group) Children aged <10 years Adolescents (aged 10-19 years) Adults (aged ≥20 years)
	b. FGDs with household members, TBAs and CSVs (qualitative)	Disposal options	Methods of disposal for specific waste fractions relevant to each group of participants: Household members, TBAs, CSVs	Disposal options for medicinal, sharps and offensive waste (household members) Disposal options for placentae, gloves, cotton pads (TBAs) Disposal options for unwanted medicines (CSVs)
3. Determine the proportion of study participants who report harm from SMW	a. Household questionnaire survey (quantitative)	In the household (%)	Percentage respondents in whose households a harmful event associated with SMW occurred in the household	(% respondents reporting accidental poisoning, needlestick or piercing injury, fires or explosion, others)

Box 3.3 contd.

Research objective	Research method	Variables	Definition	Indicators for measuring them
3. Determine the proportion of study participants who report harm from SMW (contd.)	a. Household questionnaire survey (quantitative)	In the community (%)	Percentage respondents in whose households a harmful event associated with SMW occurred in the community	(% respondents reporting accidental poisoning, needlestick or piercing injury, fires or explosion, others)
		% discarded loosely	Percentage respondents that reported discarding the specific waste fraction without a container or wrapping	% respondents
		% discarded in container	Percentage respondents that reported discarding the specific waste fraction with a container or wrapped	% respondents
		Diseases associated with SMW (%)	Percentage respondents reporting diseases they perceived to be associated with SMW	(% respondents per disease category)

Box 3.3 contd.

Research objective	Research method	Variables	Definition/sub-themes	Indicators
3. Determine the proportion of study participants who report harm from SMW (contd.)	a. Household questionnaire survey (quantitative)	SMW and offensive waste considered a problem in the community (%)	Percentage respondents reporting an item (either SMW or offensive) causing a problem/concern in the community	(% respondents per item reported)
	b. FGDs with household members, TBAs and CSVs (qualitative)	Harm associated with SMW known to the participant group	Medicinal waste Sharps waste Offensive waste	E.g. Tablets can be swallowed E.g. Sharps facilitate transmission of HIV, tetanus E.g. malodorous, poor aesthetics
4. Explore participant views about segregation of SMW at source as a management option	a. FGDs with household members, TBAs and CSVs (qualitative)	Segregation of SMW at source (Household members, TBAs, CSVs) Separate collection of SMW (key informants of private waste management companies)	Systematic separation of waste fractions according properties, treatment & disposal As above, but retrieval from households and service areas	Facilitators: Factors that would enhance segregation by participants e.g. Creating awareness Barriers: Factors that might hinder segregation by participants e.g. lack of storage facilities

3.4 Quality control

The following steps were taken to ensure data quality and reliability of information obtained:

1. Data collectors were trained by the principal investigator in data collection procedures and ethical conduct to cover the methods used during fieldwork:

a. Household questionnaire survey (4 days, 1 day pretesting)
b. Waste stream analysis (1 day plus a pre-test in 10 households at a later date)
c. Focus group discussion (1 day)

2. During the field work, the principal investigator made visits with and without field staff to observe and ensure that good ethical conduct was maintained.
3. The electronic database containing data from the household questionnaires were compared with a 10% sample of the household questionnaires by a field staff and the primary investigator for consistency. Phone calls were also placed to a random selection of households to confirm some of the responses in the questionnaire by the principal investigator.
4. All field records from SMW measurements during the household waste stream analysis were entered in an electronic database. These were re-checked by the principal investigator and one field staff twice to ensure records were accurate. The estimated per capita generation rate for household waste (0.34kg/person/day) was consistent with rates reported by Miezah et al., (2015) for districts (0.28kg/person/day) and municipalities (0.40kg/person/day) in a recently concluded national survey (Miezah *et al.*, 2015). For the waste survey, the

electronic database was checked against all questionnaires on two separate occasions by the principal investigator and one field staff.

5. Interviews with private waste contractors were concluded with a summary of key points by the primary investigator for affirmation by the key informants, with an officer of the Municipal Waste Department present. Clarifications were made where required. For the focus groups, each audio recording was replayed by the moderator to cross check transcribed notes and summarized themes for consistency.
6. The primary investigator met regularly with field staff during fieldwork to discuss work progress, resolve difficulties and plan for field activities.

3.5 Ethical considerations and clearance to conduct the study

Ethical approval for the study was obtained from the Noguchi Memorial Institute of Medical Research Institutional Research Board and the Ghana Health Service Ethical Research Committee. Written permission to conduct the study was obtained from the Municipal Chief Executive (MCE). Clearance was obtained verbally from community chiefs during a meeting convened by GSMA. At the meeting, the purpose of the study and the stages in the study were briefly explained.

Individual written informed consent was obtained from all persons prior to questionnaire administration. Verbal consent was sought from key informants at the private waste management companies and FGD participants. All participants gave their consent prior to participation in the study. Respondents were interviewed in the privacy of their homes and only eligible households participated in the study. Participants' rights to withdrawal from the study were upheld and all participants were treated with respect.

CHAPTER FOUR

4 RESULTS

4.1 Objective 1: Characterization of solid medical waste in households in Ga South Municipal Assembly

Waste characterization involves the description of generated waste in terms of quantity and composition. Results from quantitative surveys include household/respondent characteristics, quantification of SMW and factors affecting its generation, and composition of waste fractions in household waste. The qualitative aspect presented is a description of SMW recovered from sixty households in the study area. .

4.1.1 Participant characteristics

In this sample, 42 (70.0%) households were registered under the National Health Insurance Scheme, 17 (28.3%) households reported medical complaints, 23 (38.3%) households had children aged below 5 years and in 48 (80.0%) households, the respondents had attained secondary education or higher. Fifty (83.3%) households were single (nuclear) families, 27 (45.0%) households lived in compound houses, and 40 (66.7%) households had 4 sleeping rooms or less. The average household size in the low, middle and high income groups was 4 persons, 5 persons and 4 persons respectively.

4.1.2 Solid medical waste generation

Quantitative statistics of per capita generation of SMW during the study period indicate a positively skewed, leptokurtic distribution (Table 4.1). This implies that were some higher than average values in the data and the distribution was skewed towards the higher values. This indicates there were some higher than average values in the data and the

distribution was skewed towards the higher values. In both the household and per capita generation rates, the median rates were lower than the average rates which is true of positively skewed data (Boslaugh, 2013a). The average quantity of SMW generated in households was 7.26 x 10^{-3}kg/household/day (7.26 grams) and each person generated 1.77 x 10^{-3}kg/person/day (1.77grams) on average. The corresponding median values were 4.59 x 10^{-3} kg/household/day (4.59 grams) and 1.05 x 10^{-3} kg/person/day (1.05 grams).

Table 4.1 Descriptive statistics for solid medical waste generation per household (kg/hh/day) and per capita generation (kg/person/day)

Name of parameters	Household generation (kg/hh/day)	Per capita generation (kg/person/day)
Mean (n = 60 households)	7.26 x 10^{-3}	1.77 x 10^{-3}
Standard deviation	11.58 x 10^{-3}	2.64 x 10^{-3}
Coefficient of variation	1.60	1.49
Median	4.59 x 10^{-3}	1.05 x 10^{-3}
Interquartile range	4.85 x 10^{-3}	1.18 x 10^{-3}
Minimum (household number = 01/05)	28.6 x 10^{-6}	8.16 x 10^{-6}
Maximum (household number = 09/02)	7.45 x 10^{-2}	1.49 x 10^{-2}
Coefficient of skewness	4.51	3.72
Coefficient of kurtosis	24.52	17.87

Two households were outliers generating 54.85 x 10^{-3} kg/household/day (household number = 18/20) and 74.48 x 10^{-3} kg/household/day (household number = 09/02) of SMW. Both were low income households that had discarded an unusual quantity of medicines in their household waste. The rest of the households (96.7%) generated quantities of SMW ranging between 0.029 x 10^{-3}kg/household/day and 17.23 x 10^{-3}kg/household/day (approximately 17grams or less). Excluding these outliers, values for

household production and per capita generation were computed (Table 4.2, see also Appendix 19). The coefficient of skewness reduced by 73.8% for household production and by 57% for per capita generation of SMW, while the coefficient of kurtosis reduced by 83.3% for household production and 69.7% for per capita generation of SMW. This indicates that the distribution of data points was less peaked in the sample without the outliers compared to the sample with the outliers.

Table 4.2 Descriptive statistics for solid medical waste generation per household (kg/hh/day) and per capita generation (kg/person/day) without outliers*

Name of parameters	Household generation (kg/hh/day)	Per capita generation (kg/person/day)
Mean (n = 58 households)	5.28×10^{-3}	1.34×10^{-3}
Standard deviation	3.98×10^{-3}	1.23×10^{-3}
Coefficient of variation	0.75	0.92
Median	4.38×10^{-3}	1.01×10^{-3}
Interquartile range	4.71×10^{-3}	1.05×10^{-3}
Minimum (household number = 01/05)	28.6×10^{-6}	8.16×10^{-6}
Maximum (household number = 02/03)	1.72×10^{-2}	0.57×10^{-2}
Coefficient of skewness	1.18	1.60
Coefficient of kurtosis	4.10	5.41

**Two households were excluded from the original sample in Table 4.1 (household numbers 18/20 and 09/02 with household generation rates of 54.85×10^{-3} kg/household/day and 74.48×10^{-3} kg/household/day respectively).*

Based a population of 24,183 in the study areas, the daily average quantity of SMW was computed at 42.80kg with the outlier households and 32.40kg excluding them. The corresponding maximum values were 360.33kg and 137.84kg daily. If the values in 4.2 are considered typical generation rates, then corresponding daily average and maximum values generated by households in the municipality (based on a population of 411,377

and assuming similar conditions in the study areas) were calculated as 551.24kg and 2344.85kg (approximately 2.3 tonnes).The average waste generation rate per household for SMW was 9.65 x 10^{-3}kg/household/day, 4.74 x 10^{-3}kg/household/day and 5.33 x 10^{-3}kg/household/day for the low, middle and high income groups respectively. Daily per capita generation of SMW was 2.43 x 10^{-3} kg/person/day, 0.94 x 10^{-3} kg/person/day and 1.40 x $10^{-.3}$kg/person/day for the low, middle and high income groups respectively. The household production and per capita generation rates did not differ significantly across income groups for SMW (household: H(2) = 1.40, p = 0.497; per capita: H(2) = 3.08, p = 0.214).

Daily household production of medicinal waste was highest among households in the low income group (9.46 x 10^{-3}kg/household/day) and lowest in the middle income group (4.57 x 10^{-3} kg/household/day) (Table 4.3). Daily per capita generation of medicinal waste was highest among persons in the low income group (2.38 x 10^{-3}kg/person/day) and lowest among persons in the middle income group (0.91 x 10^{-3}kg/person/day). Household production of sharp waste was highest in the middle income group (0.24 x 10^{-3}kg/household/day), but per capita generation was highest in the low income group (0.05 x 10^{-3}kg/person/day), and decreased with increasing income status. The largest quantity of offensive waste generated daily in households was found in the low income group (74.64 x 10^{-3}kg/household/day), but the highest generation rate was found among households in the middle income group (22.5 x 10^{-3}kg/person/day). The lowest per capita generation of offensive waste was found among persons in the high income group (7.64 x 10^{-3}kg/person/day). The household production and per capita generation rates for any of the waste components did not differ significantly across income groups (Medicinal waste - household: H(2) = 1.42, p = 0.492; per capita: H(2) = 2.70, p = 0.260; Sharp waste

- household: H(2) = 0.85, p = 0.652; per capita: H(2) = 1.49, p = 0.475; Offensive waste

- household: H(2) = 2.92, p = 0.232; per capita - H(2) = 1.51, p = 0.469).

Table 4.3 Average daily generation of waste components during the survey period per household, per capita and percentage fraction in household waste (n = 60 households)

SMW components\ Zone	Low income			Middle income			High income		
	kg/hh/day	kg/person/day	Proportion in household waste (%)	kg/hh/day	kg/person/ day	Proportion in household waste (%)	kg/hh/day	kg/person/ day	Proportion in household waste (%)
Medicinal waste	9.46×10^{-3}	2.38×10^{-3}	0.81	4.57×10^{-3}	0.91×10^{-3}	0.44	5.19×10^{-3}	1.36×10^{-3}	2.18
Sharp waste	0.19×10^{-3}	0.05×10^{-3}	0.02	0.24×10^{-3}	0.04×10^{-3}	0.02	0.13×10^{-3}	0.03×10^{-3}	0.01
Offensive waste	74.64×10^{-3}	20.30×10^{-3}	5.75	12.31×10^{-3}	22.5×10^{-3}	5.82	28.68×10^{-3}	7.64×10^{-3}	2.43
Household waste	1.38	0.40	-	1.30	0.28	-	1.10	0.30	-

4.1.3 Percentage composition of waste fractions in the household waste stream

Table 4.3 also shows the proportions of the segregated waste components in household waste expressed as a percentage. Offensive waste accounted for the largest fraction among the segregated waste components across all income groups. The highest percent share of medicinal waste was found in the high income group (2.18%) and the lowest percent share was found in the middle income group (0.44%). The fraction constituting sharps in household waste was nearly the same across income groups. When all income groups were combined, the percent shares of medicinal waste, sharp waste and offensive waste were 1.05%, 0.02% and 4.94% respectively.

SMW accounted for 0.83%, 0.46% and 2.19% of household waste for the low, middle and high income groups respectively. Therefore, the percentage composition of SMW in household waste was highest among high income households, and lowest among middle income households. With all income groups combined, percentage composition of SMW in household waste computed for the study period was 1.07%. Medicinal waste formed the bulk (approximately 98%) of SMW from households.

4.1.4 Seasonal variation in generation rates of waste fractions

Among income groups, the daily per capita generation rates in the wet season were higher than in the dry season, except in the middle income group where medicinal waste and SMW were lower in the wet season (Table 4.4). However, when all income groups were combined, the total daily per capita generation rate of all waste fractions were significantly higher in the wet season than in the dry season, except for sharps waste. Although the daily generation of sharps waste was higher in the wet season than in the dry season across income categories, median of the differences between per capita generation in the wet and dry season was not different from zero ($z = 1.938$, $p = 0.053$).

Table 4.4 Per capita generation of waste components (kg/person/day) distributed by season (n = 60 households)

SMW components\Group	Low income		Middle income		High income		Total		Wilcoxon signed rank test
	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	z, p-value
Medicinal	4.31×10^{-3}	1.10×10^{-3}	0.81×10^{-3}	1.06×10^{-3}	1.97×10^{-3}	0.98×10^{-3}	2.79×10^{-3}	1.06×10^{-3}	3.052,0.002*
Sharps	0.06×10^{-3}	0.04×10^{-3}	0.05×10^{-3}	0.03×10^{-3}	0.04×10^{-3}	0.03×10^{-3}	0.05×10^{-3}	0.04×10^{-3}	1.938, 0.053
Solid medical waste	4.36×10^{-3}	1.15×10^{-3}	0.87×10^{-3}	1.07×10^{-3}	2.01×10^{-3}	1.01×10^{-3}	2.84×10^{-3}	1.09×10^{-3}	3.129,0.002*
Offensive waste	34.89×10^{-3}	10.65×10^{-3}	38.86×10^{-3}	10.28×10^{-3}	14.28×10^{-3}	2.90×10^{-3}	30.97×10^{-3}	8.61×10^{-3}	4.960,0.000*

*Values under wet and dry season are in kg/person/day; *statistically significant at 5% significance level*

4.1.4 Factors associated with quantity of solid medical waste

There was no correlation between the overall quantity of SMW and average household size (τ = -0.012, p = 0.897), and between overall quantity of SMW and household income (τ = -0.086, p = 0.327). The corresponding coefficients for capita waste generation were: household size (τ = -0.314, p = 0.000) and household income (τ = -0.120, p = 0.172), indicating a negative correlation between per capita waste generation of SMW and household size only. There was no correlation between household generation of SMW and average household size (τ = -0.0126, p = 0.897) and household generation of SMW and household income (τ = -0.0911, p = 0.327).

Table 4.5 shows the median values of SMW generated by households in each sub-group of the study attributes (National Health Insurance (NHIS) membership status, presence or absence of medical complaints, presence or absence of under-fives, type of house, room occupancy, and family type). For instance, among households that reported medical complaints, the median quantity of SMW generated was 2.31 x 10^{-3}kg, which was significantly lower than that from households that did not report medical complaints, 5.86 x 10^{-3}kg (W = 3.986, p<0.001). Based on the median quantity, generation of SMW was significantly lower among households with room occupancy exceeding two persons per room compared to households with two or less occupants per room (W = 2.038, p = 0.042). The median quantities of SMW generated by sub-groups based on NHIS membership, educational status, presence or absence of under-fives, type of house and family type did not differ significantly.

Table 4.5 Solid medical waste (kg/household/day) by household characteristics based on Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Characteristics	Median quantity of solid medical waste (IQR)	Test statistic (z)	p-value
NHIS			
No	3.80×10^{-3} (4.71×10^{-3})	-0.008	0.994
Yes	4.80×10^{-3} (5.08×10^{-3})		
Medical Complaints			
No	5.86×10^{-3} (4.80×10^{-3})	3.986	**0.000***
Yes	2.31×10^{-3} (1.89×10^{-3})		
Highest Education level			
None/Basic	3.81×10^{-3} (4.33×10^{-3})	0.213	0.832
Secondary or higher	4.80×10^{-3} (5.09×10^{-3})		
Children aged below 5 years			
Yes	3.89×10^{-3} (3.17×10^{-3})	0.395	0.693
No	4.71×10^{-3} (5.65×10^{-3})		
Type of House			
Compound house	3.51×10^{-3} (3.12×10^{-3})	0.319	0.749
Flat/Other	5.94×10^{-3} (6.88×10^{-3})		
Room occupancy (category)			
≤ 2 person(s) per room	5.28×10^{-3} (5.02×10^{-3})	2.038	**0.042***
>2 persons per room	2.66×10^{-3} (1.72×10^{-3})		
Family type			
Single family	4.67×10^{-3} (4.71×10^{-3})	0.344	0.731
Extended family	3.73×10^{-3} (5.29×10^{-3})		

*IQR is the interquartile range, * statistically significant at 5% level of significance*

To examine how specific study attributes influence the quantity of SMW generated at specific quantiles in the distribution, quantile regression coefficients were computed. Table 4.6 shows the regression coefficients for medical complaints, type of house and room occupancy for the 5th, 10th, 25th, 50th, 75th, 90th and 95th quantiles (or percentiles). Type of house was retained because the Ghana Living Standards Survey Round 6 (GLSS 6, p. 85), indicated that nearly 64% of households in Accra live in compound houses, therefore it was pertinent to examine how this might affect SMW generation in the model. The probability values (p-values) are presented for the hypothesis that the estimated regression coefficient is equal to zero. A p-value less than 0.05 implies that it is highly

unlikely that the difference in SMW generation represented by the regression coefficient is due to chance. Households that reported medical complaints generated significantly lower quantities of SMW than households that did not report medical complaints, controlling for type of house and room occupancy. The difference in household generation of SMW increased linearly between the 5th percentile, where the difference was 2.71 x 10^{-3}kg (2.7 grams) and the 50th percentile, where the difference was 4.60 x 10^{-3}kg (4.60 grams). On the other hand, the p-value for the OLS regression coefficient indicated that the reported presence or absence of medical complaints does not influence household generation of SMW, whereas this was applicable to the 75th, 90th and 95th percentiles (i.e. when households generated 7.53 grams of SMW or more).

The p-value for the OLS regression coefficient indicated that the type of house and room occupancy did not influence household generation of SMW. Room occupancy affected SMW generation only at the 10th percentile where households with more than two persons per room generated significantly less SMW than households with fewer persons per room, the difference being 1.41 x 10^{-3}kg (1.41 grams). The corresponding values of SMW generated in households (n = 60) daily at the 5th, 10th, 25th, 50th, 75th, 90th and 95th quantiles were 0.40 x 10^{-3} kg/household/day, 1.06 x 10^{-3} kg/household/day, 2.68 x 10^{-3} kg/household/day, 4.58 x 10^{-3} kg/household/day, 7.53 x 10^{-3} kg/household/day, 13.74 x 10^{-3} kg/household/day and 16.51 x 10^{-3} kg/household/day.

Table 4.6 Regression coefficients* of household characteristics, OLS and by Quantiles and their respective p-values (n = 60 households)

Variable	OLS	q05	q10	q25	q50	q75	q90	q95
constant	9.086	2.720	3.149	4.286	7.149	8.486	13.371	15.829
p-value	0.000	0.013	0.000	0.000	0.000	0.000	0.220	0.417
Medical complaints	-5.935	-2.711	-2.949	-3.429	-4.600	-2.943	-4.914	-10.200
p-value	0.076	0.001	0.000	0.000	0.000	0.177	0.668	0.610
Type of house	1.013	0.019	-0.171	-0.771	-1.292	-0.169	3.857	9.143
p-value	0.739	0.984	0.780	0.284	0.270	0.945	0.796	0.737
Room occupancy (category)	-5.152	-1.168	-1.406	-1.594	-3.429	-2.711	-9.651	-12.108
p-value	0.276	0.176	0.012	0.141	0.056	0.312	0.365	0.406
R^2	0.0756	0.1581	0.1645	0.1208	0.1010	0.0752	0.0769	0.0890

**All coefficient values for the study attributes are multiplied by (x 10^{-3}). The coefficient of determination (R^2) in quantile regression models are Pseudo R^2. The probability values (p-value) support the hypothesis that the computed coefficient equals zero. A p-value of 0.05 or less indicates a statistically significant effect.*

Table 4.7 shows the OLS regression coefficients, quantile regression coefficients and p-values for the sample without the outliers. The type of house and room occupancy did not influence household SMW generation as shown by the OLS regression coefficients and quantile regression coefficients. However, SMW generation differed significantly if a household reported (the presence or absence of) medical complaints, controlling for type of house and room occupancy. Households that reported medical complaints generated significantly lower quantities of SMW (compared to households that did not report medical complaints) at the 10^{th} percentile was 2.01 x

10^{-3}kg (2.01 grams) and it increased linearly up to the 75th percentile, where there was a difference of 5.11 x 10^{-3}kg/household/day (5.11 grams). The p-value for the OLS regression coefficient indicates a significant effect, but the OLS regression coefficient overestimates the difference at the 10th and 25th percentiles and underestimates the difference at the 50th and 75th percentiles. The reported presence or absence of medical complaints did not influence household SMW generation significantly at the 90th and 95th percentiles (when households generated 10 grams or higher of SMW). The corresponding values of SMW generated in households (n =58) daily at the 5th, 10th, 25th, 50th, 75th, 90th and 95th quantiles were 0.09 x 10^{-3} kg/household/day, 0.86 x 10^{-3} kg/household/day, 2.66 x 10^{-3} kg/household/day, 4.38 x 10^{-3} kg/household/day, 7.37 x 10^{-3} kg/household/day, 10.14 x 10^{-3} kg/household/day and 14.77 x 10^{-3} kg/household/day.

Evidence from both tables confirm the influence of reported presence or absence of medical complaints on SMW generation in households and confirm that SMW generation did not differ significantly by type of house and room occupancy for the most part. Quantile regression provided a better picture of how a household characteristic influenced household generation compared to OLS regression.

Table 4.7 Regression coefficients* of household characteristics, OLS and by Quantiles and their respective p-values (n = 58 households)

Variable	OLS	q05	q10	q25	q50	q75	q90	q95
constant	6.343	0.857	2.720	3.488	6.628	7.971	11.568	13.371
p-value	0.000	0.391	0.005	0.000	0.000	0.000	0.000	0.000
Medical complaints	-3.236	-0.771	-2.006	-2.631	-4.318	-5.107	-5.940	-2.457
p-value	0.005	0.406	0.030	0.001	0.001	0.005	0.154	0.666
Type of house	-0.801	-0.086	-0.686	-0.749	-1.343	-1.823	-2.801	3.114
p-value	0.465	0.914	0.318	0.322	0.266	0.281	0.380	0.480
Room occupancy (category)	0.525	1.229	-0.029	0.403	0.320	1.621	2.546	0.743
p-value	0.634	0.214	0.973	0.614	0.776	0.342	0.488	0.868
R^2	0.1523	0.1824	0.1817	0.1559	0.1306	0.1106	0.1035	0.0695

**All coefficient values for the study attributes are multiplied by ($x\ 10^{-3}$). The coefficient of determination (R^2) in quantile regression models are Pseudo R^2. The probability values (p-value) support the hypothesis that the computed coefficient equals zero. A value of 0.05 or less indicates a statistically significant effect.*

4.1.5 Description of SMW recovered from household waste

Table 4.8 shows a profile of SMW recovered from the household bins (see also Figures 4.1-4.4). The items were grouped according to categories of SMW, form of delivery and pharmaceutical category. In the category of medicinal waste, antibiotics, multivitamins, analgesics, antifungal and antimalarial drugs were the predominant therapeutic categories. Others were anti-diarrhoeal medicines, antacids, anti-helminthics, anti-tussives (cough syrup), anti-diabetic and anti-hypertensive medicines. Some specific examples (in parenthesis) included anti-malarials (artesunate- amodiaquine), anti-diarrhoeals (loperamide hydrochloride), antibiotics (ampicillin) and cough syrup (diphenhydramine hydrochloride), anti-hypertensives (nifedipine), anti-inflammatory analgesics (diclofenac), ophthalmic drugs (sodium cromoglycate) and antifungals (griseofulvin).

Syrup bottles were recovered, most of which were either pediatric formulations of antibiotics, antipyretics, multivitamins and cough mixtures. In these cases, only the bottles with residue or content were weighed, the outer packaging was discarded with general waste as these were unlikely to be contaminated with the pharmaceutical ingredients. The tablets generally came in blister packets, dispensing envelopes, and a few were found loose. All packets in direct contact with medicines were included and where contents were not present, it was assumed that there was some residue from contact with the medicines contained in them.

Table 4.8 Components of solid medical waste from sampled households (n = 60 households)

Category	Description	Therapeutic categories				
Medicinal waste		Antimalarial	Analgesic/anti-inflammatory	Antibiotic	Antihypertensive	Others
	Blister packet, dispensing envelopes with residue	Artemether – lumefantrine Artesunate - amodiaquine	Paracetamol (acetaminophen); Ibuprofen Diclofenac Piroxicam Prednisolone	Cloxacillin Ampicillin Metronidazole Doxycycline Sulphathiazole Penicillin V Ciprofloxacin hydrochloride	Lisinopril Nifedipine Amlodipine	Aluminium hydroxide, Albendazole; Cyproheptadine; Multivitamins; Iron (III) hydroxide; Griseofulvin Postinor (levonorgestrel), Folic acid, Sildenafil Loperamide hydrochloride, Ketoconazole, Glibenclamide Metformin, Mebendazole
	Blister packet, dispensing envelopes with content (capsules, tablets)		Diclofenac Tramadol hydrochloride Ibuprofen	Flucloxacillin Metronidazole Amoxicillin + clavulanic acid Chloramphenicol Cotrimoxazole Penicillin V Ampicillin	Bendrofluazide	Metformin, Multivitamins, Zinc sulphate, Cyproheptadine Bisacodyl, Magnesia, Folic acid
	Syrups bottles with residue			Amoxicillin		Gentian violet, Multivitamin, Cough syrups (diphenhydramine hydrochloride)
	Others with residue			Eye drops: Chloramphenicol 5%; Gentamicin		Eye drops: Sodium cromoglycate)
						Topical creams: betamethasone diproprionate with gentamicin sulphate; clotrimazole
	Syrup bottles with content (liquid content > 5mls	Amodiaquine		Cetrizine Amoxicillin Metronidazole		Griseofulvin, Antacid
	Vials			Penicillin G		
	Infusion bag	Normal saline (0.9% NaCl)				
Sharp waste	Objects with potential to pierce or cut that came in contact with body fluids	Gentamicin ampoule (broken), , Needles (capped and uncapped) Syringes with needles attached, Used razor blades and shaving sticks				

Figure 4.1 Medicinal waste recovered from a household at the onset of the survey (October, 2014)

Figure 4.2 Full blister packs of Metformin tablets (anti-diabetic drugs)

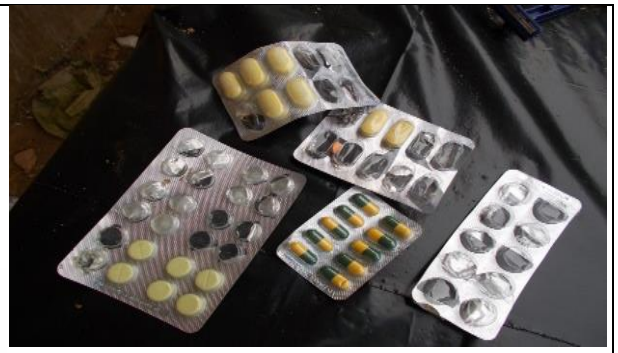


Figure 4.3 Antimalarials (artemether-lumefantrine) and analgesic (Tramadol) in blister packs

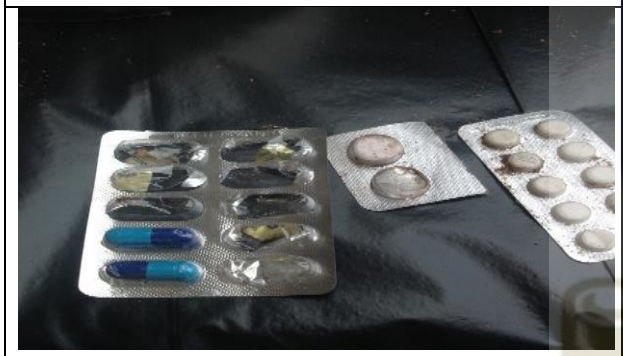


Figure 4.4 Antimalarials (artemether-lumefantrine) and analgesic (Tramadol) in blister packs

Figure 4.5 Needles and syringes recovered from household waste on the last day of the survey

Figure 4.6 An open refuse dump in the study area with a goat (left) and a scavenger (at the edge in the middle), located almost directly opposite a healthcare facility

Source: Field survey, 2014

Sharps recovered were predominantly razor blades. A few disposable shaving sticks were also present. Needles and syringes were recovered on the last day of the waste stream analysis from a single household (Figure 4.5). The individual wet weight measurements of medicinal, sharp and offensive waste for each household are listed in Appendix F.

Offensive waste was mostly soiled baby diapers, with a smaller fraction of tissue paper, sanitary pads and cotton buds. In one household, it comprised of plaster most likely involving an ulcer on a limb. Male condoms were found on two disposal events. In one of these, it was accompanied by a packet of sildenafil a drug used to treat erectile dysfunction and pulmonary arterial hypertension. A packet of Postinor (levonorgestrel) was also found with minimal residue. Postinor is a female contraceptive used for emergency contraception. Two cartridges were found, which could have been pregnancy test cartridges. The outer packaging was not found for identification. All photographs of offensive waste have been included in Appendix 17. Other observations included a long wrap of bandage soiled with serous fluid presumably from an ulcer; full, single infusion bags containing normal saline found on two disposal events (once in the wet season and once in the dry season) and one pair of examination gloves. The intravenous infusions were not accompanied with intravenous tubing or cannulae. Figure 4.6 shows a dumpsite with where both SMW and HSW are co-disposed. In the background are a female scavenger recovering items for secondary use and a goat foraging for food.

4.2 Objective 2: Disposal options for solid medical waste from household and community sources

Background characteristics of the respondents (household members, TBAs and CSVs) have been presented in the sections following. Next, the results of the quantitative and qualitative studies (FGDs and interviews) pertaining to storage, collection and disposal of SMW by households and community sources (TBAs and CSVs) have been presented.

4.2.1 Characteristics of survey participants

A total of 600 households with a population of 3241 persons were involved in a questionnaire survey. Respondents were predominantly female 411 (68.5%), of the Ga ethnic group 195 (32.5%), married 341 (56.8%), Christians 530 (88.3%) and were mostly traders 155 (25.8%). More than half of the respondents had secondary level education 322 (53.7%). Two hundred and fifty (41.7%) households reported they had visited a chemical shop vendor in the fortnight before the survey, while 99 (16.5%) households reported they had visited a health facility. Of the households that reported a visit to the chemical shop vendor, 133 (22.2%) had self-prescribed the medicines.

4.2.2 Characteristics of FGD participants (Household members)

Four FGDs were held with 2 groups each of male and female members of households, comprising a total of 17 males and 12 females. Ages across all groups ranged from 27 to 64 years, with the majority aged between 27 and 42 years. The major occupation was trading. All participants except five persons had attained secondary level education.

4.2.3 Characteristics of FGD participants (TBAs)

Ten TBAs were interviewed comprising 8 females and 2 males whose ages ranged between 42 and 69 years. While half of the TBAs had attained secondary education,

others had basic or no formal education. They provided supportive care to pregnant clients (2-12 women monthly) and attended a few deliveries (1-5 deliveries monthly) since most women had institutional births. One TBA had worked for only 2 years, while all others a minimum work experience of 6 years. Three TBAs were interviewed in September, 2014, following the household surveys (first group), while others who were interviewed in January, 2015, also participated in the FGDs (second group).

4.2.4 Characteristics of FGD participants (CSVs)

A total of eight CSVs were interviewed, comprising 5 males and 2 females. The first group were interviewed in September, 2014, while the rest were interviewed in January, 2015. Of the five interviewed in the second group, three participated in a FGD. All CSVs were educated with a minimum of secondary level education. CSVs described their role in the community as supportive as they were often the first contact for minor ailments and injuries. They were also approached when households could not afford to go to the hospital.

4.2.5 Storage of solid medical waste in households - results from surveys

Different items were used to store waste in the households with the majority using a bucket with/without a lid 197 (32.9%), a sack or cellophane bag 142 (23.7%) standard bins provided by waste collection companies 116 (19.3%), followed by a basket, basin or carton 73 (12.2%). Others used a pit 38 (6.3%), an empty gallon 21 (3.5%) or nearby bush 9 (1.5%).

4.2.6 Storage of solid medical waste in households - results from FGDs

FGDs held with members of households confirmed results of the quantitative methods pertaining to storage, collection and disposal of SMW. Among the five female

participants, three of them reported they had different ways of storing household waste which included the use of a bucket, standard bin and cellophane bag. Solid medical waste (SMW) was mixed with household waste. Discussions with the male members of households unfolded challenges with waste storage. Of the nine male members of households, two confirmed that people dump refuse in the gutter and surroundings when it rains, the main reason being that people in their part of the community did not have refuse bins.

4.2.7 Collection of solid medical waste from households – results from surveys

When removed from the household, respondents reported that the waste was deposited at communal collection bins, 258 (43.0%), picked up by refuse trucks, 208 (34.7%), and dumped in a nearby bush or gutter, 22 (3.7%). Where it was not removed, it was burnt or buried on site, 109 (18.2%). Conveyance to the disposal point was often undertaken by adults members of the household aged older than 20 years, 402 (67.0%) and adolescents, 161 (26.8%) and 4 (0.7%) children aged below 10 years.

4.2.8 Collection of solid medical waste from households – results from FGDs

During the FGDs, householders in both sub-groups expressed dissatisfaction over waste collection. It was scheduled to be done weekly, but it was often delayed. A female householder expressed it in these words:

"*Sometimes the refuse will be there for two weeks and they won't come for it and therefore I send it to the communal bin*…." (Female participant, 39 years, trader).

Two male householders also shared their views about the delays in waste collection and its consequences for the public:

"*The waste management companies do not come for the waste on time. Sometimes for weeks or a month, they haven't come for it.*"(Male participant, aged 27 years, trader)

"*The waste management companies do not come for the waste on time when the bins are full, so people fall sick and lose their life from diseases like cholera and for that reason they do not pay for the waste and dump it in the rain.*" (Male participant, aged 34 years, computer technician).

4.2.9 Interviews with key informants at private waste management companies on household waste collection

As SMW was mixed with household waste, household waste collection included SMW. To further explore challenges with waste collection reported by participants of FGDs with household members, interviews were held with 5 key informants representing the waste management companies assigned in the study area. The interviews confirmed some of the challenges with waste collection reported by households (Table 4.9).

The schedule of weekly collection from residential premises was often interrupted during the rains because of the difficult terrains. Some parts of GSMA were waterlogged during the rains. The heavy compactor trucks often got stuck in the mud and it took several days to dislodge. To avoid this problem, some of the contractors had an arrangement with households to bring their refuse bins to an agreed location close to where the compactor truck could be parked. The waste contractors then used their staff to move the refuse bins to the truck for emptying and returned the bins to the agreed location after they had been emptied. This was an arduous manual task. Occasionally if a truck got stuck, some parts got stolen before the contractors were able to remove it from the location.

Table 4.9 Summary of key informant interviews at solid waste management companies, 2014

Solid waste contractor	Areas of service in the municipal	Service provision	Challenges
A	New Oblogo, White Cross, Choice, Mandela, State Construction Company Estate, Azuma, Kalabule Part of Galilea, Right from Weija towards Kasoa	Registration of users Bin provision Waste collection: weekly from residential premises	Affordability of monthly dues for users (GHC15) Difficult terrain Staff shortage Inadequate landfill sites Payments at the landfill sites (GHC12 per ton of waste) Attack by landguards
B	Top base, Djaman Weija, New Weija Bulame, Zero house, Part of Constructional Pioneers	Registration of users Bin provision Waste collection: weekly from residential premises	Inadequate dump sites Payments at the landfill sites (GHC 15 – 18)
C	Gbawe New Town, Lafa, McCarthy Hill/Mallam, Part of Top base, Oblogo/Manchester	Registration of users Bin provision, house stickers; Waste collection: weekly from residential premises; more often from commercial premises	Difficult terrain, especially during the rains (June/July) Breakdown of compactor trucks
D	Beach drive Estates Tuba Junction & Township, Brigade Iron City, Galilea Market Area	Registration of users Easy payment plan Bin provision, house stickers Waste collection: weekly from residential premises	Difficulty getting users to pay for services Difficult terrains during rains Inadequate dump sites Payment at dumpsite (GHC 20)
E	McCarthy Hill (south), Sampa Valley, Mendskrom, Old Barrier, New & Old Aplaku, New & Old Bortianor, GBC Towers, Tuba Junction, Mallam Junction after bypass	Registration of users (sometimes free) Bin provision, house stickers Waste collection: weekly from residential premises	Difficult terrain during the rains Limited access to landfill sites due to long queues, some sites do not open on Sundays

To address the problems of storage, all the companies registered and provided users with refuse bins (240 litres) at a rate of GHC5 ($1.32). There were two companies (D and E) that provided free bins to households that were unable to pay. At D, an easy payment plan existed for those who preferred the more sturdy bins which came at higher costs (GHC150 – GHC 220 or $39.47 - $57.89). This plan enabled households to spread payment over 4 months. Most of the contractors mentioned the inability of some households to pay for the weekly collection of refuse. Company B had devised a method which ensured at least 80% compliance with payments. A warning notice was given after a missed payment, followed by a court action if the default exceeded one month.

Final disposal was a major challenge to all the waste contractors who bemoaned the inadequate landfill and dump sites. At the landfills, payments had to be made (in proportion to the waste load) before clearance was given to empty the truck's contents. Various charges were mentioned by the waste contractors which were not deemed cost effective based on the rates assigned by the Municipal Assembly. They all emphasized that it had become necessary to review households' payment rates upwards, but this had not happened at the time of the interview. Other dump sites existed but were not functional, leaving the landfill site at Kpone, Tema as the only functional site at the time of the report. This implied a long travel distance (up to one and a half hours) and long queues making it impossible to meet the weekly collection schedule.

4.2.10 Disposal of solid medical waste in households – results from surveys

Reuse of old medication bottles and disinfectant containers was reported in 23 (3.8%) households, while selling of medication bottles was reported by 6 (1.0%) households. Forty seven households (7.8%) reported bringing home placenta after delivery, in which case all but one reported that the placenta was buried. The survey did not cover other forms of anatomical waste like fetuses and removed body parts.

Table 4.10 shows the disposal options for the types of SMW. Four hundred and eighty one (80.2%) respondents discarded unused medications in a household bin. Thirty four respondents (5.6%) reported giving unused medicines out to other people who needed them. Nearly nine of out ten households (89%) discarded sharps in the household bin. Blood soaked items were reportedly discarded in the dustbin, 250 (42.2%), but also burnt or buried, 200 (33.8%).

Table 4.10 Disposal options by category of solid medical waste

Waste category	Number of respondents	Dustbin N (%)	Burn/Burial/Others N (%)	Not applicable N (%)
Sharps waste	600	534 (89.0)	56 (9.3)	10 (1.7)
Medicinal waste	600	481 (80.2)	113 (18.8)	6 (1.0)
Soiled items	582	454 (78.0)	116 (19.9)	12 (2.1)
Blood soaked items	592	250 (42.2)	240 (40.6)	102 (17.2)
Disposable items	593	395 (66.6)	162 (27.3)	36 (6.1)

N = number of respondents, (%) = percentage; 'Others' in each category: sharps waste = drop anywhere - 2, bush -5; unwanted medicines = drop in the gutter - 1, toilet - 1, keep them - 2, bush - 7, give out to others - 34; soiled items = bush - 1, toilet - 1; blood soaked items = toilet – 35, bush – 5; disposable items = toilet – 22, bush – 6, unspecified – 1.

Among respondents who reported discarding unwanted medicines and sharps in the household bin, 139 (23.2%) and 210 (35%) discarded them loosely (without containers) respectively. Out of 582 respondents, 409 (70.3%) reported that soiled items were wrapped or discarded in a container.

4.2.11 Disposal of solid medical waste in households – results from FGDs

Other than the household bin, other options of managing SMW reported by participants were selling the empty medicine bottles to vendors, throwing unwanted medicines into the refuse bin, backyard burning, and dumping them in an empty plot or anywhere in the surrounding. The dosage forms of medicines influenced the ways in which they were handled when discarding them. A female participant and a male participant stated respectively:

"…*The expired ones are buried in the ground. I also empty the expired liquid medicines into the gutter and wash the bottle before I throw it away*." (Female, aged 39 years, JSS).

"…..*I empty syrups into a bowl of water and throw it away with the water. The tablets are thrown in the bin and the waste companies will come for it*……" (Male, aged 64 years, post-secondary education).

Participants from the FGDs reported different ways of disposing sharps:

"*If I see blade, I wrap it and throw it away*." (Male participant, aged 52 years, sprayer)

"*If I see a syringe, I take the needle off and throw it in the latrine*." (Male participant, aged 42 years, herbalist)

Offensive waste investigated in the study comprised of soiled items (e.g. bandages), blood soaked items (e.g. sanitary pads) and disposable items (e.g. condoms). Most of these items were reportedly wrapped before disposal:

"*We wrap it* [bandages] *and burn it*." (Female participant, aged 55 years, trader). However, during the waste stream analysis, most bandages were found loosely discarded in household waste. Sanitary pads were not found in some of the household waste bags, though the seals for the inlay and plastic wraps were seen suggesting that they had been used, but disposed by alternative means. This was confirmed by female FGD participants:

"*Dogs can come for all these items if not kept well. Because of this problem, we dig a pit at home for all bandages and wrap sanitary pads and Pampers and throw them into the pit*…." (Female participant, aged 39 years, trader).

"*I wrap and bury them*" (Female participant, aged 45 years, trader)

Male participants reported discarding condoms in the toilet or refuse bins:

"With the used condom, we put it in the toilet, and also sometimes you will find them floating around in rain water. […]" (Male participant, aged 39 years, car dealer)

"*I mix it with household waste and discard it*." (Male participant, aged 34 years, computer technician).

FGDs revealed that although household bin was the main method of disposal in the household, SMW was also discarded in other ways depending on the type of waste. For instance, a male participant stated how he disposed of unwanted medicines in these terms: "Any place I find, I will throw it [*unwanted medicines*] there."

Another male FGD participant grouped residents into three categories in relation to waste disposal: those registered with waste contractors and had their waste picked up every

week, those who register with waste contractors but also burn refuse in their compound and those who are not registered with the companies and either leave their waste in front of a house that is registered with a waste contractor (at night) or throw waste into empty plots around their home.

Furthermore, participants reported that placentae from childbirth was usually buried by the birth attendant, female relative or spouse:

"*I stayed with a woman who helps with childbirth so when I delivered, she buried them herself.*" (Female participant, aged 45 years, trader)

"*I delivered twice by myself. My grandmother dug a special pit for all those things [afterbirth]. She buried them herself. She doesn't allow anyone to do it because she believes it can cause problems.*"(Female participant, aged 39 years, trader)

"*I just put it in a rubber [cellophane] bag and then bury it in the ground.*"(Male participant, aged 28 years, trader).

4.2.12 Disposal of solid medical waste by TBAs – results from FGDs

TBAs confirmed the reports made by members of households, elucidated the way placentae were treated and a traditional belief underlying the practice. TBAs reported discarding placentae, gloves, absorbent materials and sharps used to assist their clients in childbirth. Placentae and sharps were buried in the compounds of their clients, as TBAs often visited their clients at home. Other potentially infectious waste was either buried or burnt (Table 4.11). For women who had facility births, the placentae were usually disposed in a placenta pit at the healthcare facility if one was available.

Table 4.11 Disposal of solid medical waste by traditional birth attendants

Respondent	Pathological waste	Pharmaceutical waste	Sharp waste	Potentially infectious waste
First group				
TBA (A)	Buried	N/A	Buried	Buried
TBA (B)	Client takes it home	N/A	Buried	Burnt
TBA (C)	Buried	N/A	Buried	Buried
Second group				
TBA (1)	Buried	N/A	Buried	Buried
TBA (2)	Buried	N/A	Buried	Buried
TBA (3)	Buried	N/A	Buried	Buried
TBA (4)	Buried	N/A	Buried	Buried
TBA (5)	Buried	N/A	Buried	Buried
TBA (6)	Buried	N/A	Buried	Buried
TBA (7)	Buried	N/A	Buried	**Reused

** N/A = Not applicable; **In reference to sanitary waste such as sanitary and maternity pads. Some rural women use cloth which is usually washed and reused unlike sanitary pads which are discarded after use.*

In the clients' compounds, there was usually no designated pit for placenta, so it could be buried in more than one place in the compound:

"*We don't have one pit for all the placentae. We dig different pits*." (Male TBA, aged 62 years, secondary education)

"*The reason we don't put them in one pit is that it takes time for us to get deliveries and we will be called to the person's house to do it there. So after that we bury it there.*" (Female TBA, aged 50 years, basic education)

One female TBA mentioned that the way the placenta was buried was important. She reported a traditional belief that the placental stump had to be buried facing upwards so that the mother could still conceive another child:

"I drop the placenta carefully into a pit by not turning upside down. If it is turned upside down, there is a traditional belief that the woman will not be able to conceive again." (Female TBA, aged 49 years, no formal education)

All the TBAs affirmed that sanitary napkins were discarded in pit latrines. One of the TBAs stated:

"*I have not used pad before, but my children use it and after using them [sanitary pads], they throw the in the pit latrine.*"(Female TBA, aged 49 years, no formal education)

The TBAs indicated that sanitary items were buried to prevent malodor. One of the TBAs reported securing the burial spot to prevent the materials from being exposed:

"*If we don't bury them, even the smell can make you sick.*" (Female TBA, 42 years, basic education)

"*After burying them [sanitary pads], I put stones on it so that animals cannot dig it out or erosion can't bring it out again.*"(Female TBA, aged 50 years, basic education)

Therefore it was not surprising that all TBAs agreed that they had not found sanitary items or SMW littered indiscriminately in the communities where they worked. Regarding women who did not use sanitary pads, pads were made out of old cloth which they washed with soap and disinfectant and re-used:

"*They* [women who do not use sanitary pads] *use torn cloth and after that they wash with soap and Dettol* [antiseptic/disinfectant] *and reuse.*" (Female TBA, aged 42 years, basic education)

None of the TBAs reported any difficulties with managing SMW in their respective practices.

4.2.13 Disposal of solid medical waste by CSVs – results from interviews and FGDs

The main type of SMW generated from their stores was pharmaceutical waste. Other than this, it was mostly packaging and cartons that came with medicines when they were procured or left behind by clients. These were often disposed as general waste. Three of the eight CSVs burnt pharmaceutical waste, while two CSVs discarded them in dustbins alongside general waste. Sharp waste and potentially infected waste were reportedly uncommon, but where present these were often burnt (Table 4.12).

Table 4.12 Disposal practices of chemical shop vendors

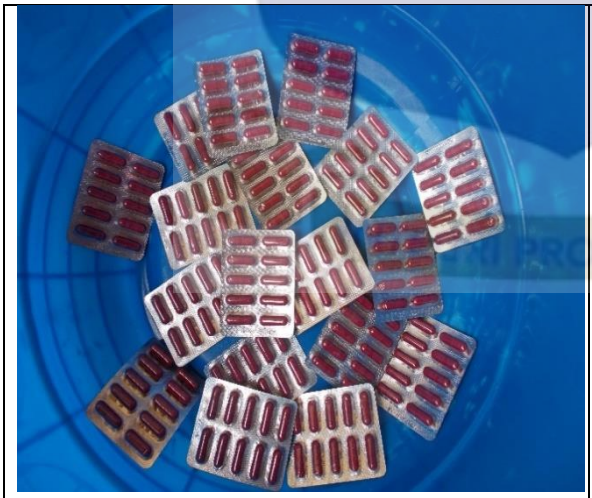
Respondent	Pathological waste	Pharmaceutical waste	Sharps waste	Potentially infectious waste
First group				
CSV (A)	N/A	Burnt	Not used	Burnt
CSV (B)	N/A	Returned to clinic*	Returned to clinic*	Returned to clinic*
CSV (C)	N/A	Burnt	Not used	Burnt
Second group				
CSV (1)	N/A	Dustbin	N/A	N/A
CSV (2)	N/A	Burnt	Dustbin (placed in a container)	Burnt
CSV (3)	N/A	Dustbin	N/A	Dustbin (wrapped)
CSV (4)	N/A	No unwanted medicines	Burnt	Burnt
CSV (5)	N/A	Return to suppliers	Burnt	Burnt

*N/A = Not applicable; *A clinic outside the municipal receives their waste and takes responsibility for disposal. N/A = Not asked in the respective questionnaires*

During interviews with the first group of CSVs, it was reported that bottles of syrups were buried after emptying the syrup in a sink. One CSV returned pharmaceutical waste to a clinic outside the municipal for disposal. The CSV disposed of general waste at a

centralized container using the services of a motor cyclist. Two CSVs did not dispose sharps waste as they claimed they did not handle sharps in their practices. CSVs noted unpleasant odors from backyard burning of pharmaceutical waste, but felt their disposal options were limited. They declined to offer drug return services to households in their communities, because of difficulties they had with disposing their own waste.

Interviews with the second group revealed that expired medicines were dumped in the dustbin, burnt or returned to suppliers. One of the 5 CSVs claimed the medicines in his shop hardly ever expired because they were sold out before then. During an interview, one CSV mentioned the use of malaria test kits in her shop. When asked what happened to the cartridges afterwards, she reported that the program picked up the any waste generated during monitoring visits. Most of the CSVs who were interviewed in their shops had nearly empty bins at the time of the visit. When waste was present, it was packaging or general waste (Figure 4.7). The CSVs in this group did not report any dissatisfaction with their method of SMW disposal.



Expired vitamin and mineral supplements recovered from waste at a chemical shop

The supplements with empty packaging from other medicines recovered from waste at a chemical shop

Figure 4.7 Expired medicines and packaging collected from a chemical shop vendor's waste

During an FGD with CSVs, they reported that when general waste and expired medicines were discarded in the dustbin, the services of informal waste porters called "kaya borla" (Figure 4.8) were used. The waste porters charged fees by the volume of the waste load which was determined by visual estimation:

"*They* [kaya borla] *bill according to the load of waste…they don't weigh…but they look at it [waste] and they will say "GHC 2", and then we will pay…..sometimes we bargain*."

(Female CSV, aged 68 years, senior secondary education).

The waste porter's vehicle parked during waste collection from a residential area and kiosks

A vehicle used by a porter making its way through traffic close to a market

Figure 4.8 Motorized vehicles used for waste collection by waste porters ("kaya borla")

Expired medicines were burnt either in the yard where the shop was located or elsewhere (at the residence of the owners):

"……..*it is not good for expired drugs to be kept for a long time because some of the drugs give a bad odour, so we burn them…….When we store expired drugs, I take them to the house. In the house we have a big pit that we burn them in….so I don't have any problem with the community*."

(Male CSV, aged 22 years, senior secondary education)

"*It is ok, I burn* [unwanted medicines] *behind the shop*." (Male CSV, aged 31 years, senior secondary education)

One of the CSVs mentioned reported her inability to burn pharmaceutical waste at the location of the shop due to the cluster of shops in the vicinity:

"*Normally, expired goods in my shop are not burnt since we are many around the place, we don't burn things like that. I add it to the rubbish…. But if it is syrup, I pour it out and add the bottle to the rubbish.*" (Female CSV, aged 68 years, senior secondary education)

All the CSVs indicated that they did not deal with sharps as they were not authorized to do so. They reported that they sold bandages, but that these were purchased and taken away. As such they were not routinely discarded in their shops. Other potentially infectious waste, if present was burnt.

4.3 Objective 3: Estimation of the relative proportion of household members reporting harm due to solid medical waste at household and community levels

The background characteristics of participants are the same as for objective 2. The results pertaining to objective 3 are presented in the same order as for objective 2, starting with household members, then TBAs and CSVs.

4.3.1 Harm from SMW reported by household members

Harm from SMW was reported for the past month and categories included accidental poisoning, piercing injury/needlestick, foreign body in the nose/ear, fire or explosion and others for options other than those listed. Table 4.13 shows the number and relative proportion of households that reported harm associated with SMW in households, and in the community.

Respondents from 29 households (4.8%) reported harm from SMW within the household, affecting 32 household members. Given a sample population of 3241, reporting rates for harm from SMW in the household was 10 per 1000 household members (or 1 per 100 household members) in the past month. The harm reported involved cuts from razor blades in most of households affected, 11 (1.8%). In two households, more than one individual was reportedly harmed by sharp waste (needles and razor blades). In the households only one case of accidental poisoning from medication was reported.

Respondents from 16 households (2.7%) reported harm from SMW found outside their household, but within the community where they reside. This affected 16 household members as only one person was affected in each household. Therefore reporting rates for harm within the community in the past month was 5 per 1000 in the sample population. Harm was mostly attributed to broken medication bottles/glass, 9 (1.5%).

Table 4.13 Items of solid medical waste reported to have caused harm in households and the community

Item causing harm	**In the household Number (%)**	**Individuals affected**	**In the community Number (%)**	**Individuals affected**
Needle (with or without syringe)	7 (1.2)	8	4 (0.7)	4
Broken medication bottle/glass	10 (1.7)	10	9 (1.5)	9
Used razor blade	11 (1.8)	13	2 (0.3)	2
Other specify	1 (0.2)*	1	1 (0.2)**	1
Not applicable	571 (95.2)		584 (97.3)	

*Medication (tablets), **Sharp/cutting instrument

In most of the households reported that harm from SMW encountered in the community, most incidents occurred in an open field 8 (1.3%). Others incidents were reported to have occurred along the road, 4 (0.7%) and near a refuse dump, 3 (0.5%). One respondent was unable to specify the actual location.

4.3.2 Diseases perceived to be associated with SMW by household members

Each respondent was asked about diseases which can be associated with SMW and body fluids. Respondents were allowed to list up to five diseases, but most listed three diseases. Each disease is presented as a relative proportion of the total responses and the relative proportion of respondents who listed it (Table 4.14). The top three diseases listed were tetanus (48%), HIV/AIDS (45%) and tuberculosis/chronic cough (23%).

Table 4.14 Diseases reported by respondents to be associated with solid medical waste

Diseases	Number of responses	% of responses (n=806)	% of respondents (n=600)
HIV/AIDS	267	33%	45%
Tetanus	287	36%	48%
Tuberculosis/Chronic cough	139	17%	23%
Hepatitis B	27	3%	5%
Mild cough/Catarrh	14	2%	2%
Skin rashes/infections	7	1%	1%
Diarrhoeal disease	12	1%	2%
Other infectious/febrile diseases	39	5%	7%
Other not categorized	14	2%	2%

Among the items (solid medical waste and offensive waste inclusive) considered a problem in the community, condoms ranked highest (19%), used blades ranked second (13%) and soiled diapers ranked third (11%) (Table 4.15). Altogether offensive waste (condoms, diapers and sanitary pads) constituted a major concern to household members, compared to sharp waste (39% vs. 25%).

Table 4.15 Solid medical waste and offensive waste considered a problem in the community

Items	Number of responses	% of responses (n=387)	% of respondents (n=600)
Broken medication bottles	59	15%	10%
Used condoms	112	29%	19%
Soiled diapers	67	17%	11%
Used sanitary pads	51	13%	9%
Used blades	75	19%	13%
Needles/syringes	10	3%	2%
Others*	13	3%	2%

*Unclear how to categorize

4.3.3 Harm associated with solid medical waste by household members – results from FGDs

Participants mentioned HIV, tetanus and skin rashes as potential infections associated with SMW, particularly with regard to sharp waste.

"*We should throw away blades or it can cause HIV/AIDS*." (Female participant, aged 35 years, trader)

"*If there is blade in it, it can hurt us. It can give us tetanus."* (Male participant, aged 52 years, sprayer)

"*We can get HIV or even debolah* [Ebola]." (Male participant, aged 31 years, pastor)

Other hazards suggested were penetrating injuries from cuts and needles, as well as acute poisoning from expired medicines:

"*With the medical needle, our children can pick it and inject themselves and if the person who used it before has any diseases, they can also be infected by it*."(Male participant, aged 34 years, computer technician)

"*Some medicines are too potent and if care is not taken, children can pick them and swallow which can kill them*."(Male participant, 64 years, businessman)

"*Expired drugs are poisonous, so we should handle them with care.*" (Male participant, aged 24 years, trader)

The suggestion of penetrating injuries supports the high ranking of tetanus and HIV (Table 4.14). Participants appreciated that inadequate disposal of SMW had adverse consequences leading to hospital visits and avoidable medical expenses:

"*If we don't take care of the* [medical] *waste and the children get hurt, we will spend a lot, so we should keep it well.*" (Female participant, aged 38 years, trader)

"*We will save money by not going to the hospital.*" (Female participant, aged 35 years, trader).

Regarding offensive waste, participants also reported they were concerned about children picking up condoms, playing with them, and getting infected from this exposure which further supports the high ranking of condoms as a problem in the study area (Table 4.15). As one participant reported:

"*If I see condoms anywhere, I use a polythene bag and wrap it and throw it away.....because children can take it and play with it, and it can give them sickness.*" (Male participant, aged 42 years, businessman).

One participant enumerated the hazards of both SMW and offensive waste this statement:

"*Not everybody likes to see blood and it can make a person vomit. Also some of our children like to play at the dumpsite and risk being pierced or getting diseases*."(Male participant, aged 39 years, car dealer).

Additionally, comparisons were made to indicate the severity of harm posed by SMW:

"*….Last time a nail pierced my brother's leg and it got swollen. These medical items can be more dangerous than that, which is why we should be neat. Medical items can cause skin rashes*……." (Female participant, aged 54 years, ward assistant)

4.3.4 Perspectives of TBAs on harm associated with solid medical waste – results from FGDs

All TBAs associated exposure to SMW with potential transmission of HIV/AIDS because they were often saturated with blood. In order to minimize exposure to body fluids, two of the TBAs in the second group reported that they had been trained to use examination gloves to prevent exposure to body fluids. They also identified pests as hazards associated with SMW:

"*If we don't handle it well, houseflies can spread disease by coming into contact with the items*."

(Male TBA, aged 62 years, Form 4)

4.3.5 Perspectives of CSVs on harm associated with solid medical waste – results from FGDs

CSVs were asked if they had noticed SMW lying indiscriminately in the community. One CSVs responded that people bought medicines because they needed them and often could not afford to buy much, therefore it was unlikely that they would leave behind any medicines, much less discard them. Another reason was that left over medicines were kept for other members of the household to use:

"*For the medicines disposed of in the community, I don't see because sometimes they keep it for others to use.*" (Female CSV, aged 68 years, post-secondary)

Other CSVs affirmed that they had not seen any medicines lying around in the community.

However, they acknowledged that the primary concern about SMW in uncollected waste was children meddling with it:

"....because there are children walking around who will try to pick, thinking it [tablets] is toffee." (Male CSV, aged 22 years, SSS).

It was also reported that domestic and stray animals, such as dogs, interfered with the refuse bins:

"*…I don't think it will be [a problem], because the bins are covered. Sometimes the dogs spoil them.*" (Female CSV, aged 68 years, post-secondary).

4.4 Stakeholder views about segregation of solid medical waste at source as a potential management option at community level

Results are based on interviews with key informants of the private waste management companies assigned in the study area as well as focus group discussions with household members, TBAs and CSVs. Participant characteristics have been described in earlier sections. Table 4.16 summarizes the views of participant groups regarding segregation of SMW at source as a potential management option in the household and other settings in the community. The interviews with the key informants at the waste management companies were extracted from the same interviews reported in Section 4.2.9. The FGDs with TBAs and CSVs were the same as those reported in Sections 4.2.12 and 4.2.13.

Table 4.16 Participants' views about segregation of solid medical waste at source as a potential management option at community level

Target group	Facilitating factors	Barriers
Households	Community education	Difficulties with storage
	Provision of required logistics	Time consuming
	Subsidized collection cost	Lack of logistics
		Difficulty remembering to segregate
		Physical harm
		Affordability
Private waste companies	Business opportunity	Willingness of households to pay
	Final disposal site	
	Marginal cost recovery	
Traditional birth attendants	Having a placenta pit at the health center	Distance to the facility
	TBAs permitted by facility staff to use the pit	Existing norms
		Housing tenure
Chemical shop vendors	Not applicable	Lacked support for 'take back' of unwanted medicines from community

4.4.1 Perspectives of household members on segregation of solid medical waste

Ways of segregating SMW in the household as listed by participants were: wrapping medicinal waste and burying or burning it in a pit, informal recycling of medicine bottles and the use of a separate bin. The hazards posed to children and potential transmission of diseases were noted as the main reasons to justify potential segregation of SMW as a management option. In spite of these reasons, their attitudes towards its potential practice was different. Their experience of waste collection and final disposal shaped their judgement about its potential practicality. When asked their views about separating SMW from HSW, some of the participants stated:

"*In my home, we don't separate, because we feel it is all waste.*" (Male participant, aged 48 years, businessman)

"*If we say we are separating* [SMW], *where will we take it? Therefore I think we should gather all and burn in a pit, and the ones which do not burn will be left in the pit.*" (Female participant, aged 38 years, trader).

"*Even if you separate normal waste from it* [SMW] *in homes, the waste collector come for it with one vehicle where the two separate wastes are kept together, so there is no need for separation. They will mix them because they use only one vehicle for the waste*." (Male participant, aged 34 years, computer technician).

The time that would be consumed segregating SMW was a potential barrier reported by male participants:

"*…the time one will have to separate two* [types] *of waste is a big problem*."
(Male participant, aged 34 years, computer technician)

"*Some people don't have time to separate it* [SMW]*."*
(Male participant, aged 42 years, herbalist)

Yet another potential barrier was the lack of equipment to support segregation of SMW at source as stated by the participants:
"*I have one bin, so I put all waste together*." (Male participant, aged 40 years, village elder)

As participants enumerated potential barriers, their gender roles in waste management emerged and appeared to influence the concerns they raised. Male members of households provided direction, created awareness about issues in the household, and were responsible for paying for waste collection.

Regarding the directing role, one of the male participants emphasized it in these words:

"*We men, should tell them* [wives] *what to do*." (Male participant, aged 42 years, driver).

Therefore, there was the possibility of forgetting to direct the household to separate SMW:

"…….*One problem is forgetfulness on our part*." (Male participant, aged 28 years, trader)

Regarding awareness and cost of collection, some male participants stated the following:

"*Our level of education about waste separation is low. So we must all get bins in our houses and also the money the waste management companies collect is a big problem in this area*." (Male participant, aged 39 years, car dealer)

"*There will be money problems in getting separate waste bin and paying Zoomlion* [private waste management company]."(Male participant, aged 24 years, trader)

"*Before separation* [of SMW], *we should create awareness*." (Male participant, aged 42 years, driver)

"*I think the government should help because the private companies charge a lot."* (Male participant, aged 52 years, sprayer)

The female gender roles included directly supervising and/or undertaking the cleaning of the home as illustrated in the following statements:

"*You are supposed to do that* [manage waste in the household] *if you are a woman: washing, sweeping and cleaning utensils*." (Female participant, aged 38 years, trader)

"*If the town council comes to our houses, they question the woman* [about the state of the environment]." (Female participant, aged 35 years, trader).

Therefore, women were more concerned about the practical issues surrounding the potential separation of SMW. One of the critical issues was separate storage of SMW. Providing a separate location in the house or compound to store SMW would prove difficult particularly for people living in rented accommodation:

"*My house is rented so the separation* [of SMW] *is a problem….there is a storage problem*." (Female participant, aged 38 years, trader)

"*During separation, we have to get a particular place for storage*." (Female participant, aged 30 years, social volunteer)

"*I can't dig a pit in my house because I live in a compound house. Therefore I wrap them* [SMW] *or put it in a box and dump in a dustbin. It is important to wrap it because children can go near and sometimes play with them*." (Female participant, aged 25 years, trader)

Female participants had a different view about segregation of SMW in the household because of children. One participant pointed out that within the household, children were less likely to interfere with SMW if it was left in the dustbin. She reported that children were told that anything in the household bin is waste and should not be meddled with. In addition, when SMW was mixed with household waste, it was hidden from view. Other participants in the group agreed with this view. Another view was the possibility of an injury occurring if SMW is separated, especially with sharps. Therefore, disposing SMW with HSW would ensure that children avoided it since it was mixed with other waste in

the dustbin. In conclusion, female participants agreed it was sufficient to wrap SMW and discard in the household bin.

However, the male FGD participants expressed willingness to segregate SMW if adequate education and equipment were provided to do so:

"*If you tell us the ones to separate, we will*." (Male participant, aged 31 years, pastor)

"*If you tell us the reason why we should do it, we will*." (Male participant, aged 48 years, businessman)

While the participants had divergent views about segregation of SMW in the household, they all agreed that household and community education would be helpful in improving management of SMW as indicated in the following excerpts:

"*I think you should come and help educate the community about this* [management of SMW]." (Male participant, aged 31 years, pastor)

"*I think you should come to my area to study and talk to the community about all these problems* [hazards associated with SMW]." (Female participant, 25 years, trader).

"…….*It helps prevent diseases among ourselves*." (Female participant, aged 30 years, social volunteer)

"*We are educating ourselves here, now we should go out to the communities to educate others*." (Male participant, aged 28 years, trader).

4.4.2 Perspectives of key informants at private waste management companies on segregation of solid medical waste

At the waste management companies, all key informants stated that if SMW were to be collected separately, it would have to have a disposal point. A key informant at one of the private waste companies disclosed that plans to provide a treatment facility for SMW in the country's capital city were advanced. When asked if SMW from households could be accepted at the plant, a new need emerged. It was speculated that a depot may be necessary to accumulate quantities from districts which could then be conveyed to the treatment facility in scheduled deliveries. This would entail separate planning as it was not considered in the original plan for the treatment facility. Notwithstanding, all the companies perceived source segregation as a business opportunity and were willing to collect SMW separately from households if costs could be recovered with a marginal profit. Noting that the quantities generated would be small, some suggestions were proposed as potential ways of collecting the source segregated SMW in households.

The use of smaller vehicles for collection such as the 'Bola taxi' was recommended and considered to be more cost effective than deploying a compactor truck. The 'Bola taxi' is a motorized cart often used for waste collection within smaller neighborhoods and informal settlements where surface access is more difficult. Another option was to designate one company to be responsible for SMW collection in a municipal/district assembly. A major concern raised by all key informants was the ability of the households to pay for the services when provided. It was hypothesized that a separate collection would attract an additional cost which would only worsen the existing difficulties the companies faced with households paying for weekly collection of household waste.

4.4.3 Perspectives of TBAs on segregation of solid medical waste

TBAs were asked about the possibility of using a placenta pit at a health center near them, so that all the placentae were confined to a particular location, where it could be managed appropriately. At the time the focus group held, there was no placenta pit at the nearest health centre which was a limitation. One TBA was doubtful about the health centre staff allowing them to use the placenta pit (if one was in place):

"*We have understood this but will the hospital allow us? If they will allow us, yes, we will bring it* [placenta]." (Male TBA, aged 62 years, SSS/Form 4)

Other TBAs had a divergent view. The distance of between the communities where the TBAs worked and the health center was the main barrier:

"….*I stay far away. If I accept, I will find it difficult to bring it since I don't have a motor* [car], *and they are not common here*." (Female TBA, aged 49 years, no formal education) (Figure 4.9).

A section of the long road connecting the communities with the health center, vehicles were seen periodically

One of the communities in the vicinity of the health center, along the road on the left

Figure 4.9 Photographs depicting the circumstances in which TBAs work: the long distance between the health centre and communities

One of the questions posed to the participants was whether it was possible to have a placenta pit dug within the communities they served or in their residence if home births took place there. The issue of housing tenure emerged. Digging pits or modifying property was not acceptable in a compound where accommodation was rented:

"*The landlord will not allow me to be digging … pits in his house, but I can also dump it in the latrine*." (Female TBA, aged 49 years, no formal education)

Conventional practice and suspicion that the placenta could be used in unacceptable ways were other barriers to the option of a pit in the community:

"*It will be a problem, even in the hospital some people take their placenta back home. So they won't understand why we are taking their placenta somewhere else. They will think we are going to use it to perform rituals*." (Female TBA, aged 50 years, basic education)

The group reached a consensus that placenta pits would be difficult to locate except at the health center, therefore this was not explored further. It also emerged that if the current practice of burying placenta at home had to change, that change had to be initiated first in the health facilities:

"*Before people can understand this well, the hospital shouldn't allow them to take the placenta back home so that others will know that they do not return with it*." (Male TBA, aged 62 years, SSS/Form 4).

4.4.4 Perspectives of CSVs on segregation of solid medical waste

CSVs stated that other than expired medicines, the bulk of their waste was packaging. Packaging is generally classified as general waste, therefore they saw no need for segregation. Expired medicines could be burnt in a convenient location and they did not see any difficulties with this in their community. When asked if they would consider offering take back services to the public, some of the CSVs declined indicating they already had difficulties disposing of waste from service provision and were unable to take accept more waste.

CHAPTER FIVE

5 DISCUSSION

5.1 Objective 1: Characterization of solid medical waste in households in Ga South Municipal Assembly

5.1.1 Generation of solid medical waste

The results of the present survey indicated that 'typical values' (the sample without outliers) for SMW generated in households daily is under 6 grams. This is lower than generation rates of 0.010kg/patient/day (10 grams) in primary level healthcare facilities reported in Mongolia (Shinee *et al.*, 2008). It is also slightly less than generation rates of 0.008kg/patient/day (8 grams) reported for public clinics in South Africa (WHO, 2014a). The highly skewed distribution of daily per capita SMW generated in households was also reported about hazardous medical waste generation rates in healthcare facilities (Komilis *et al.*, 2012). The positively skewed data indicate low waste generation rates at high frequencies and high waste generation rates at low frequencies as seen in Tables 4.1 and 4.2. It also implies that generation of SMW would never be lower than zero, while the upper bound could vary. The reduction in kurtosis when the outlier households were removed indicates a less peaked distribution of data points. While household production and per capita waste generation of SMW did not show significant differences by income groups, there was a significant seasonal variation which confirms the assumption a priori that SMW generation would vary by season. The higher generation of SMW in the wet season may be partly attributed to seasonal patterns of common acute illnesses which tend to peak with the rains, such as malaria, respiratory tract infections and some diarrhoeal diseases. The medicines recovered during the waste stream analysis included therapeutic

categories corresponding to these conditions. Therefore the consumption of medicines may be higher in these seasons and left over medicines and their containers generate SMW. It is also possible that at the onset of the survey which was in the wet season, a few households may have utilized the opportunity to discard stored waste items since waste collection from households was free, while the services rendered by the waste management companies had to be paid for monthly. However, these outliers were limited to less than 5% of households. Assuming that approximately 551kg of SMW is generated daily in the municipality, most of which is finally disposed without treatment in landfills, this might pose a potential hazard in the face of existing difficulties with waste management. The tendency for some household waste (containing SMW) to be dumped indiscriminately in open spaces by informal waste porters and household members portends a risk of exposure to SMW by scavengers and waste workers. Although, quantities of SMW in this survey can only be considered indicative, they provide useful baseline data for future studies in areas with contextual similarity.

Waste quantification is useful for the design of infrastructure and facilities used for waste management (Oribe-Garcia *et al.*, 2015). While several studies have provided quantification data for HSW Delgado, Ojeda-Benitez, & Marquez-Benavides, 2007; Ojeda-Benitez *et al.*, 2008; Philippe & Culot, 2009; Qu *et al.*, 2009; Al-Khatib, Monou, Abu Zahra, Shaheen, & Kassinos, 2010; Thanh *et al.*, 2010) and SMW in healthcare facilities (Cheng *et al.*, 2009; Coker *et al.*, 2009; Taghipour & Mosaferi, 2009; Bazrafshan & Mostafapoor, 2010; Komilis *et al.*, 2012), studies that quantify SMW in household waste are rare. One study reported quantification and composition of potentially infectious waste in municipal solid waste, mostly of residential origin (Cussiol *et al.*, 2006). Another study quantified active pharmaceutical ingredients from discarded

medicines in municipal solid waste (Musson & Townsend, 2009). No study was found that quantified SMW in HSW in Ghana.

Per capita generation of SMW decreased with increasing household size. Being a component of household waste, this finding was expected as previous studies have shown that daily per capita generation rates had a negative correlation with household or family size (Bandara, Hettiaratchi, Wirasinghe, & Pilapiiya, 2007; Qu *et al.*, 2009; Pirani, Al-Khatib, Halaweh, Arafat, & Arafat, 2015). Other studies have reported a positive correlation between waste generation and family size (Sajauddin *et al.*, 2008; Alias *et al.*, 2014). Daily household and per capita generation rates were not significantly different across income groups during the survey period. The arbitrary assignment of income groups could have accounted for this in part. It is also possible that some medicines or healthcare items may have been funded from sources other than the household income. It is not uncommon for household members to rely on support from relatives. In such cases, financial assistance from a relative outside the household would not be considered part of the household's income.

The reported presence or absence of medical complaints was found to influence household generation of SMW. A probable explanation for this is that during the period of illness, household members are more likely to keep the medicines and containers while they are taking the medications. The unwanted items are likely to join the household waste stream or are otherwise discarded when the period for which the medication(s) were intended has expired or once they experienced symptom relief (Chien *et al.*, 2013). In circumstances where leftover medicines are given out to someone else who may need them, then they will remain in use and do not become SMW. However, when unusually large quantities of SMW were generated in a household (up to 13.74 kg/household/day

or more), the reported presence or absence of medical complaints no longer contributed significant differences in SMW generation and other factors that could account for these differences were not accounted for in the model.

5.1.2 Composition of solid medical waste

Most studies that report the weight and proportion of medicinal waste and biological-infectious waste (both being types of SMW) are studies conducted on household hazardous waste (Slack, Gronow, & Voulvoulis, 2004; Delgado, Ojeda-Benitez, *et al.*, 2007; Otoniel, Liliana, & Francelia, 2008; Gu *et al.*, 2014) which was not the focus of the present study. A study by Cussiol et al. (2006) measured types of SMW in municipal waste (largely of residential origin). The study was considered the closest to the present study and used as a reference, although the waste sampling methods were different. It is worth noting that SMW from other sources in municipal waste may partly account for some differences between the latter study and this study. Unwanted medicines were referred to as 'chemical waste' in the reference study and it accounted for 1.91% of the waste sample. The corresponding proportion in the present study was 1.05%, which was lower. In a study by Otoniel et al. (2007), unwanted medicines represented 8.4% of household hazardous waste and 0.31% of municipal solid waste in Mexicali, Mexico (Delgado, Ojeda-Benítez, & Márquez-Benavides, 2007). The proportion of medicines in the latter study was obviously lower than in the present study. The proportion of sharps waste in the study by Cussiol et al., (2006) is similar to the proportion found in the present study. We found a lower proportion of non-sharp waste (4.94% compared to 5.47% in the reference study). The relatively lower proportion in the present study can be explained in part by alternative routes of disposal for offensive waste such as burning, especially sanitary waste. Reasons for this could have been the offensive odor from prolonged

storage and unsightliness of it in exposed waste as deduced from the FGDs with household participants and TBAs.

5.1.2.1 Medicinal waste

Unwanted medicines comprised the bulk of SMW in households (offensive waste was excluded). Apart from antibiotics, the majority of medicines discarded were analgesics, antacids, multivitamins and haematinics, medications generally used for symptom relief. A large quantity of anti-diabetic medication was also recovered, similar to a study on medication waste in Taiwan (Chien *et al.*, 2013). It was not possible to make out the expiry date as this was effaced and not explored in the survey. The medicinal waste recovered from household waste had therapeutic categories consistent with acute and chronic diseases prevalent in Ghana. Acute conditions such as malaria, respiratory infections and diarrhea (Fink, Weeks, & Hill, 2012) are prevalent, as well as chronic conditions such as hypertension (Bosu, 2010; de-Graft Aikins, Kushitor, Koram, Gyamfi, & Ogedegbe, 2014) and diabetes mellitus (Amoah, Owusu, & Adjei, 2002; Danquah *et al.*, 2012).

During the waste stream analysis, syrup bottles labelled with antimalarial, antibiotic and multi-vitamin preparations, were found with either some content left or minimal residue which could have been left over from prior use or rinsed and discarded in the household bin as some of the participants explained during the focus groups. Such practices can potentially contribute to the presence of active pharmaceutical ingredients in the environment. Additionally, a few loose tablets were found in the household waste which suggests that some tablets may have been crushed or dissolved during the storage time. Therefore, dissolved medicines lost in dirt would be excluded from the measurable quantity of medicinal waste. By extension, the weight of medicinal waste and overall

weight of SMW may have been higher (Musson & Townsend, 2009). While it may be argued that the weight of containers could influence the weight of SMW, it must be noted that the residue in containers can affect the environment through the active ingredients.

There was a low yield of antimalarial medicines with content in household refuse. This can potentially be attributed to the high prevalence of malaria in the study area. Malaria accounts for up to 38% of outpatient attendance in Ghana (Buabeng, Duwiejua, Dodoo, Matowe, & Enlund, 2007; Abuaku, Duah, Quaye, Quashie, & Koram, 2012; Fenny, Asante, Enemark, & Hansen, 2015). Due to wide public education about malaria, most individuals would tend to complete their antimalarial medicine which explains why it was found mainly in the category with minimal residue. Only one packet was found with content which could have been due to the individual stopping treatment following an improved clinical response or side effects. When found with content in syrup bottles, it was usually a pediatric formulation.

Antibiotics were the largest group of medicines recovered from household waste (by frequency of occurrence), particularly the penicillin group. In a similar study of municipal solid waste in Florida, USA, antibiotics as a group was found in the largest quantity, followed by non-steroidal anti-inflammatory drugs (Musson & Townsend, 2009). Syrup of bottles of amoxicillin with residue or content were found mostly as pediatric formulation in the present study. Adult capsules of cloxacillin and penicillin V were also found. An earlier study in Oklahoma, USA also noted a large proportion of returned medicines were antibiotics in a community pharmacy take back program (Lystlund, Stevens, Planas, & Marcy, 2014). This category of medicinal waste was higher in the wet season. Apart from disease conditions which peak during the wet season and require antibiotics such as respiratory tract infections and some diarrhoeal illnesses, there was a

contribution by two households of a large quantity of antibiotic syrup bottles with minimal content and residue in two separate disposal events (House number 18/20 in week 1: 1.567kg; House number 09/02 in week 2: 2.427kg). Antifungal medicines were also recovered with content and residue and were most likely due to the presence of skin infections.

As malaria was prevalent in the study area, and is associated with fever and body pains, analgesic consumption and subsequent disposal appeared to be high. This was evident both by loose tablets of Paracetamol identified as well as several packets Paracetamol and non-steroidal anti-inflammatory drugs (ibruprofen) with content or residue found in household waste. Additionally, aches and pains from occupations involving manual labour such as agriculture, fishing, construction and housekeeping, often predispose individuals to use analgesics. Most of these drugs are sold over the counter and are often self-prescribed. The patronage of chemical shop vendors was high in the study areas, mostly for stressful conditions and headaches and a fifth of the sample reported the medicines were self-prescribed.

5.1.2.2 Sharps waste

The distribution of sharps waste showed a decreasing trend from low to high income groups. Razor blades were the commonest in this category, as found in the report by Cussiol et al. (2006) (Cussiol *et al.*, 2006). Razor blades were included on account of their ability to cause cuts if not properly handled which is included in the definition for sharps. The actual use of the blades was not explored in the households and this makes it difficult to clearly attribute reasons for the higher generation rates by households in the low income group. The presence of needles (capped and uncapped) found loosely in

household waste as well as other sharps confers hazardous properties on the household waste stream.

5.1.2.3 Offensive waste

Although, not considered medical waste, offensive waste deserves mention because it had a higher overall proportion of waste (5.58%) compared to SMW (0.84%), it was considered a problem by the community, and was characterized by soiling with faecal matter or body fluids. Faecally soiled diapers and used sanitary pads were recovered from the household waste stream analysis, with the former in large quantities. It has been estimated more than 120 different types of viruses can be introduced to the environment through faecal matter, including hepatitis and polio virus may be present in human faeces, especially where live viruses are used for immunization (Primomo *et al.*, 1990; Stenström, Seidu, Ekane, & Zurbrügg, 2011). An earlier study demonstrated that polio and echoviruses were isolated from 11% of faecally soiled diapers (Peterson, 1974). A later study detected human papilloma virus from menstrual fluid or vaginal discharge collected in sanitary napkins, although these were not obtained from waste (Tong *et al.*, 2003). On the basis of these and similar studies which confirm the presence of microbes, offensive waste can be considered potentially infectious. WHO posits that where safety measures are limited or absent and waste is discarded in dumpsites that are easily accessible to the public as it is in most developing countries, such wastes may have to be treated as infectious (WHO, 2014b). Secondly, when left uncollected in overflowing communal containers, they create an aesthetic nuisance, attested to during the FGDs by both male and female household members. Furthermore, uncollected waste containing offensive waste can attract insect vectors and rats, and contribute to microbial contamination of surface water during rains (Fobil, May, & Kraemer, 2010). Enteric

pathogens such as *E. coli*, *Salmonella* and *Shigella* when introduced into flowing water have been reported to survive up to 117km from source (Manson, 1991; Mangizvo, 2014). *Salmonella* and *Shigella* are infective agents of diarrhea and dysentery which can be transmitted from drinking contaminated water.

5.2 Objective 2: Disposal options for solid medical waste from household and community sources

5.2.1 Lack of specific receptacles for solid medical waste

Field observation showed that household waste receptacles were often sub-standard and included cellophane bags, sacks, old plastic buckets often kept outside the dwelling. Some of these receptacles were not covered and because they were placed outside, stray animals had easy access to receptacles of smaller dimensions. Earlier studies have reported the use of some of these receptacles (Addo-Yobo & Ali, 2003; Babanowo, 2006; Monney *et al.*, 2013; Yoada, Chirawurah, & Adongo, 2014). In the study by Mooney et al. (2013), over half of the respondents used plastic buckets compared to 33% in this study. The use of plastic buckets has also been reported in India (Kumar *et al.*, 2009). Babanowo (2006) reports their use. Yoada et al. (2014) reported the use of cellophane bags by 18% of their respondents compared to 24% in the present study. The use of standard household refuse bins was reported in 19% of households. Household members who handle waste in the other households using non-rigid receptacles are faced with a high risk of physical injury from sharp waste, when it is present. Those potentially at risk within households are young children and unsuspecting household members charged with waste management chores. Outside the household, other persons at risk include informal waste workers, municipal waste workers, intravenous drug users and street children who play around refuse dumps (Wyatt *et al.*, 1994; Mangizvo, 2014; Oteng-Ababio, 2014).

5.2.2 Disposal options

As there was no formal segregation of SMW in households, disposal options applicable to household waste were also used for SMW as discussed in the following sections, unless otherwise indicated.

5.2.2.1 Household bin and ultimate disposal in the landfill

The most prevalent option of disposal for SMW was the household bin. All the investigated waste fractions were recovered from waste collected from the household bin. Anatomical waste such as placenta was not found, mainly because it was buried according to cultural norms. One of the key informants at a waste management company pointed out that on a few occasions, the workers had reported finding a dead fetus in collected waste. Disposal of unwanted medicines in the refuse bin by most households in this study, was also reported in most parts of the world including Nigeria, UK, Kuwait, Lithuania and Austria (Auta *et al.*, 2011; Tong *et al.*, 2011; Vogler *et al.*, 2014). The co-mingling of SMW with general waste in the household may result in cross contamination with pathogens from household waste and vice versa, especially where SMW is deposited loosely and pathogens are present. When SMW is mixed with general waste in healthcare facilities, the whole load is assumed and treated as contaminated or potentially infectious (Prüss *et al.*, 1999; WHO, 2005). According to standard practice, the waste should be treated using alternative technology or incineration to render the waste relatively harmless before it is deposited in a landfill. While this is the case in hospitals, it is not replicated in households despite the potential microbial burden of the waste. Household bins were often kept outdoors and in some cases uncovered, which offers a leeway for insect vectors and rats to have access to the waste. Occasionally, bins may be knocked over by dogs as mentioned by one of the CSVs in this study. The spilled waste can attract insect vectors

and rats which are known passive carriers of microbial pathogens, and play a role in the spread of microbes in the environment (Majara & Leduka, 2009; WHO, 2014c).

Condoms were found during the waste stream analysis and in one of two disposal events, it was found with a packet of sildenafil, a drug used to treat erectile dysfunction and pulmonary arterial hypertension. During the focus groups, participants reported that condoms could be found floating around uncollected waste during the rains and they feared that children could get infected with diseases by playing with used condoms. Similar fears were reported in a study in Botswana where caregivers expressed concern about children playing with condoms because they resembled balloons (Phorano *et al.*, 2005). Even if these materials did not hold liquid body fluids, it can be argued that pathogens from dirt in the environment are a potential source of infection and could be transmitted through oral contact with condoms when they are blown by the children to simulate balloons. The oral contact therefore can be seen as a likely route of exposure.

5.2.2.2 Burning

Burning household waste in compounds was found at higher rates than found in an earlier study (15.7% in the present study vs 10.8%) (Anaman & Nyadzi, 2015). However, the latter study reports three categories of burning waste: burning waste alone (cited here), burning and throwing into the bush, burning and/or used public dumps and containers. If these categories are considered together, then the rates in the present study would be much lower. The study by Anaman and Nyadzi (2015) was limited to only one of the thirty enumeration areas covered in the present study. The practice of backyard burning by some of the households could predispose to upper respiratory tract infections in the study area (Boadi & Kuitunen, 2005). Burning and burial combined was the second most common of disposal for SMW, after the household bin. It was mostly used for offensive wastes,

especially sanitary pads. During the waste stream analysis, the plastic inlay of some used sanitary products were found while the pad itself was missing suggesting disposal by alternative routes, most likely burning. Given the nature of waste receptacles that some of the households used (buckets, sacks, gallons), it was not possible to deal with large volumes of offensive waste and burning reduced the volume of such bulky waste, in addition to altering its appearance and eliminating associated odour. The latter would most probably explain the findings during the waste stream analysis, since they were provided with 80-litre refuse bins and bin liners.

During the focus groups, burning of expired medicines was reported by CSVs and one of them described it as having an objectionable odour. Complete combustion of pharmaceutical compounds cannot be guaranteed with backyard burning. Therefore, oxidized residue can still be discharged into the environment (Tong *et al.*, 2011). Incomplete combustion at low temperatures encountered in backyard burning permits the release of harmful pollutants such as particulate matter, heavy metals and dioxins into the atmosphere (Gullett, Lemieux, Lutes, Winterrowd, & Winters, 2001; Hedman, Naslund, Nilsson, & Marklund, 2005; Zhou *et al.*, 2014). In Sweden, reverse distribution programs have existed since 1971 which ensure that unwanted medications are returned through pharmacies and ultimately destroyed by incineration at high temperatures. The effectiveness of the program has probably been influenced by public awareness and compliance with state protocols (Tong *et al.*, 2011). In a pilot study involving a retrieval system for unwanted medications conducted in Ghana, only 4% were found to have returned medicines (Sasu *et al.*, 2012).

5.2.2.3 Disposal in Pit Latrines

A small percentage (5.8%) of households discarded sanitary pads in pit latrines. TBAs also reported that in the rural areas, these items were discarded in pit latrines. While this practice is advantageous in terms of aesthetics, sanitary pads take nearly one year to decompose under aerobic and anaerobic conditions in a pit latrine (SEI, 2012). This excludes the plastic inlay. Plastics and diapers are non-biodegradable and can persist in the environment for 1000 years and 500 years respectively, contributing to pollution (Pynthamil & Amarnath, 2011). TBAs and female household members reported the use of cloth by some women for menstrual purposes. Where cloth is used for menstrual purposes, it is often reused. However, it has been reported that cloth used for menstrual purposes is often discarded in pit latrines at end of use and take longer to decompose. Sanitary items also make evacuation of the latrine pits difficult as these have to be removed mechanically (SEI, 2012). There is a pressing need to give attention to disposal of offensive waste, particularly sanitary items because of the sheer amounts generated. It has been reported that an average woman discards 125kg to 150kg of sanitary pads and tampons in her lifetime (Bharadwaj & Patkar, 2004; SEI, 2012).

5.2.2.4 Burial of placentae

From the focus groups, it was clear that most women had facility deliveries even in the rural areas. Placentae produced from hospital births are often disposed in the hospital. However, a few women take the placenta home for burial. In these circumstances, the family took the responsibility of burying the placenta, a task often handled by men or older female relatives. Burying the placenta with the stump facing upwards was tied to the belief that otherwise the woman would no longer conceive. No specific areas were marked for burial of the placenta. If the labour took place in the premises of a TBA, it

was buried in a similar way or the placenta was handed over to the family. In the survey conducted, only 7% of households disposed of placenta by burial. In advanced countries, placentae have been diverted to alternate uses such as the production of human albumin and polyvalent immunoglobulins for parenteral use (Barry, 1994). The placenta is also a source of stem cells for transplantation, a form of therapy useful for both malignant and non-malignant diseases (Burlacu, 2013).

5.2.2.5 Waste collection

For 43% of households, waste was conveyed from the household to the communal container, similar to 45% reported in Wa, Ghana (Bowan, Anzagira, & Anzagira, 2014). Field observation showed that these communal containers were generally not covered, which left unrestricted access to scavengers and stray animals. We observed scavengers rummage through waste from containers and from landfills periodically. Earlier studies report that scavengers can divert SMW (expired drugs and syringes) for sale to unsuspecting public (Solberg, 2009; Patwary, O'Hare, & Sarker, 2011). The use of expired drugs results in sub-optimal treatment of diseases and used syringes were associated with an outbreak of hepatitis in India (Solberg, 2009). During a previous survey in Ghana, syringes were found to be diverted for use in hair salons as rollers (EPA, 2002b).

Waste collection by private waste companies was reported by 35% of households. FGDs revealed that collection of waste by the private service providers was infrequent. Participants also blamed indiscriminate disposal on the inability of the private waste contractors to empty the communal bins. Waste contractors confirmed the infrequent collection, attributing them to long queues at the landfill. Most of the existing landfills had been sealed off leaving only one major landfill functioning at the time of the survey.

Without emptying, it was impossible for them to collect more waste. Therefore the refuse trucks had to wait their turn, at the expense of nuisances arising from uncollected waste. Payment for waste collection appeared to be a serious concern in the study area. This was re-iterated by private waste contractors and played out during the early phase of fieldwork. Some of the selected households did not believe that the waste collection during the waste stream analysis would not attract any charges. Although they agreed on a schedule for waste collection, these households defected until they witnessed or confirmed from others that no fees were collected during the study. The problem of uncollected waste is not peculiar to the study area and has been reported in other countries including Manila, Philippines (Bernardo, 2008), Haiti (Philippe & Culot, 2009) and Uganda (Komakech *et al.*, 2014).

5.3 Objective 3: Estimation of the relative proportion of household members reporting harm due to solid medical waste at household and community levels

Within the household, harm associated with SMW was indicated as needlestick and penetrating injuries, acute poisoning, and explosion and fires in the questionnaires. Reporting rates for harm associated with SMW in the household was low at 4.8% and lower still in the community, 2.6%. No reports were made about fires and explosions, other hazards that were reported are discussed in the respective sections. The recall period for a harmful event was limited to one month which should yield high report rates for non-fatal injury, regardless of severity of injury (Mock C., 1999). The low rates compared to that reported in occupational settings is consistent with literature. Occupational settings potentially offer a greater possibility of contact with SMW compared to the community and SMW in healthcare facilities may contain a wide range of pathogens (Blenkharn,

2011). Both quantity and composition of SMW in the households support the low reporting rates.

5.3.1 Reported harm from sharps waste

During the waste stream analysis, needles and syringes were found in the waste of only one household. Needle stick injuries and cuts from blades and broken glass together accounted for 4.6% of reported harm from SMW. Public sensitivity was greatest regarding infection with tetanus and potential transmission of HIV on account of penetrative injuries with sharp waste. This was evident in both the questionnaire surveys and FGDs and explains in part, why majority of the respondents listed these diseases above others that they associated with SMW (Table 4.9). However, existing evidence indicates that HIV seroconversion rates are very low, because most community acquired exposures are low risk exposures among other factors (van Wijk *et al.*, 2006). Transmission of bloodborne viruses following exposure from needlestick injury has been reported mostly for Hepatitis B and Hepatitis C viruses. Of the five cases reported by Osowiki and Curtis (2015), two cases were non-occupational resulting in chronic hepatitis B and C infections (Osowiki & Curtis, 2014). Both cases involved discarded needles, one discarded by a neighbor co-infected with HBV and HIV, and the other encountered while walking through a park with high local prevalence of injecting drug use. In both these cases, there was no immunoprophylaxis and this may have enhanced their susceptibility to infection. In the present study, harm was reported within and outside the household (open field, along the road and near a refuse dump), but we did not explored these cases any further at the time of investigation. Therefore we are unable to comment on the outcome of the harm.

5.3.2 Potential hazards of medicinal waste

Only one case of acute poisoning involving a discarded medication was reported in this study and the pharmaceutical ingredients were unknown. Apart from obvious risk to human health from accidental or deliberate ingestion, discarded medicines also pose a threat to the ecosystem. All household waste from which medicinal waste was recovered in this study was ultimately destined for landfills or dump sites. In poorly engineered landfills, such discarded medicines can eventually leach into surrounding soil, join run off, and pollute water bodies, if they escape degradation. Most medicines are non-biodegradable and their residue can accumulate in living organisms in the environment (Díaz-Cruz, López de Alda, & Barceló, 2003; Zuccato *et al.*, 2006; Mathew & Unnikrishnan, 2012). One of the most commonly used anti-inflammatory non-steroidal analgesics, diclofenac, was recovered with content during the household waste stream analysis in this study. Diclofenac has been associated with toxic effects on terrestrial and aquatic ecosystems. For example, renal lesions and alteration of the gills in rainbow trout have been reported following exposure to diclofenac at doses of 5µg/L (Chen *et al.*, 2015). Both diclofenac and ibruprofen have been associated with adverse effects in algal chloroplasts (which play an important role in photosynthesis) resulting in their death, eutrophication and disruption of the food chain (Vannini *et al.*, 2011; Li, 2014).

In the study areas, the daily overall quantity of medicinal waste was relatively low, based on generation rates. However, regular accumulation in the environment may exceed natural attenuation capacity in landfills and open dump spaces, if it remains unchecked. Urban run-off can carry pharmaceutical compounds into the aquatic environment, and point source pollution from inadequately managed landfills can contaminate ground water (Li, 2014). Although it is not clear how continual exposure to low environmental doses

in synergy with other medicines may affect humans, prevailing evidence suggest that limiting diclofenac and other medicines in the environment may be beneficial. The predominance of antibiotics recovered during the household waste stream analysis is worrisome given global concerns about antibiotic resistance (Boxall *et al.*, 2012; Pruden *et al.*, 2013). Antibiotics have also been reported to be harmful to organisms and algae (Vannini *et al.*, 2011; Li, 2014). In relation to human health, the introduction of antibiotics in the environment results in selection of pathogens that are resistant to conventional therapy (Mathew & Unnikrishnan, 2012). Alternative therapeutic options which are more expensive are not readily available in most developing countries. Five packets of metformin were found with full content. Metformin is an antidiabetic drug which has been demonstrated to have high mobility in soil and is slowly biodegradable under aerobic conditions (Mrozik & Stefanska, 2014). It is often transformed to a stable product, guanylurea which is best removed from drinking water by treatment plants using chlorination, ozonation and underground passage (riverbank filtration and artificial ground water recharge) (Scheurer, Michel, Brauch, Ruck, & Sacher, 2012). Given the quantity, we assumed that this may have resulted from a change in regimen or they had not expired.

5.3.3 Potential hazards associated with offensive waste

Condoms were found on twice during the waste stream analysis, in one disposal event there was a packet of sildenafil accompanying it. They were tied in a dark cellophane bag presumably to hide the contents from view. No child was found playing with condoms during the field visits. However, the concerns raised by FGD participants and the manner in which the condoms were disposed suggest that households are sensitive to the potential harm of discarding condoms carelessly. One participant reported that condoms could be

found floating around uncollected waste during the rains and both men and women feared that children could get infected with diseases by playing with used condoms. Similar fears were reported in a study in Botswana where caregivers expressed concern about children and condoms because they resembled balloons (Phorano, Nthomang, & Ngwenya, 2005). Even if the condoms did not contain body fluids at the time of contact, it can be argued that pathogens from dirt in the environment are a potential source of infection and could be transmitted through oral contact with condoms when they are blown by the children. The oral contact therefore can be seen as a route of exposure. Small bandages stained and a large gauze bandage with serous secretions were also found in this study, but the infectiousness of these items were not determined. The large bandage could have been used on an ulcer, most likely the lower limb, as Buruli ulcer was reported in the study area (Amoakoh & Aikins, 2013).

5.4 Stakeholder views about segregation of solid medical waste at source as a potential management option at community level

In considering a management option suitable for application in the community, it was apparent from the lack of treatment technology adapted to household use, that SMW would have be segregated at source and treated elsewhere. This would ensure that all SMW is appropriately treated and rendered safe before committing it to the environment. Segregation at source can further ensure a clean waste stream for recyclable materials.

Managing SMW was not strange to households as it was generally considered part of household waste. Every participant in the study could identify SMW, perhaps aided by the poster that helped to visualize some of the items. FGD participants could identify a potential hazards of SMW as injury and disease transmission, especially to young

children who may be inadvertently exposed at home or in the community. However, none of the participants expected that these hazardous properties which characterize SMW was a sufficient reason to practice waste segregation in the household. It was clear both from quantitative and qualitative data that people in the community knew that exposure to SMW was associated with diseases such as tetanus (48% of households) and HIV/AIDS (45% of households). However, several practical realities related to daily living conditions posed barriers to accepting potential segregation of SMW as a practice.

5.4.1 Storage & housing tenure

One of the problems raised by the female participants was the issue of storage of SMW. Based on suggestions such as the use of a pit, they felt it was not possible to dig pits on property that they did not own. Modifying the house to create a storage place was subject to the same limitations. These could not be achieved if you were a tenant in the house and it did not appear likely that other tenants would cooperate to provide additional storage. The inability to modify one's residence to meet needs as a tenant has been discussed in an earlier study (Luginaah, Arku, & Baiden, 2010). The issue of housing tenure was also raised by a TBA when asked if the burial of placentae from homebirths could be limited to a pit close to the practice area. She claimed that as a tenant she would not be permitted to dig a pit on the property, but she could dispose the placenta in an existing latrine as a last resort. It was further explained that since TBAs tend to conduct deliveries in clients' homes, it was not possible to use a single pit for disposal. The availability of open space for storing segregated waste was identified as an important consideration for source segregation of household waste in a study done in Kumasi (Owusu, Adjei-Addo, & Sundberg, 2013).

5.4.2 Lack of equipment/logistics

The questionnaire survey revealed that some of the households did not have standard bins, which explains the use of various items such as gallons, buckets, cellophane bags, baskets and sacks discussed earlier (see section 5.2.1). Inadequate storage space and receptacles was often catered for by backyard burning. Under these circumstances, potential segregation was not considered in a favourable way because they lacked additional bins to support its practice. Interviews held with private waste contractors revealed difficulties with households registering for services and procuring bins, therefore on some occasions they had given out bins without charging fees. These bins were locally made and less sturdy than the standard bin size. During the waste stream analysis, it was further observed that the majority of households did not have household bins other than the ones provided for the exercise. Male FGD participants pointed out the absence of additional bins for separation and the use of only one vehicle for waste collection which appeared to negate the purpose of segregating SMW. Equipment is an important requirement for source segregation. A previous study in Sweden showed that the installation of sorting equipment in households improved segregation, compared to the distribution of written information (Bernstad, 2014). Although the latter study focused on separation of food waste, this could well apply to any other form of waste segregation. In a pilot study which involved selected cities and towns in Ghana, source segregation of household waste into two basic categories (biodegradable, excluding paper and other waste) was successful largely because all the needed logistics were provided (Miezah *et al.*, 2015).

5.4.3 Disposal costs & affordability

There were two sides to disposal costs. On one hand, households who registered with private waste companies assigned to their neighbourhood were expected to pay monthly fees, with a maximum limit of GHC15. This amount was reported in another study (Anaman & Nyadzi, 2015). On the other hand, the waste management companies were expected to pay for waste loads at the landfill according to truck load of waste. The key informants at the waste management companies reported that the fees fixed by the municipal authorities did not adequately cater for this cost. The difficulties with getting households to pay for waste collection was such that one of the waste company informants reported taking court action against defaulting households (after issuing warning letters) as a means of ensuring that they fulfilled their obligation of payment. As a separate collection of SMW would potentially attract additional costs, it would seem unlikely that households struggling with paying for a single waste stream would afford to pay for another waste fraction. Indeed for the waste companies, the only barrier to separate collection was the willingness of households to pay.

However, there are lessons to be learnt from previous studies on source segregation. One study showed that collecting several types of waste simultaneously increased efficiency of waste collection (Tanskanen & Kaila, 2001). Therefore collection of SMW can be integrated with collection of other waste components. Although, the cost of household waste collection may still increase, this can be minimized by high participation rates (Tanskanen & Kaila, 2001). In China, the active support and investment of a real estate committee and a community residential committee contributed significantly to public participation and source separation of waste was found to be cost-effective compared to

collecting and transporting the mixed waste stream (Zhuang, Wu, Wang, Wu, & Chen, 2008).

5.4.4 Time consuming task

During the FGD, two male participants objected to segregation of SMW on the basis that it would take time to create 2 separate streams of waste. Although, they were not as men directly charged with waste management – they had a decision making role which implied that they would have to ensure this task was carried out in the household. Furthermore, private waste providers often brought a single truck for waste collection which appeared to defeat the purpose of segregation, if the collected wastes were deposited into the same truck. The task of segregating SMW from HSW was deemed additional and unnecessary if it was not collected separately. Similar reasons were cited in a study in Kinondoni, Tanzania during its investigation of resource recovery potential from household waste (Oberlin, 2013).

5.4.5 Physical injury

The fear of injury from separating SMW as expressed by female participants could potentially create difficulties in accepting source segregation of SMW. A previous study showed that female gender and sorting or health-related perceptions regarding source separation positively influenced solid waste separation (Owusu *et al.*, 2013). In most studies, waste source separation usually refers to separation of recyclables and organic waste for composting; rarely has SMW been considered a fraction for separation. It is arguable that without appropriate education, women can be expected to have more reservations about source segregation of SMW as a potential management option. This is because source separated waste in the context of SMW could result in exposing items that would otherwise have remained hidden from sight and contact in household waste. In this

study, women affirmed their responsibility for practical aspects of waste management in the household. Therefore the disposition of women toward a waste management option would be one of several factors critical to its implementation. Therefore overcoming these fears with public education about SMW and simple guidelines about how it can be conducted safely will be crucial if source segregation of SMW should be adopted as an option in the future.

5.4.6 Others

Participants felt that it would be difficult remembering to segregate SMW at the point of disposal. Segregation of household waste was not the norm and therefore it would require some time and effort to adopt the practice. The perspectives from the focus groups should be interpreted in this context.

5.5 Policy implications and future directions

The current policy of healthcare waste management issued by the Ministry of Health has healthcare facilities as its primary focus. Although its application can be extended to other healthcare settings, the domestic environment deserves specific attention. The domestic environment differs in routine activity, infrastructural layout, human resource, and disposal norms from healthcare facilities. Therefore guidelines should be developed for household members in appropriate handling and disposal of SMW taking these factors into account. The difficulties with storage in rented accommodation and other practical considerations raised in this study should be noted. The large proportion of pharmaceuticals, particularly antibiotics and non-steroidal anti-inflammatory analgesics in household SMW should be diverted for environmental protection and prevention of antibiotic resistance. The handling and disposal of sharps waste to reduce potential harm

is crucial. Legislation regarding the responsibilities of household members, healthcare workers, district assemblies, waste management companies and other stakeholders, and sanctions for non-compliance should be specified and known to the public to enhance compliance. The public requires guidance to safely segregate waste categories at source. Treatment outside the household can be considered if logistics for storage and collection are convenient for households in terms of cost, household members' responsibility and time.

For source segregation to be successful given the present context, it would rely heavily on intensive public education as well as adoption and monitoring of public collection points as household collection may not be feasible in all areas. Monitoring and enforcement at household level has been considered impractical, which implies that individuals must be self-motivated to segregate SMW or be otherwise incentivized. The availability of community health workers who can make home visits, reinforce appropriate information and lend technical support when trained, presents a potential opportunity, if given the necessary logistic support and motivation.

Based on the preceding discussion, recommendations have been summarized into 2 schematic diagrams (and section 6.2). The first diagram summarizes steps required to develop a community model for management of SMW. A synthesis of relevant local research in the short term and additional studies in the long term can provide empirical evidence upon which to plan SMW management and develop public guidance. Presenting evidence base at discussion fora with field experts, infection control and public health practitioners, civil society groups and relevant agencies offers the opportunity for awareness and improvement of existing waste management strategies. The output of such fora should be clearly defined and include a strategy that considers SMW management

from a holistic perspective (both facility based and community sources). In addition, decision making and public guidance should take into account consumer and service provider perspectives and incorporate a feedback mechanism that allows for continuous improvement of the model based on lessons learnt (Figure 5.1).

The second diagram presents a hypothetical community model of SMW management that takes into account the three main stakeholders in this research, storage and disposal mechanisms. It offers opportunity for medicinal waste to be collected using appropriate containers at supported CHPS compounds and chemical vendor shops, from where discarded medicines will be channeled for appropriate treatment and disposal. It offers the possibility of accepting placentae from health centres in collaboration with an approved medical laboratory for the production of blood derivatives for therapeutic purposes or returned to patients with guidance for safe disposal. In addition, it assumes that SMW treatment is done in a centralized incineration facility with final disposal of residue by landfilling. Beyond the community management, it makes provision for environmental monitoring and feedback from lessons learnt for improvement of the model (Figure 5.2).

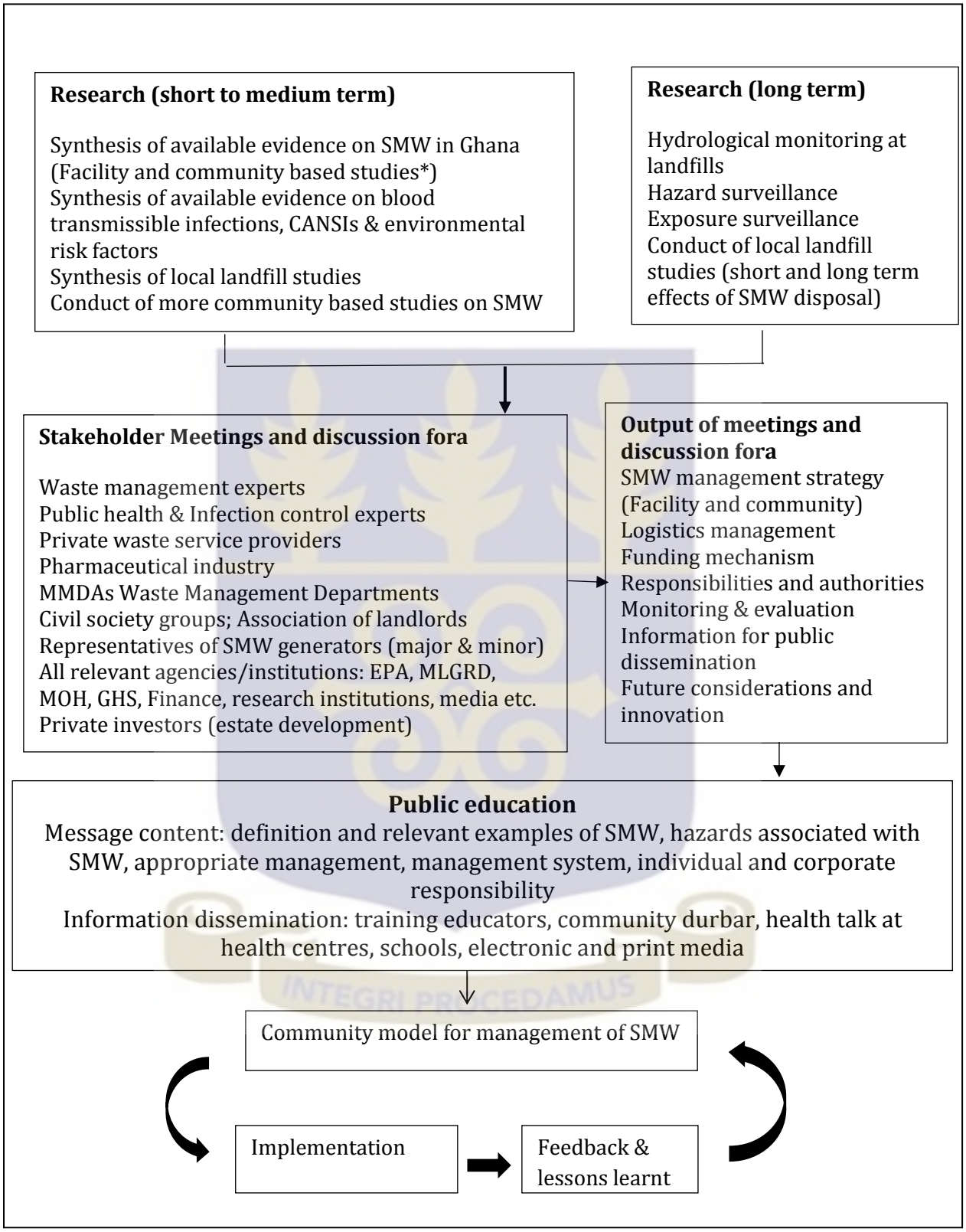


Figure 5.1 Steps in development of a community model for management of solid medical waste

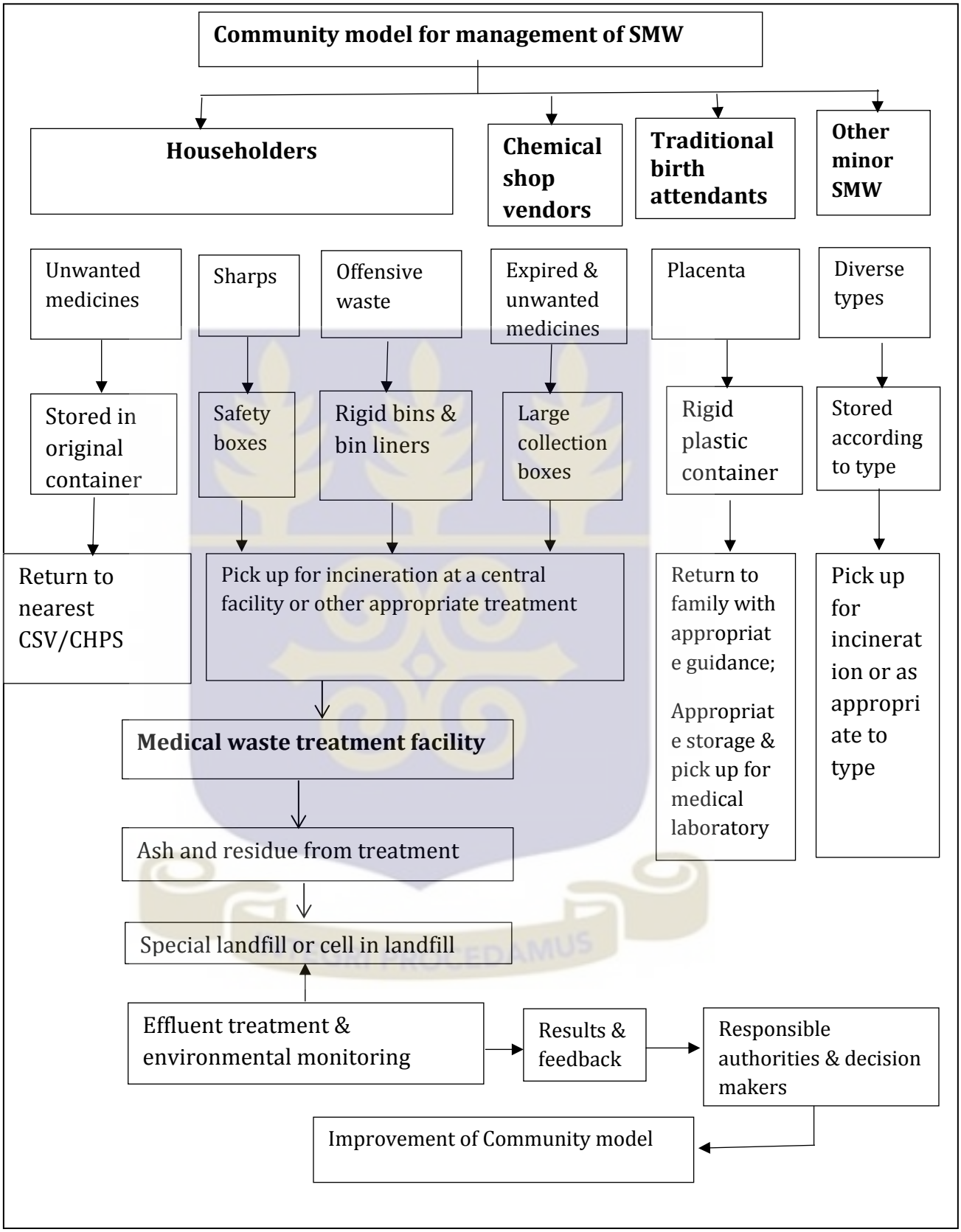


Figure 5.2 A hypothetical model for community management of solid medical waste

5.6 Strengths of the study

This study has a number of strengths. It presents a comprehensive discourse on SMW in a community setting in Ghana, an African country. Only a few studies in Africa have reported on SMW in the community and these often lack any estimates of the quantity of waste generated. It highlights current disposal options and discusses potential implications for the environment and human health. The waste stream analysis enabled recovery of antibiotics and anti-inflammatory analgesics frequently discarded in household waste in the study area (and ultimately in landfills) which should raise concerns regarding long term exposure to low doses of pharmaceuticals in the environment. It also highlights barriers to segregation at source as a management option for SMW, which is useful for planning for healthcare waste in households. The use of a mixed methods approach enhanced the validity of the results as qualitative data corroborated quantitative data, added depth to understanding stakeholder perspectives regarding management of SMW (affirming earlier studies) and generated a discussion tool and community model for management of SMW.

5.7 Limitations of the study

Due to attrition at the onset, calculations were done using single mean imputation with Stata version 14.0 (StataCorp LP, Lakeway Drive, Texas, USA). The sample size could also contribute to the wide confidence intervals. Therefore, computed waste generation rates obtained are limited to the study area and can only be considered indicative. Larger samples taken over successive surveys are recommended for quantitative estimates for regional planning. However, the study provides a baseline for planning within the study areas. The non-normal distribution of weight measurements of SMW in households was

expected as SMW is generated in much smaller quantities in most residential settings compared to health facilities. This often results in a positive skew. During the household questionnaire survey which investigated disposal practices and reported harm from SMW, the sampling of subsequent households by proximity could be a limitation. Although the first household was selected by ballot from the first twenty households along a random directional line in each enumeration area, selection of subsequent households would potentially exclude those at the periphery. Future studies on household SMW in such areas within the municipal assembly or in other areas of contextual similarity may be useful in clarifying whether differences from the present study findings are remarkable. Finally, the assignment of income groups arbitrarily limits the application of the results in settings where the income groups are determined differently or have values outside the range in this study. Therefore the study findings disaggregated by income groups may not be applicable outside the study area.

CHAPTER SIX

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Household generation of SMW compared with outpatient production at public clinics, comprised mostly of pharmaceuticals, showed seasonal variation and was influenced in part by the reported presence or absence of medical complaints. Based on the quantities generated in the study locations daily, and the ultimate disposal of household solid waste containing SMW in landfills, the cumulative amounts are a source of concern. They could eventually overwhelm the natural mechanisms of degradation. A large proportion of pharmaceuticals was recovered, with non-steriodal anti-inflammatory drugs and antibiotics being present in most of the households. The accumulation of antibiotics in SMW generated daily raises concerns about the possibility of antibiotic resistance with continual disposal of SMW mixed with household waste in landfills. Among the NSAIDs, diclofenac, which was recovered in this study, has been reported to have ecotoxicological effectis in earlier studies. Regarding reported harm from SMW, only once case of acute poisoning was reported. Sharps waste accounted for most reports in households and in the community, even though its relative proportion in SMW and household waste were small. Based on these findings, it was concluded that considerable diversion can be achieved by implementing source segregation at household level. This should be the focus of future policy on management of SMW in households and in the community. To achieve this, sensitizing the public, provision of adequate logistics and stakeholder commitment are crucial. Offensive waste was present in relatively higher proportion than SMW, posed

a problem in the study area, and managing this waste should receive attention in future research.

6.2 Recommendations

6.2.1 Recommendations at community level

Community members have a right to appropriate information about the composition of SMW, what harm it poses to human health and the environment and how to safely dispose of it. To ensure that such information is put to use, some legislation will be required that makes it unlawful to discard SMW in an unsafe manner. Information dissemination should be done in local dialects on electronic media as well as in English which is also the common language for print media. Regarding harm from SMW, community members need to know what should be done in the event of harm, how and where to report such events. The reporting pathway for the public should be short and the cost reasonable (or subsidized) to enhance compliance to care and improve reporting rates. Within communities, traditional leaders, queen mothers play a vital role in community mobilization and information dissemination. They can mobilize women groups, landlords associations, youth groups to help promote compliance with future guidelines.

6.2.1 Recommendations at district level (municipal assembly)

The present study provides indicative quantities for SMW from households within a district. In pursuit of segregation at source as a potential management option, further waste quantification is required at regional level to plan for storage capacity and equipment at source (households or other sources) and at potential collection points. This can be undertaken by waste management departments of MMDAs, in collaboration with research based universities, other public and private stakeholders in waste management.

It would be helpful for MMDAs to compile relevant literature on waste stream analysis and waste survey conducted in their districts. These are useful for monitoring trends, provide statistics for computing sample size in future surveys, and inform decision making. Quantification and composition should be undertaken periodically to monitor changes in waste quantity and composition by source as this affects modes of treatment and final disposal. Further landfill studies are required in areas where mixed waste streams existed and in cells specific for SMW to detect hazardous effects in the environment, particularly where attenuation processes may have been overwhelmed. In such areas, stringent measures are needed to limit further pollution to the environment and ultimately protect public health. Funding for studies can be periodically from development partners that have waste management and related research as part of their scope of activity in districts.

To reduce backyard burning, particularly of offensive waste, frequent and timely collection is required. Sanitary waste in particular tends to leave offensive odors, encouraging households to resort to burning them as a convenient means of disposal. The frequency of collection is dependent on availability of treatment, transfer stations and/or final disposal sites so that waste management companies can make their rounds in shorter cycles. If fees are required for collection, service providers, municipal assemblies and communities should dialogue to reach a consensus on pricing. The municipal assembly in fixing tariffs for households and commercial premises, should find a balance between service providers' costs and affordability to households.

6.2.1 Recommendations to the Ministry of Health (Ghana Health Service)

The Ministry of Health plays a key role in ensuring adequate public health education. The study findings emphasize the importance of educating the public about SMW as this is

not restricted to hospital settings. To promote awareness about SMW, the content of public messages should emphasize among others: (i) unwanted medicines, sharps and potentially infectious items confer some hazardous properties on household waste, (ii) household SMW is untreated and eventually deposited in landfills where regular accumulation of SMW poses a hazard to our ecosystem; (iii) eliminating any waste that poses a hazard helps to achieve a cleaner waste stream, from which resource recovery is desirable and (iv) as the real magnitude of harm may not be immediately evident but cumulative, a sensible and sustainable approach would be elimination of preventable harm at source i.e. waste segregation fully supported with necessary logistics, information and stakeholder commitment. Electronic and print media can be used to disseminate messages in the various dialects as well as English.

To avert harm from inappropriately discarded sharps waste, provision of free or highly subsidized mini-safety boxes for household use at chemical shops and pharmacies and supplied when sharps are purchased is essential. Supervised public collection systems should exist where stored sharps can be deposited for appropriate disposal. Other receptacles can be improvised such as rigid containers with tight fitting lids, improvised empty disinfectant containers and metal cans. However, public guidance should indicate where collection points are located and safe options for transfer of safety boxes. Pick up from collection points to final disposal should be regular and monitored to avoid diversion for illegitimate purposes. Joint monitoring teams representing the Environmental Protection Agency, Ministry of Health, Ghana Health Service Pharmacy Council, Ghana Police Force and respective MMDAs should conduct periodic checks on collection points and final disposal sites. Where house to house pick up is feasible, this should be the preferred option as it is more convenient for households. Transporting safety boxes may

be cumbersome for households, may encourage non-compliance and disposal at unauthorized sites.

For medicinal waste, initiating and institutionalizing a drug return system with adequate logistic support for storage and collection to points of destruction or final disposal would divert medicinal waste from the household waste stream, allowing appropriate treatment prior to disposal at a landfill. Collection points should include CHPS compounds and chemical vendor shops which offer convenience, exist in proximity to community members, and often constitute the first point of care. The frequency of emptying storage containers would depend on the rate of generation at source and number of collection points. Capacity building of vendors should be supported by adequate storage and pick up facilities, public sensitization, led by the Pharmacy Council in collaboration with Licensed Chemical Seller Association, Environmental Protection Agency and civil society groups. As recommended for sharps waste, house specific pick up is preferred where feasible for the same reasons. Both systems can be combined because of the existence of unplanned settlements or areas where surface accessibility is challenging. A single multi-compartment vehicle can pick safety boxes containing sharps waste and unwanted medicines from households and channel them to appropriate treatment and disposal facilities. Households only need to ensure that each sub-stream of SMW is appropriately containerized. In this regard, logistics have to be planned with MMDAs, civil society representatives and an existing medical waste management facility to ensure smooth operations.

To encourage early reporting or harmful events, sentinel sites for injury surveillance should be set up at district level and linked up with infection control experts at regional and tertiary hospitals via hotlines. Public health nurses and community health workers

which are closer to the community should be trained to conduct preliminary assessments. Public health nurses can initiate prophylaxis and make appropriate referrals to higher levels of specialization with infection control staff. Future policy on the management of SMW should include household management taking into account context specific barriers and facilitating factors. In addition, specific and separate guidelines should be developed for use in community settings and simplified, pictorial documents made available for public guidance.

6.2.2 Recommendations to other stakeholders in management of solid medical waste

Academic institutions can support research on various aspects of SMW management. For instance, the option of diverting placentae for production of useful derivatives for human treatment can be explored in Noguchi Memorial Institute for Medical Research laboratories. A similar laboratory should be upgraded and licensed to serve the northern part of the country. Qualitative research investigating acceptability of this innovative practice and a quantitative assessment of the local need for derivatives should provide evidence for its introduction. If found acceptable, ethical requirements of informed consent should be integrated. Community Health Departments can conduct research, as well as serve as advocates for appropriate management of SMW at household and community level. The role of the media and civil society groups is critical to dissemination of information and ensuring that the entire management system is well understood by the public and in providing feedback on public response and challenges in implementation.

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APPENDICES

Appendix 1. Consent Form for Household Member

Title: A Study of Solid Medical Waste at the Community Level: Generation and Collection in Households, among Traditional Birth Attendants and Chemical Shop Vendors, and Impacts on Health

Principal investigator: Dr. Emilia A. Udofia

Address: Department of Biological, Occupational and Environmental Health, School of Public Health, University of Ghana, Legon

General Information about Research

To be read to the respondent by interviewer:

Introduction

"Good morning/afternoon/evening. My name is _____

This is a survey coordinated by Dr. Emilia Udofia of the Department of Biological, Occupational and Environmental Health, at the School of Public Health, University of Ghana, Legon. The reason for the survey is to learn about what happens to waste from healthcare facilities within the facility and in the community. The results of this survey will improve our understanding about the handling of waste from healthcare facilities.

In a brief interview, questions will be asked about how the waste from the medicines or any form of medical treatment administered to any member of your household is handled within your home, your practices regarding the storage, collection and treatment of this waste, your experience of injuries or accidents at home or in the community and what may be responsible for such accidents. The interview will take about 30 minutes. If any of the questions I ask make you uncomfortable, you may decline to answer.

In some of the houses, the research team wishes to collect some samples of healthcare materials that are discarded in your home. You will be informed if your house is selected for this exercise and your permission will be requested. Solid materials from healthcare activities used and discarded the at home are to be collected for a maximum of thirty five days. If your house is selected and you accept to have the waste samples collected, you will be provided leak-proof bags and bins to store your household waste. The bags will be collected from your house at an agreed time weekly and taken to a place where the contents will be separated and weighed. Thereafter the contents of the waste bag will be disposed safely.

Possible Risks and Discomforts

The risks from participating in this survey are no more than what you would experience with your regular handling and storage of waste. There will be the slight inconvenience of separating the waste from medicines or treatment and keeping the bag away from children and animals while awaiting collection by the field staff. Collection of waste bags containing the medicine or treatment items will be done weekly in order to limit the number of visits in respect for your privacy.

Possible benefits

Your participation will improve our understanding about how waste from the services you provide to the community is handled. The information will be useful to the government in planning for safe ways to manage waste from your services and similar services in communities. This will help you maintain a healthy home.

Confidentiality

All the information will be kept confidential and will not be discussed with anyone who is not involved in this research.

Compensation

You will be given an incentive of GH₵10 for your participation in the waste collection exercise at the conclusion of the 35-day exercise.

Voluntary participation and Right to Leave the Research

Your participation is voluntary and you do not have to agree to participate in this research. If you choose not to participate, this decision will not affect you or your household in this community.

Would you like to ask me anything about the survey? If you agree to take part in the survey, please state that now. I will make a note of it on this form to show I obtained your oral consent in the presence of a witness who will also sign the form.

Volunteer Agreement

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

_____ _____

Date Name and signature of witness

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

_____ _____

Date Name signature of person who obtained consent

Contacts for additional information

If you have any further concerns or enquiries, you may contact the researcher at the Department of Biological, Occupational and Environmental Health, School of Public Health, Legon and Department of Community Health, University of Ghana Medical School, Korle Bu, or call the phone no.:
Dr. Emilia A. Udofia 024 325 9018

The following may also be contacted:

1. Dr. Julius Fobil Ag. Head, Department of Biological, Occupational and Environmental Health 024 3462 514

2. The Noguchi Memorial Institute of Medical Research Institutional Review Board, Legon 030 2916 438

3. The Ethical and Protocol Review Committee, University of Ghana Medical School, Korle Bu, Accra

Your rights as a Participant

This research has been reviewed and approved by the Institutional Review Board of Noguchi Memorial Institute for Medical Research (NMIMR-IRB). If you have any questions about your rights as a research participant you can contact the IRB Office between the hours of 8am-5pm through the landline 030 2916 438 or email addresses: nirb@noguchi.mimcom.org or HBaidoo@noguchi.mimcom.org and at the Ghana Health Service Ethical Research Committee: Ms. Hannah Frimpong (landline: 030 2681 109).

Appendix 2. Consent Form for Chemical Shop Vendor/Traditional Birth Attendant

Title: A Study of Solid Medical Waste at the Community Level: Generation and Collection in Households, among Traditional Birth Attendants and Chemical Shop Vendors, and Impacts on Health

Principal investigator: Dr. Emilia A. Udofia

Address: Department of Biological, Occupational and Environmental Health, School of Public Health, University of Ghana, Legon

General Information about Research

To be read to the respondent by interviewer:

Introduction

"Good morning/afternoon/evening. My name is _____

This is a survey coordinated by Dr. Emilia Udofia of the Department of Biological, Occupational and Environmental Health, at the School of Public Health, University of Ghana, Legon. The reason for the survey is to learn about what happens to waste from healthcare facilities within the facility and in the community. The results of this survey will improve our understanding about the handling of waste from healthcare facilities.

In a brief interview, questions will be asked about whether or not you received any training about how to handle the waste from the services you provide, your practices regarding the storage, collection and treatment of this waste, your experience of injuries or accidents while working and what may be responsible for such accidents. I will also ask about health problems you know that may be linked with the handling of waste from the services you provide. The interview will take about 30 minutes. If any of the questions I ask make you uncomfortable, you may decline to answer.

In addition, I would like to collect your solid waste samples from the services you provide daily for seven days. If you agree to allow me collect the samples, you will be provided two leak-proof bags per day to enable you separate your regular waste from the waste from services you provide. The bags must be kept in a place protected from animals and children until they have been collected by the research team. The bags containing the waste from the services you provide will be collected at an agreed time daily for seven days and taken to a place where the team will weigh the waste and separate the contents. The contents of the waste bags will be disposed safely after the contents have been weighed.

Possible Risks and Discomforts

The risks from participating in this survey are no more than what you would experience with your regular storage of waste. There will be the slight inconvenience of separating the waste from medicines or treatment and keeping the waste bag away from children and animals while awaiting collection by the field staff.

Possible benefits

Your participation will improve our understanding about how waste from the services you provide to the community is handled. The information will be useful to the government in planning for safe ways to manage waste from your services and similar services in communities. This will help you maintain a healthy work place.

Confidentiality

All the information will be kept confidential and will not be discussed with anyone who is not involved in this research.

Compensation

You will be given an incentive of GH₵10 for your participation in the waste collection exercise at the conclusion of the 7-day exercise.

Voluntary participation and Right to Leave the Research

Your participation is voluntary and you do not have to agree to participate in this research. If you choose not to participate, this decision will not affect you or your work in this community.

Would you like to ask me anything about the survey? If you agree to take part in the survey, please state that now. I will make a note of it on this form to show I obtained your oral consent in the presence of a witness who will also sign the form.

Volunteer Agreement

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

_____ _____

Date Name and signature of witness

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

_____ _____

Date Name signature of person who obtained consent

Contacts for additional information

If you have any further concerns or enquiries, you may contact the researcher at the Department of Biological, Occupational and Environmental Health, School of Public Health, Legon and Department of Community Health, University of Ghana Medical School, Korle Bu, or call the phone no.:

Dr. Emilia A. Udofia 024 325 9018

The following may also be contacted:

1. Dr. Julius Fobil Ag. Head, Department of Biological, Occupational and Environmental Health 024 3462 514

2. The Noguchi Memorial Institute of Medical Research Institutional Review Board, Legon 030 2916 438

3. The Ethical and Protocol Review Committee, University of Ghana Medical School, Korle Bu, Accra

Your rights as a Participant

This research has been reviewed and approved by the Institutional Review Board of Noguchi Memorial Institute for Medical Research (NMIMR-IRB). If you have any questions about your rights as a research participant you can contact the IRB Office between the hours of 8am-5pm through the landline 030 2916 438 or email addresses: nirb@noguchi.mimcom.org or HBaidoo@noguchi.mimcom.org and at the Ghana Health Service Ethical Research Committee: Ms. Hannah Frimpong (landline: 030 2681 109).

Appendix 3. Consent to participate in Focus Group

Title: A Study of Solid Medical Waste at the Community Level: Generation and Collection in Households, among Traditional Birth Attendants and Chemical Shop Vendors, and Impacts on Health

Principal investigator: Dr. Emilia A. Udofia

Address: Department of Biological, Occupational and Environmental Health, School of Public Health, University of Ghana, Legon

Request for consent:

Dear Sir/Madam,

You have been invited to participate in a focus group organized by a research team led by Dr. Emilia Udofia of the Department of Biological, Occupational and Environmental Health, School of Public Health, University of Ghana, Legon. The group is made up of 5 other people of the same gender who live in this community, the researcher and a recorder/timekeeper. The purpose of the focus group is to understand how materials used for tests or treatment at health facilities or by health providers which are brought home are discarded at home and in the community. The information learned in the focus groups will be used to plan acceptable ways of handling this type of waste in households and communities and plan public health messages.

You may choose whether or not to participate in the focus group and withdraw at any time. The focus group will be taped so that we can capture all opinions and ideas during the discussion but names will not be used to maintain confidentiality. The tapes will be destroyed after the information has been taken from them. We hope that this will encourage you to express yourself freely. We would like to hear the views of everyone in the group. There is no right or wrong answer to the questions and you may disagree with other views. In respect for one another, we request that only one person speak at a time while others listen and all responses be kept within the group and not discussed elsewhere.

If you have any questions now or after the focus group, you may contact the researcher or other team member at the above department, whose names and contact phone numbers are listed below:

Dr. Emilia Udofia 024 325 9018
Dr. Julius Fobil 024 3462 514
The Noguchi Memorial Institute of Medical Research Institutional Review Board (NMIMR-IRB), Legon 030 2916 438

To show that you agree to participate in the focus group, kindly check the corresponding box below:

I understand this information and agree to participate under the conditions described above. ☐

I understand this information and do not wish to participate in the focus group. ☐

Witnessed by: _____ Date:_____
(Name and signature of research team member)

Your rights as a Participant

This research has been reviewed and approved by the Institutional Review Board of Noguchi Memorial Institute for Medical Research (NMIMR-IRB). If you have any questions about your rights as a research participant you can contact the IRB Office between the hours of 8am-5pm through the landline 030 2916 438 or email addresses: nirb@noguchi.mimcom.org or HBaidoo@noguchi.mimcom.org and at the Ghana Health Service Ethical Research Committee: Ms. Hannah Frimpong (landline: 030 2681 109).

A STUDY OF SOLID MEDICAL WASTE AT THE COMMUNITY LEVEL: GENERATION AND COLLECTION IN HOUSEHOLDS, AMONG TRADITIONAL BIRTH ATTENDANTS AND CHEMICAL SHOP VENDORS, AND IMPACTS ON HEALTH

Appendix 4. Questionnaire for Household Head or Most Informed Person

Contact information for the household:

Location Information	
Name of Head of Household	
Contact (mobile) phone number	

	INTERVIEWER VISITS		
	1	2	3
DATE			
INTERVIEWER'S NAME			
RESULT*			
NEXT VISIT: DATE			
TIME			

*RESULT CODES:

1 = COMPLETED 2 = HOUSEHOLD ABSENT 3 = DATE AND TIME SET FOR LATER	4 = DWELLING NOT FOUND 5 = ELIGIBLE RESPONDENT ABSENT 6 = INCOMPLETE INTERVIEW	7 = REFUSED 8 = OTHER (SPECIFY) …… ……

	NAME	DATE	SIGNATURE
Field-edited by:			
Keyed by:			

SECTION 1: SOCIODEMOGRAPHIC INFORMATION Sex:……..

Q. #	QUESTION	CODES	GO TO Q.
1	How old are you now?	Age in completed years…….. ☐☐	
2	What is your native language?	Akan……1 Ga/Dangme……....2 Fante……..3 Twi……....4 Ewe……5 Mole-Dagbon……...6 Northern tribes……..7 Hausa……8 Non-Ghanaian……..….9	
3	What is your religion?	Christianity……1 Islam……..….2 Traditional African Religion.….3 Other specify……....4	
4	What is your marital status now?	Never married/Single……..…1 Married……2 Divorced/Separated…….3 Cohabiting……...4 Widow……5	
5	Are you living with a partner?	Yes……1 No……...2	
6	Have you ever attended school?	Yes……1 No……...2	
7	What is the highest level of schooling you have completed?	Primary……...1 JSS……2 SSS……3 Other (Arabic schools etc) …..4 Vocational/Technical training…5 Post-basic (diploma, teacher training college, nursing etc)……..6 Tertiary……7 Not applicable……..……....8	
8	Has your partner ever attended school?	Yes……1 No……..2 Don't know..……..3	
9	What is the highest level of schooling your partner has completed?	Primary…….....1 JSS……2 SSS……...3 Other (Arabic schools etc) …….4 Vocational/Technical training.....5 Post-basic (diploma, teacher training college, nursing etc)……6 Tertiary……..……..7 Not sure……..…..8 Not applicable…….9	

10	Do you do any kind of work for which you are paid in cash or in kind?	Yes……..1 No……..2	
11	What kind of work do you do?	Agriculture/Fishing……..1 Artisanship…….....2 Energy/Communications/Manufacturing.3 Banking/Finance/Insurance……..4 Public administration/Education/Health/Legal/Other civil servants……....5 Large scale transport/Construction…….....6 Small scale transport/Services…….....7 Armed forces/Uniformed service men…..8 Clergy…….,,,..9 Manual labour……...10 Pensioner……..11 Unemployed……12 Other specify……....13	
12	Does your partner do any work for which she is paid in cash or in kind?	Yes……..1 No……...2 Don't know…….....3	
13	What kind of work does she do?	Agriculture……,...1 Energy/Communications/Manufacturing……..2 Banking/Finance/Insurance……..……3 Public administration/Education/Health/ Legal/Other civil servants……..…..4 Services……..…….....5 Armed forces/Uniformed service……..…6 Clergy…….....7 Manual labour……..…8 Pensioner……..…….9 Unemployed/housewife..……..……10 Other specify……..……...11	
14	How many children do you have?	No. of children ……	
15	How many people live in this house?	No. of people in the house…….	

SECTION 2: MEDICATION RELATED PRACTICES

Q. #	QUESTION	CODES	GO TO Q.
16	Is there any member of your household who has visited a chemical shop/ drug store in the past two weeks?	Yes……..….1 No…….…..2 Not sure…..…….....3	
17	What condition led to the visit?	Stress/Headaches…….…..…1 Abdominal pain/upset……....2 Genital discharge/sore/itch.....3 Febrile illness……..…...4 Pregnancy/STI prevention……..5 Drug refill for chronic illness.....6 Injury/burn……..7 Other (specify)……8 Not applicable……9	
18	If any medication was bought, who prescribed it?	Self……...1 Recently prescribed by physician….2 Prescribed earlier by physician…….3 Prescribed by known health worker……...4 Chemical shop vendor……..5 Friend/Neighbour/Church member...6 Other (specify)……7 Not applicable……...8	
19	Is there any member of your household who has visited at a health facility in the past two weeks?	Yes……1 No……..….2 Not sure…..…….....3	
20	What condition led to the visit?	Not aware……..1 Pregnancy……..2 Schedule immunization date…..…3 Domestic accident(scald, burn, injury, fall/collapse, choking).....4 Road traffic accident……....5 Acute illness (specify)…..…….6 Chronic illness (specify)……..7 Other (specify)……8 Not applicable……..9 Specify as applicable: Acute illness…… Chronic illness……	
21	Did he/she receive treatment?	Yes……1 No……..….2 Not sure…..……..….3	

22	What type of treatment did he/she receive?	No treatment was given……1 Prescription (oral drugs only)……2 Prescription (oral & injection)…...3 Prescription (injection only)……...4 Physiotherapy……5 Delivery (vaginal)……...6 Delivery (operative)……....7 Admitted & discharged on medication…….....8 Admitted & had surgery.....9 Died on admission……10 Other (specify)…….....11 Don't know……..…….....12 Not applicable……..……13	
23	Was the person taking any medication at home (within the past two weeks)?	Yes……1 No……2 Don't know……3	
24	Is there any household member who was being nursed at home in the last two weeks?	Yes……1 No……2	If the response to Q.24 is no, skip to Q. 27
25	What type of care did the person require?	Oral drugs……1 Injections……2 Wound dressing……...3 Liniment……...4 Infusions (drips)……..5 Glucometer checks……...6 Other (specify)……7 (Multiple responses allowed)	
26	Who offered the care at home?	A household member……..…1 A known health worker……..2 A community health worker…...3 Friend/Neighbour/church member…4 Other (specify)……5	
27	Where do you discard drugs that you do not need any longer in your home?	In the toilet/sink……1 Give them out to other people…...2 Drop them in the dustbin (wrapped/in container)…….3 Drop them in the dustbin (unwrapped/not in container)…..……4 Bury them ……..5 Burn them……...6 Drop them in any bin by the roadside……..7 Other (specify)…….……..8	

28	How do you discard sharp objects like broken injection bottles, syringes and needles in your home?	In the toilet……1 Drop them in the dustbin (covered/in container)……..2 Drop them in the dustbin (uncovered/not in container)……3 Drop them in any bin by the roadside…….…...4 Other (specify)…….5	
29	What is the nature of the dustbin in your home?	Cellophane bag……....1 Bucket with lid……...….2 Rice or garri bag……..3 Basket……..4 Basin……5 Carton…….....6 Standard bin……..…...7 Other (specify)……..……...8	
30	How do you finally get rid of the waste in your dustbin?	Bury in a pit in the compound…….1 Burn in the compound…….……2 Carry to a communal bin……3 Pick up by refuse truck……4 Dump in any nearby bush……....5 Other (specify)…….....6	
31	If the waste has to be carried to the point of final disposal, who does it?	Children (aged <10 years)……1 Adolescents (aged 10 – 19 years)..…2 Adults (aged ≥20 years)…..……..3	
32	How do you discard soiled* items (cotton wool, bandages from wound dressing, soiled cloth etc)?	Bury in a pit in the compound…..……1 Burn in the compound……2 Wrap and discard in the dustbin……..3 Drop in a (pit) toilet……4 Other (specify)……..…5	
33	Do you re-use old medicine containers like syrup bottles or disinfectant bottles?	Yes……1 No……..……2	
34	Have you ever sold old medicine bottles to willing buyers?	Yes……1 No……..…..2 Not sure……..3	
35	When a woman in your compound delivers, is the placenta brought home?	Yes……1 No……..…2 Not sure……3	
36	If so, how is it discarded?	Buried in the ground……....1 Discarded in a pit latrine……....2 Other (specify)…….3 Not applicable……..….4	
37	How do you handle blood soaked items (sanitary towels, diabetes test strips)?	Buried in the ground……..……1 Burnt……2 Discarded in a pit latrine…..……..3 Other (specify)……..4 Not applicable……...5	

38	If a family member is coughing at home, how is the sputum discarded?	Directly on the ground……..1 Directly into a sink/flush toilet …2 Directly into the dustbin……...…3 In the dustbin (contained)....…….4 In a re-usable container, contents emptied outside/bin……..5 In a re-usable container, contents emptied in sink/toilet……6 Other (specify)……..7 Not applicable……...8	
39	How do you discard disposable items (baby diapers/napkins, urinary pads & tubes, pregnancy strips, condoms)?	Flush in a toilet……..……....1 Dump in a pit latrine……2 Gather items and burn……....3 Bury in a pit……..…....4 Dump in the dustbin..…..…5 Other (specify)…….....6 Not applicable……..…7	

SECTION 3: EXPOSURE/ACCIDENTS RELATED TO MEDICAL WASTE

Q. #	QUESTION	CODES	GO TO Q.
40	In the past month, did any member of your household report any injury or other harm involving a discarded medical item at home?	Yes……1 No……..2 Not sure……..…3	If the response to Q. 40 is no or not sure, skip to Q.44
41	How many people were affected?	No. of people affected…… ☐	
42	What item (s) was involved in the injury or harm?	Specify……	
43	What harm was done?	Accidental poisoning……...1 Piercing injury/needle stick……2 Foreign body in nose/ear etc...3 Fire or explosion……....4 Other (specify)……5	
44	In the past month, did any member of your household report any injury or other harm involving a discarded medical item in the community?	Yes……1 No……2 Not sure……..……3	If the response to Q. 44 is no or not sure, skip to Q.49
45	How many people were affected?	No. of people affected…… ☐	
46	What item (s) was involved in the injury or harm?	Specify……	
47	Where in the community did the injury or harm occur?	Along the road……..1 Near a refuse dump……..2 In an open field……3 Other (specify)……..4	

48	What harm was done?	Accidental poisoning…… Piercing injury/needle stick…….……....2 Foreign body in nose, ear etc…3 Fire or explosion……..…..4 Other (specify)……...5	

SECTION 4: RISK PERCEPTION ABOUT DISEASES ASSOCIATED WITH MEDICAL WASTE

Q. #	QUESTION	CODES	GO TO Q.
49	What diseases do you know that can be associated with exposure to body fluids or discarded medical items?	1…… 2…… 3…… 4…… 5……	
50	Can you arrange them in an order that places the one you feel is the most important first and the least important last?	1…… 2…… 3…… 4…… 5……	
51	Do you think that it is possible for you to be affected by any of these diseases?	Yes……1 No……..…..2 Not sure……..3	
52	Have you been affected by any of these diseases in the past month?	Yes……1 No……..…..2 Not sure……..…..3	
53	Are there any problems with discarded medical items or materials soiled by body fluids in this community?	Yes……1 No……..…..2 Not sure……..……3	
54	If yes, what are the problems?	(List the top three in order of importance) 1…….. 2…… 3……	

Do you have any comments or questions?

Thank you for your participation!

A STUDY OF SOLID MEDICAL WASTE AT THE COMMUNITY LEVEL: GENERATION AND COLLECTION IN HOUSEHOLDS, AMONG TRADITIONAL BIRTH ATTENDANTS AND CHEMICAL SHOP VENDORS, AND IMPACTS ON HEALTH

Appendix 5. Questionnaire for the Chemical Shop Vendor

SECTION 1: SOCIODEMOGRAPHIC INFORMATION

Q. #	QUESTION	CODES	GO TO Q.
1	How old are you now?	Age in completed years……☐☐	
2	What is your native language?	Akan……1 Ga/Dangme……2 Fante……3 Twi……4 Ewe……5 Mole-Dagbon……6 Northern tribes……7 Hausa……8 Non-Ghanaian……9	
3	What is your religion?	Christianity……1 Islam……2 Traditional African Religion.3 Other specify……4	
4	What is your marital status?	Never married/Single……1 Married……2 Divorced/Separated……3 Cohabiting……4 Widow……5	
5	Have you ever attended school?	Yes……1 No……2	
6	What is the highest level of schooling you have completed?	Primary……1 JHS……2 SHS……3 Vocational/Technical training..4 Tertiary……5 Not sure……6 Not applicable……7	
7	Do you have children?	Yes……1 No……2	
8	How many children do you have?	No. of children……☐☐	

SECTION 2: WORK EXPERIENCE AND CHARACTERISTICS

Q. #	QUESTION	CODES	GO TO Q.
9	How long have you been doing this work?	No. of completed years……. ☐☐	
10	Have you received any formal training since you started this work?	Yes……..1 No……2	
11	What are the common complaints of clients who buy medicines from you?	Febrile illnesses……..…1 Diarrhoeal diseases……2 Headaches/stress……3 Skin disorders…….....4 Pregnancy symptoms…….5 Genital discharge/sores/itch...6 Injuries……..……..…7 Burns/scalds……..….8 Family planning needs……...9 Other (specify)…….10	
12	Have you received any training about how to dispose of materials soiled with body fluids?	Yes……..1 No……2	
13	Have you received any training about how to discard expired or unused drugs?	Yes……..1 No……2	
14	When did you attend to your last client?	……day(s)/week(s)/month(s)/year(s) ago	
15	In active practice, what is the average number of clients you attend to in a day?	No. of clients/day……... Calculate the no. of clients/month ☐☐	
16	How do you discard expired or unused drugs?	Buried in a pit……....1 Open burning……....2 Sell to other shops……..……3 Sell to local private practitioners……4 Return to suppliers……..5 Dump in a bin……..6 Other (specify)……7	
17	How do you discard materials soiled with blood or other body fluids (wound dressings, cotton wool, gloves etc)?	Bury in a pit……..1 Burn in a pit or open ground….2 Discard in a bin……..…3 Discard in a nearby bush..…….4 Other (specify)……..5	

18	How do you discard sharp items such as used razor blades?	Buried in a pit……....1 Burnt in a pit or open ground….2 Discarded in a pit toilet……..…3 Dump in a container and put in a bin….4 Discard in a nearby bush……...5 Other (specify)……..….6	
19	How do you collect your refuse?	In a standard dustbin…….1 In a cellophane bag……...2 In a carton…….3 In a plastic bucket (uncovered)…4 In a plastic bucket (covered)…….5 Other (specify)…….6	
20	How is your refuse removed?	Buried in a pit……..…1 Burnt in a pit or open ground….2 Taken to a communal bin……...3 Discarded in a nearby bush……4 Other (specify)……...5	

SECTION 3: EXPOSURE/ACCIDENTS RELATED TO MEDICAL WASTE

Q. #	QUESTION	CODES	GO TO Q.
21	In the past month, did you suffer any injury or other harm involving the materials you work with?	Yes……1 No……..…..2 Not sure……...……3	
22	How many times did you have this experience with work materials?	No. of times/month…….. ☐	
23	What item(s) was involved in the injury or harm?	Specify……	
24	What harm was done?	Accidental poisoning……1 Piercing injury/needle stick……..……..2 Foreign body stuck in a body opening (nose, ear etc)……..…3 Fire or explosion……...…...4 Other (specify)……5	
25	In the past month, were you exposed to body fluids from a client through a cut in your skin?	Yes……1 No……...….2 Not sure……..3	
26	How many times did you have this experience of exposure to body fluids?	No. of times/month…… ☐	
27	Do you think that such injury/exposure can be harmful?	Yes……1 No……..…..2 Not sure……..3	

SECTION 4: RISK PERCEPTION ABOUT DISEASES ASSOCIATED WITH MEDICAL WASTE

Q. #	QUESTION	CODES	GO TO Q.
28	What diseases do you know that can be associated with exposure to body fluids or discarded medical items?	1…… 2…… 3…… 4……... 5……	
29	Can you arrange them in an order that places the one you feel is the most important first and the least important last?	1…… 2…… 3…… 4…….... 5……	
30	Do you think that it is possible for you to be affected by any of these diseases?	Yes……1 No……..2 Not sure……..3	
31	Have you been affected by any of these diseases in the past month?	Yes……1 No……..2 Not sure……....3	
32	Are there any problems with discarded medical items or materials soiled by body fluids in this community?	Yes……1 No……..2 Not sure……..3	
33	If yes, what are the problems?	(List the top three in order of importance) 1…… 2…… 3……	

Observation:

Request to see where waste is collected – Are any of the following present? (Tick as applicable)

Sharps [ ] Pills [ ]Cotton swabs, gauze, bandages [ ] Broken glass vials [ ]

Medication bottles [ ] Specimen bottles [ ] Gloves [ ] Human tissue [ ]

Other specify [ ]…….

Thank you for your participation!

A STUDY OF SOLID MEDICAL WASTE AT THE COMMUNITY LEVEL: GENERATION AND COLLECTION IN HOUSEHOLDS, AMONG TRADITIONAL BIRTH ATTENDANTS (TBAs) AND CHEMICAL SHOP VENDORS (CSVs), AND IMPACTS ON HEALTH

Appendix 6. Questionnaire for the Traditional Birth Attendant

SECTION 1: SOCIODEMOGRAPHIC INFORMATION

Q. #	QUESTION	CODES	GO TO Q.
1	How old are you now?	Age in completed years…… ☐☐	
2	What is your native language?	Akan……1 Ga/Dangme……..2 Fante…….....3 Twi……..4 Ewe……..5 Mole-Dagbon……...6 Northern tribes…….....7 Hausa……...8 Non-Ghanaian…….9	
3	What is your religion?	Christianity……1 Islam……...2 Traditional African Religion..3 Other specify……..4	
4	What is your marital status?	Never married/Single…….1 Married……..2 Divorced/Separated……3 Cohabiting…….....4 Widow……..…..5	
5	Have you ever attended school?	Yes……1 No……..2	
6	What is the highest level of schooling you have completed?	Primary……..…....1 JHS……2 SHS……3 Vocational/Technical training..4 Tertiary……..5 Not sure……6 Not applicable……...7	
7	Do you have children?	Yes……...1 No……2	
8	How many children do you have?	No. of children…… ☐☐	

SECTION 2: WORK EXPERIENCE AND CHARACTERISTICS

Q. #	QUESTION	CODES	GO TO Q.
9	How long have you been doing this work?	No. of completed years…… ☐☐	
10	Did you receive any formal training for this work?	Yes……..…..1 No……2	
11	Was this work handed down to you by tradition?	Yes……..…..1 No……2	
12	What range of services do you offer your clients?	Prenatal care……1 Delivery services (normal birth)…....2 Referrals for complicated pregnancies/births……..…….3 Postnatal care……..…...4 Family planning commodities……5 Ear piercing for girls……..6 Male circumcision……7 Female circumcision……..8 Other (specify)……...9	
13	Did the training/tradition you received include how to dispose of waste from childbirth and soiled articles such as blades, cotton wool, maternity pads?	Yes……...1 No……2	
14	When did you attend to your last client?	……week(s)/month(s)/year(s) ago	
15	In active practice, what is the average number of clients you attended to in a day?	No. of clients/day……... ☐☐ Calculate the no. of clients/month	
16	In active practice, what is the average number of babies you delivered in a week?	No. of babies/week……. ☐☐ Calculate the no. of babies/month	
17	How do you discard placenta?	Buried in a pit……1 Packed in a cellophane bag for mother to take home……..2 Discarded in a pit toilet….3 Other (specify)……..4	
18	How do you discard materials soiled with blood or other body fluids (maternity pads, cloth, cotton wool, gloves etc)?	Buried in a pit……1 Burnt in a pit or open ground….2 Discarded in a pit toilet……..…3 Discard in a nearby bush…….....4 Wrap in newspaper/cellophane bag and put in a bin……5 Other (specify)……...6	

19	How do you discard sharp items such as used razor blades?	Buried in a pit……....1 Burnt in a pit or open ground….2 Discarded in a pit toilet……..3 Dump in a container and put in a bin…….....4 Discard in a nearby bush……5 Other (specify)……...6	

SECTION 3: EXPOSURE/ACCIDENTS RELATED TO MEDICAL WASTE

Q. #	QUESTION	CODES	GO TO Q.
20	In the past month, did you suffer any injury or other harm involving the materials you use for your work?	Yes……1 No……..2 Not sure……..3	
21	How many times did you have this experience with work materials?	No. of times/month…….. ☐	
22	What item(s) was involved in the injury or harm?	Specify……	
23	What harm was done?	Accidental poisoning…..……1 Piercing injury/needle stick……..2 Foreign body stuck in a body opening (nose, ear etc)……3 Fire or explosion……..…..4 Other (specify)……...…5	
24	In the past month, were you exposed to body fluids from a client through a cut in your skin?	Yes……1 No……2 Not sure…….3	
25	In the past month, were you exposed to body fluids from a client through a splash in your eye(s) and/or nose?	Yes……1 No……2 Not sure…….....3	
26	How often in the past month have you experienced exposure to body fluids?	No. of times/month…….. ☐	
27	Do you think that such injury or exposure can be harmful?	Yes……1 No……..2 Not sure……..…3	

SECTION 4: RISK PERCEPTION ABOUT DISEASES ASSOCIATED WITH MEDICAL WASTE

Q. #	QUESTION	CODES	GO TO Q.
28	What diseases do you know that can be associated with exposure to body fluids or discarded medical items?	1…… 2…… 3…… 4…… 5……	
29	Can you arrange them in an order that places the one you feel is the most important first and the least important last?	1…… 2…… 3…… 4…… 5……	
30	Do you think that it is possible for you to be affected by any of these diseases?	Yes……1 No……..2 Not sure……..3	
31	Have you been affected by any of these diseases in the past month?	Yes……1 No……..2 Not sure……3	
32	Are there any problems with discarded medical items or materials soiled by body fluids in this community?	Yes……1 No……..2 Not sure……..3	
33	If yes, what are the problems?	(List the top three in order of importance) 1…….. 2…… 3……	

Observation:

Request to see where waste is collected – Are the following present? (Tick as applicable)

Sharps [ ] Pills [ ] Cotton swabs, gauze, bandages [ ] Broken glass vials [ ]

Medication bottles [ ] Specimen bottles [ ] Gloves [ ] Human tissue [ ]

Other (specify)…….. [ ]

Thank you for your participation!

A STUDY OF SOLID MEDICAL WASTE AT THE COMMUNITY LEVEL: GENERATION AND COLLECTION IN HOUSEHOLDS, AMONG TRADITIONAL BIRTH ATTENDANTS AND CHEMICAL SHOP VENDORS, AND IMPACTS ON HEALTH

Appendix 7. Household Data Capture (Waste Survey)

Waste Sampling: Household Information Code No.:……...

Descriptors	**Information to be filled in**
Enumeration Area	
Name of person interviewed	
Contact phone number *(check that the number of digits is complete)	
Age at last birthday (years)	
Gender	Male [ ] Female [ ]
Educational status of respondent	None [ ] Basic[ ] Secondary [ ] Tertiary [ ]
Number of persons in this particular household (Write the actual number in the next column)	……
Type of family (mark X in the bracket)	Single family: Husband/Wife, children (biological or adopted) and domestic help or a single, unmarried person. [ ] Multi-family: all of above plus cousins, aunty/uncle or other relatives. [ ]
Type of house	Flat: single detached/semi-detached house, usually with one household present. [ ] Compound house: house with several rented rooms or sections, usually with more than one household [ ] Other: any which does not fit the above descriptions [ ]

Occupation of household head (write the occupation in the space below and tick the corresponding category in the next column) ……	Agricultural [ ] Trading [ ] Civil servant [ ] Artisan/Services/Transport [ ] Unemployed/Pensioner [ ] Others: [ ]
Ownership of House	Owner [ ] Caretaker/Squatting [ ] Rented [ ]
Number of sleeping rooms in house where the household stays (write the actual number in the next column)	
On the average, how much do you pay for electricity? (Tick category and indicate actual amount on dotted lines)	GHC <50 [ ] GHC 50 – 100 [ ] GHC >100 [ ] Actual amount……..
Contact with a chemical seller or healthcare facility in the past week?	Yes [ ] No [ ]
Any family member on regular medication?	Yes [ ] No [ ] Not sure [ ]
Any family member registered with NHIS (health insurance)?	Yes [ ] No [ ] Not sure [ ]
Has any family member used any of these at home in the past week?	**Medical waste** Medicines (syrups) [ ] Medicines (tablets) [ ] Needles + syringes [ ] Syringes only [ ] Lancets [ ] Blade [ ] Cotton wool to wipe blood/pus [ ] Test kit requiring blood [ ]

	Offensive waste Bandages [ ] Gloves [ ] Pregnancy test kit [ ] Diaper [ ] Baby wipes [ ] Sanitary pad [ ] Condoms [ ] Cotton wool for cosmetic purposes [ ] Cotton bud [ ]Infusion set (drip set) [ ] Catheter/urine bag [ ] Other health related item [ ] Item was……..
What could happen if a household member is exposed to these items when they have been thrown away?	Nothing [ ] Injury (cut/needle stick) [ ] Rash/Itch [ ] Sickness [ ] Children swallow medicines [ ] Children play with condoms [ ] Unsightliness of waste [ ] Any other [ ] Describe……
Do you think you could be harmed from the way waste items from healthcare are discarded?	Yes [ ] No [ ] Not sure [ ]
Has anyone in your home been pricked from a medical needle that was thrown away?	Yes [ ] No [ ] Not sure [ ]

Has anyone in your home had a cut or injury from an item used for testing or treatment at home?	Yes [ ] No [ ] Not sure [ ]
If yes, what happened after that?	Nothing [ ] Used first aid at home [ ] Went to chemical seller [ ] Went to health facility [ ] Other [ ] Specify……..
Is waste collected from your home?	Not collected [ ] Collected [ ]
How many times is your waste collected in a month? (Write the number in the 2nd column)	……/month
How much do you pay for waste collection? (Write the last amount paid on dotted lines in next column)	I don't pay [ ] ≤ GHC20 [ ] > GHC20 [ ] (Actual amount) GHC……..
How is waste collected from your home?	By a wheeled cart [ ] Send it by a cyclist [ ] Waste (contractor) truck [ ] By rain water/gutter [ ] Other means [ ] Describe ……
Have you had any of these symptoms in the past month?	Cough [ ] Runny nose [ ] Fever [ ] Rash [ ] Headache [ ] Abdominal pain [ ] Urge to vomit [ ] Eye irritation [ ]

	Difficulty breathing [ ] Discharge from the eyes [ ] Loose stools (>3 times/day) [ ] Itchy skin [ ]
Which healthcare items used at home are burnt in your compound?	None [ ] Offensive waste [ ] Medical waste [ ] Specify item(s)…….. …… ……
Which healthcare items used at home are buried in your compound?	None [ ] Offensive waste [ ] Medical waste [ ] Specify item(s)…….. …….. ……...
Has anybody ever told you about how to discard waste from healthcare activities?	Yes [ ]No [ ] If yes, who told you?.....
Is disposing this type of waste a concern to you?	Yes [ ] No [ ]
Do you have any children aged < 5 years in this house?	Yes [ ] No [ ] How many……..

Date of interview:…… Time of interview:……..

Thank you for participation.

A STUDY OF SOLID MEDICAL WASTE AT THE COMMUNITY LEVEL: GENERATION AND COLLECTION IN HOUSEHOLDS, AMONG TRADITIONAL BIRTH ATTENDANTS AND CHEMICAL SHOP VENDORS, AND IMPACTS ON HEALTH

Appendix 8. Focus group discussion guide 1 (Household member)

Engaging Questions:

1. How is household refuse removed from your community? (bins & collection trucks, backyard burning, throwing into the bush or nearby dumps)
2. What are the difficulties with removal of household refuse in your community?

Exploring Questions:

3. How do people discard unwanted medications at home?

4. How are other waste items from healthcare activities in the home discarded? (Soiled bandages or cotton wool, used condoms, used sanitary pads, needles and syringe)

5. If a woman delivers in a compound, what happens to the placenta and afterbirth?

6. Why should medical items, unused or expired medicines or wound dressings/bandages discarded at home be separated from regular household waste? (Reasons)

7. What accidents can result from medical items discarded at home? (Needle stick, other physical injury, accidental poisoning in young children, fire or explosive accidents)

8. What accidents can result from medical items discarded carelessly in the community?

9. How can you separate discarded medical items from regular household waste at home?

10. What problems can one experience in separating discarded medical items from regular household waste? (Storage, collection, payment/tariffs, registration etc.)

11. How can the community ensure that discarded items from healthcare activities at home are removed safely?

12. Why is it important to educate people about how to discard items from healthcare activities at home? (To prevent harm to people, to protect the environment)

Exit Question:

13. What are your final thoughts about the removal of waste from medical items and human tissue from homes?

A STUDY OF SOLID MEDICAL WASTE AT THE COMMUNITY LEVEL: GENERATION AND COLLECTION IN HOUSEHOLDS, AMONG TRADITIONAL BIRTH ATTENDANTS AND CHEMICAL SHOP VENDORS, AND IMPACTS ON HEALTH

Appendix 9. Focus group discussion guide 2 (Chemical shop vendors)

Engaging questions:

1. Let's start the discussion by talking about your role in the community as a chemical seller.

2. What challenges do you experience working as a chemical seller in the community?

Exploring questions:

3. How do you dispose of unwanted and expired medicines in your shop? Why do you use the methods that you mention?

4. How do you dispose of sharp objects (needles and syringes)? Bandages? Test kits (malaria, pregnancy)

5. How do you dispose of unwanted and expired medicines in your home? How do you feel about the way you dispose of them?

6. What are advantages (and disadvantages) of disposing of medical items by burning? Burying? Throwing them in the dustbin?

7. How can disposal services be improved for unwanted, expired and left over medicines or related items in chemical shops? (Explore potential for source segregation).

Exit question:

8. Is there anything you would like to say about the way you discard medical items from your work? Or at home?

That concludes our focus group. Thank you so much for coming and sharing your thoughts and opinions with us. If you have additional information that you did not get to say in the focus group, please feel free to share by contacting us using the phone numbers provided in the consent form.

A STUDY OF SOLID MEDICAL WASTE AT THE COMMUNITY LEVEL: GENERATION AND COLLECTION IN HOUSEHOLDS, AMONG TRADITIONAL BIRTH ATTENDANTS AND CHEMICAL SHOP VENDORS, AND IMPACTS ON HEALTH.

Appendix 10. Focus group discussion guide 3 (Traditional birth attendant)

Engaging questions:

9. Let's start the discussion by talking about your role in the community as a traditional birth attendant (TBA).

Exploring questions:

10. What items do you use for your work in the community?

11. How do you dispose of waste from your work? (placenta, maternity pads)

12. What do community women use for vaginal bleeding? (sanitary pads, other options)

13. What happens when these items are not disposed properly? (Littered in the community? Odious smells?)

14. How can the placenta be buried in a central pit? (in a hospital placenta pit, in a location in the community, TBA's home)

15. What are the traditional beliefs surrounding burial of the placenta?

Exit question:

16. Is there anything you would like to say about the way you discard medical items from your work? Or at home?

That concludes our focus group. Thank you so much for coming and sharing your thoughts and opinions with us. If you have additional information that you did not get to say in the focus group, please feel free to share by contacting us using the phone numbers provided in the consent form.

Appendix 11. List of equipment used for household waste stream analysis

a. 1 table 4m by 2m with foldable legs
b. 2 10L containers, 1 24 litre container and 2 large 120L bins (all plastic)
c. Pre-weighed container for smaller items
d. Screen for sieving out fines
e. Weighing scales
f. Plastic covering for the table
g. Duct tape
h. Masking tape and markers for labels
i. Utility forceps
j. Note pad/ledger, calculator and/or laptop with statistical software and spreadsheet for data entry
k. First aid items
l. Protective gear for each field staff and the researcher that consisted of:
   -Tyvek coveralls
   -Face shields
   -Utility gloves
   -Nitrile gloves
   -Nose mask
   -Dunlop boots

Appendix 12. Solid medical waste and offensive waste collected from households in Week 1 (n=39 households)

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
A + B	1	0.184	0.005	6.130	22.650	.834	Medicine bottles (2 plastic) 1 vial, shaving stick (1), sanitary pads (4), baby diapers (38)
	2	0.005	-	-	11.525	.043	Medicine container (residue)
	3	0.017	0.005	2.050	7.025	.313	Medicine container with content and with residue (paracetamol), baby diapers
	4	-	-	7.690	20.830	.000	Baby diapers
	5	-		5.966	26.640	.000	Baby diapers (17), sanitary pads (4)
	6	-	0.005	-	6.150	.081	Used razor blades
	7	-	-	0.002	1.237	.000	Used cotton bud
	8	0.193	-	-	.920	20.978	Medicine bottle with contents (anti-tussive syrup)
	9	0.017	-	0.003	4.170	.408	Medicine container with content (bendrofluazide, paracetamol) and with residue (aluminium hydroxide), cotton wool (not blood stained)
	10	0.040	-	1.100	4.995	.801	Diapers (7), 1 sanitary pad, medicine packets with contents (paracetamol, multivitamins)
	11	0.005	-	0.405	1.215	.412	Baby diapers (2), Medicine packets with residue
	12			20.975	27.620	.000	Baby diapers (59), 1 sanitary pad

	13	-	-	2.39	22.006	.000	Baby diapers (12)
	14	0.006	-	0.915	7.060	.085	Baby diapers (5), medicine packet (paracetamol)
	15	0.026	-	-	27.375	.095	Medicine packet with content (ampiclox, metronidazole, cloxacillin)
	16	0.026	-	0.008	20.829	.125	Medicine packets with residue (albendazole, Lisinopril, aluminum hydroxide, cloxacillin), bathroom tissue
C	17	-	-	-	7.314	.000	Nil
	18	0.006	-	-	2.026	.296	Medicine pack with residue (paracetamol/ibuprofen/ caffeine)
	19	0.003	-	0.112	7.955	.038	Diapers, medicine packet with residue
	20	-	-	0.010	.845	.000	Bathroom tissue
	21	0.006	-	0.920	5.645	.106	Baby diapers (5), 1 sanitary pad, Medicine packet with residue
	22	0.095	-	-	8.290	1.146	Medicine container with contents (5 full packs, 1 pack ¾ full of Metformin), medicine pack with residue
	23	0.034	0.045	5.795	36.065	.219	Baby diapers (24), medicine blister packs with residue, blades (3)
	24	0.10	0.008	0.001	9.105	.198	Medicine packets with residue, batteries, used razor blades, cotton bud
	25	0.002	0.009	0.080	4.065	.271	Medicine container with residue (multivitamins), sanitary pad & plastic, used razor blades, cotton buds.

	26	1.567	0.006	0.280	13.490	11.66	Medicine container with residue (gentian violet, cough syrup, multivitamin syrups, parecetamol) and with content (cetrizine syrup, multivitamin syrups, zinc sulphate tablets, garlic herbal mixture, multivitamin tablets, other herbal mixture), blades, baby diapers (4), sanitary pad and plastic (3), cotton buds
	27	0.012	0.002	0.002	24.730	.057	Medicine dispensing packs (residue - diclofenac, piroxicam, ampicillin; with content- flucloxacillin), cotton bud
	28	0.004	-	-	3.657	.109	Medicine container with residue
D + E	29	0.008	-	0.008	2.775	.288	Medicine packet with residue (aluminium hydroxide, metronidazole), used cotton wool
	30	-	-	-	.880	.000	Nil
	31	0.482	-	-	.527	91.461	Medicine packs with content (cyproheptadine and vitamins), medicine bottles (2,blood tonic and antacid)
	32	0.542	-	1.18	4.660	11.631	Baby diapers(8), gauze bandage, sodium chloride infusion
	33	-	-	-	4.415	.000	Nil
	34	-	-	-	23.970	.000	Nil
	35	-	-	-	11.730	.000	Nil
	36	-	-	0.110	2.940	.000	Baby diapers and cotton buds

37	0.083	0.002	0.132	24.445	.348	Medicine packets with content, blades, baby diapers
38	-	-	-	3.715	.000	Nil
39	0.019	-	1.475	10.909	.174	Medicine packs with residue, condom (1), baby diapers (11)

Appendix 13. Solid medical waste and offensive waste collected from households in Week 2 (n = 49 households)

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive Waste (kg)	Household waste (kg)	Per cent SMW	Description
A+B	1	0.164			3.002	5.463	Medicine packet with minimal residue (artemether-lumefantrine), syrup with content (metronidazole +furazolidone, amoxicillin+clavulanic acid)
	2	0.006		2.740	19.698	.030	Medicine packet with content (diclofenac sodium), gauze, baby diapers (13)
	3				9.465	.000	Nil
	4				6.130	.000	Nil
	5				5.705	.000	Nil
	6	2.427		0.755	9.030	26.877	Baby diapers (4), sanitary pad (1), syrups with content and with residue (19 bottles, 5 plastic), medicine packs with content
	7	0.134		1.11	2.434	5.505	Glass syrup bottles with minimal residue (2), baby diapers (6), pad plastic (2)
	8	0.041		1.534	9.835	.417	Cotton, baby diapers (12), multi-vitamin syrup bottle
	9			2.585	10.765	.000	Baby diapers (7)
	10	0.131			.690	18.986	Syrup bottles (glass, plastic, medicine packet with residue (griseofulvin tablet)

	11	0.004	0.009		3.963	.328	Medicine pack with content (folic acid), blades
	12			0.005	15.115	.000	Cotton bud, pad plastic
	13				4.759	.000	Nil
	14			0.864	2.759	.000	Cotton buds (2), baby diapers (10)
	15	0.115		1.833	10.957	1.050	Medicine bottle with minimal residue, medicine pack with minimal (metronidazole), tissue paper, baby diapers (9)
	16	0.051		1.167	28.568	.179	Baby diapers (8), bandage, empty medicine bottles (2, plastic), medicine pack with minimal residue (Vit. B complex)
	17	0.009	0.004		8.930	.146	Razor blade, medicine packets (Postinor, cyproheptadine, paracetamol)
	18	0.180	0.002	0.004	20.850	.873	Medicine packet with minimal residue (Doxycycline), razor blade, bottle of antacid with residue
	19			0.002	3.485	.000	Cotton bud
C	1		0.002		5.850	.034	Razor blade
	2	0.014	0.002	0.005	17.041	.094	Medicine packet with residue (antimalarial), syrup with contents, cotton buds, razor blade
	3			0.059	9.234	.000	Baby diaper (1)
	4				.545	.000	Nil

5	0.004	0.002	0.001	4.805	.125	Razor blade, medicine packet (with residue), cotton bud
6	0.006		0.109	2.780	.216	Medicine pack with residue (mefenamic acid+dicyclomine hydrochloride), baby diaper (1)
7				1.000	.000	Nil
8	0.007			1.287	.544	Medicine packet with residue (diclofenac sodium)
9		0.013	0.007	3.706	.351	Shaving stick, cotton bud
10	0.006		0.004	11.970	.050	Medicine packet with residue (nifedipine), cotton bud
11	0.006			6.220	.096	Medicine packet with residue ibruprofen/ paracetamol/caffeine)
12			0.006	.771	.000	Pad plastic
13		0.007	0.935	7.520	.093	Shaving stick, baby diapers (4)
14	0.010		0.005	13.135	.076	Medicine packets with content (folic acid) and residue (glizone, artemether-lumefantrine, pioglitazone hydrochloride, paracetamol, Lisinopril), cotton buds
15	0.041	0.005	3.015	13.005	.354	Razor blade, baby diapers (10), residue in bottle of herbal mixture

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
D+E	1				2.015	.000	Nil
	2	0.004			.255	1.569	Medicine packet with residue (metronidazole)
	3		0.001	0.036	30.580	.003	Pad plastic, sanitary pad (1), razor blade, cotton bud
	4	0.024		0.002	7.241	.331	Medicine packet (Osteovite), syrup with content (multivitamin, iron, zinc)
	5	0.087			27.625	.315	Medicine packs with contents (diclofenac sodium)
	6				12.194	.000	Nil
	7	0.136	0.005		12.210	1.155	Syrup bottles, medicine packet without residue
	8	0.008	0.008		4.087	.391	Medicine packets with residue (ampicillin, ascorbic acid), shaving stick
	9	0.004		2.791	9.865	.041	Medicine packet with residue (sildenafil), condoms, cotton bud, pad plastic, baby diapers (18)
	10				3.465	.000	Nil
	11				6.565	.000	Nil
	12	0.020		2.795	19.565	.102	Medicine packets with (cotrimoxazole, antacid, albendazole, bisacodyl, chloramphenicol) and residue (paracetamol, vitamin C & glucose, amoxycillin), baby diapers (9), plaster of Paris

	13	0.017	0.012	1.181	13.990	.207	Medicine packets with residue (paracetamol), baby diapers (6), pad plastic, razor blades and shaving stick
	14	0.007			11.960	.059	Medicine packet with residue (paracetamol)
	15	0.032			2.622	1.220	Medicine packets with content and residue (paracetamol)

Appendix 14. Solid medical waste and offensive waste collected from households in Week 3 (n=56 households)

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
A + B	1	.002	.007	.000	11.455	.079	Medicine packet with content (Tramadol), used blade, used shaving stick
	2	.000	.000	.000	1.901	.000	Nil
	3	.010	.000	.434	13.035	.077	Medicine packet with content (artemether-lumefantrine) and with residue (peppermint & eucalyptus oil), diapers (3)
	4	.000	.000	.000	.745	.000	Nil
	5	.000	.000	.002	12.830	.000	Used cotton buds
	6	.000	.000	.000	12.610	.000	Nil
	7	.156	.000	.522	6.635	2.351	Medicine container with content (antacid syrup: simethicone, aluminium hydroxide, magnesium hydroxide) and with residue (metronidazole and cotrimazole pessaries), baby diapers (3), soiled cotton wool

8	.131	.017	1.845	13.760	1.076	Medicine packet with content (zinc sulphate, Danacin, [aspirin, paracetamol & caffeine], [ibruprofen, paracetamol & caffeine], artemther-lumefantrine) and with residue (paracetamol, Cafalgin syrup bottle), soiled sanitary pads (4), baby diapers (9), used cotton bud, used shaving sticks (3) and blade (1)
9	.153	.000	1.379	32.355	.473	Medicine container with residue (diphenhydramine hydrochloride, cyproheptadine, antimalarial syrup), baby diapers (8), soiled sanitary pads (2), used cotton bud
10	.003	.000	.161	1.380	.217	Medicine packet with residue (haematinic [folic acid, Vitamin B12]), baby diaper
11	.007	.006	.001	12.810	.101	Medicine packet with content (paracetamol, Septrol: [menthol, eucalyptus]), and with residue (mebendazole), used cotton bud, used shaving stick
12	.006	.000	.000	1.685	.356	Medicine packet with content (folic acid) and with residue (vitamin B complex, analgesic [EFPAC], cyproheptadine hydrochloride)
13	.000	.006	.000	3.740	.160	Shaving stick

14	.007	.003	.689	6.299	.159	Medicine container with content (topical cream [clotrimazole, betamethasone diproprionate, neomycin sulphate]), used blade, baby diapers (7), used examination gloves (1 pair)
15	.000	.006	1.034	1.755	.342	Used shaving stick, baby diapers (6)
16	.003	.000	.002	5.930	.051	Medicine packets with content (paracetamol) and with residue (cyproheptadine hydrochloride), used cotton bud, pad (plastic)
17	.000	.000	1.008	21.720	.000	Baby diapers (6), used cotton bud
18	.044		.001	21.200	.208	Medicine packets with content (griseofulvin, [ibuprofen, paracetamol, caffeine], aspirin, paracetamol, [acetycylic acid, caffeine] and with residue (glibenclamide, albendazole, metformin hydrochloride, clindamycin, piroxicam, used cotton bud

	19	.279	.000	.000	11.595	2.406	Medicine bottles (2 syrup bottles: multivitamin, unknown), medicine container with residue (cyproheptadine hydrochloride and multivitamins, multivitamins, [cyproheptadine and L-lysine hydrochloride])
C	20	.000	.000	.000	9.405	.000	Nil
	21	.000	.000	.047	3.600	.000	Soiled sanitary pads (2)
	22	.000	.000	.000	16.770	.000	Nil
	23	.010		.000	8.880	.113	Medicine packets with content (vit B complex, cyproheptadine & multivitamins)
	24	.004		.002	4.400	.091	Medicine packet with content (folic acid & iron), used cotton buds
	25	.045	.001	.147	21.285	.216	Medicine container with content (amoxicillin syrup) and with residue (paracetamol), used cotton bud, baby diapers (1), used blade

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
C	26	.000	.000	.001	7.710	.000	Used cotton bud
contd.	27	.038	.000	.108	8.315	.457	Medicine packet with residue (ibuprofen, albendazole syrup), baby diaper
	28	.000	.000	.000	3.580	.000	Nil
	29	.000	.000	.042	5.540	.000	Soiled sanitary pads
	30	.089	.000	.007	6.230	1.429	Medicine container with content (Gastracid: calcium carbonate, simethicone, magnesium trisilicate) and with residue (amoxicillin trihydrate, artemether-lumefantrine, metronidazole (2), cyproheptadine hydrochloride & vitamins, [Kwick action: paracetamol, ephedrine hydrochloride, caffeine], amoxicillin (2), metronidazole, bandage, used cotton wool
	31	.004	.001	.000	20.440	.024	Medicine packets with residue (bendrofluazide, paracetamol, amlodipine besilate), used blade
	32	.000	.000	.008	1.880	.000	Blood stained tissue paper
	33	.000	.000	.000	2.395	.000	Nil

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
C Contd.	34	.020	.000	.094	30.799	.065	Medicine packet with residue (artemether-lumefantrine, misoprostol, [cyproheptadine hydrochloride & multivitamins (2)], diclofenac sodium, haematinics, ascorbic acid), pregnancy test kit, soiled sanitary pads
	35	.000	.000	.160	11.965	.000	Baby diaper
	36	.000	.000	.000	5.135	.000	Nil
	37	.017	.000	.000	1.510	1.126	Vial (unlabeled)
	38	.054	.000	2.096	13.210	.409	Medicine container with residue (folic acid, herbal syrup [Azadinrachta indica, mordic charantia], paracetamol, menthol balm, baby diapers, used cotton bud (8)
D + E	39	.000	.000	.000	1.875	.000	Nil
	40	.002	.000	.000	.900	.222	Medicine packet with content (ampicillin) and with residue (paracetamol, amoxicillin), batteries and used blade
	41	.000	.006	.000	13.000	.046	Shaving stick, empty medicine packet (penicillin V)
	42	.000	.000	.000	9.845	.000	Nil
	43	.104	.004	.001	22.920	.471	Medicine container with residue (aluminum sulphate syrup, metronidazole)

44	.000	.003	.000	7.550	.040	Used blade
45	.008	.000	1.154	17.485	.046	Medicine packet residue (paracetamol), baby diapers (10)
46	.280	.002	.157	24.135	1.168	Medicine container with residue (chloramphenicol eye drops 5%; calcium suspension with vitamin D; antipyretic [Teedar syrup], cream with content (betamethasone valerate with gentamicin sulphate)
47	.000	.000	.000	2.750	.000	Nil
48	.219	.000	.007	2.185	10.023	Medicine packet with content (zinc sulphate monohydrate, naphazoline hydrochloride) and with residue (gentamicin eye drops, paracetamol, haemoglobin syrup), chinese oil balm, used cotton buds
49	.316	.001	.000	6.700	4.731	Medicine container with content (2 paracetamol syrup bottles) and with residue (cough syrup [diphenhydramine hydrochloride, guanfenesin, menthol], ascorbic acid, naproxen, vitamin B complex, Pectol, iron hydroxide), used blade

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
	50	.077	.000	2.861	10.705	.719	Medicine packet (sildenafil), medicine container (cough syrup[ipecacanha tincture, honey and squill oximal]), diapers (11)
	51	.002	.000	.000	6.930	.029	Medicine packet with residue (penicillin V)
	52	.000	.000	.000	13.660	.000	Nil
	53	.004	.007	.547	9.730	.113	Medicine packet with content (ibuprofen), used blade, used shaving stick, baby diapers (2), used sanitary pad (1)
	54	.004	.000	.000	14.175	.028	Medicine packets with content (piroxicam) and with residue (metronidazole, albendazole)
	55	.000	.000	.000	11.335	.000	Nil
	56	.001	.000	.381	10.600	.009	Medicine packet with content (paracetamol), used cotton bud, baby diapers (2)

Appendix 15. Solid medical waste and offensive waste collected from households in Week 4 (n=59 households)

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
A + B	1	.000	.000	.000	.725	.000	Nil
	2	.000	.000	.000	1.315	.000	Medicine packet with residue (ketoconazole)
	3	.000	.000	1.465	15.030	.000	Medicine packet with residue (Septrol [menthol, eucalyptus oil]), baby diapers (9)
	4	.010	.000	.000	.600	1.667	Medicine packet with content (loperamide hydrochloride) and with residue (paracetamol [2], cyproheptadine hydrochloride [2]
	5	.004		.000	13.235	.030	Medicine packet with residue (metronidazole, multivitamins)
	6	.014		.000	12.490	.112	Medicine packet with content (piroxicam, ascorbic acid) and with residue (amoxicillin)
	7	.002	.000	.000	1.000	.200	Medicine packet with residue (diclofenac sodium)
	8	.007	.003	.000	3.375	.296	Medicine container with content (amoxicillin oral suspension) and with residue (paracetamol, ephedrine hydrochloride, caffeine)
	9	.000		1.083	6.920	.000	Baby diapers (7), cotton bud, soiled bandage
	10	.003		.414	12.895	.023	Medicine packet with residue (diclofenac sodium, albendazole), unlabeled dispensing pack, baby diapers (3)

11	.000	.000	.329	4.865	.000	Baby diapers (2)
12	.000		.000	10.340	.000	Nil
13	.000	.000	.000	1.415	.000	Nil
14	.014		.000	7.895	.177	Medicine pack with content (amoxicillin capsules, multivitamins, paracetamol)
15	.010	.000	.000	.320	3.125	Medicine container with residue (menthol, peppermint oil, eucalyptus oil)
16	.000	.005	.990	5.970	.084	Used shaving stick, baby diapers (5)
17	.000	.000	.000	6.125	.000	Nil
18	.005	.000	1.836	9.165	.055	Medicine packet with residue (ascorbic acid, amoxicillin and clavulanic acid), used cotton bud, baby diapers (5)
19	.005	.005	1.01	13.415	.075	Medicine with residue (paracetamol), used shaving stick, baby diapers (6)
20	.185	.000	.000	5.130	3.606	Medicine container with content (metronidazole syrup) and residue (artemether-lumefantrine, expectorant[diphenhydramine hydrochloride, menthol, sodium citrate, ammonium chloride], cyproheptadine, oral rehydration salts
21	.000	.000	.000	17.300	.000	Used blade
22	.045	.000	.000	6.690	.673	Medicine container with content (griseofulvin oral suspension, multivitamins) and with residue (cyproheptadine, multivitamins)

C	23	.000	.000	.000	6.020	.000	Nil
	24	.001	.000	.000	6.125	.016	Medicine packet with content (penicillin V)
	25	.000	.000	.001	5.550	.000	Cotton bud
	26	.006	.000	.000	2.635	.228	Medicine packet with residue (ciprofloxacin hydrochloride)
	27	.000	.000	.000	5.760	.000	Nil
	28	.002	.000	.004	3.825	.052	Medicine packet with residue (paracetamol), test cartridge (?pregnancy)
	29	.000	.000	.686	15.340	.000	Baby diapers (3), cotton buds, blood soaked tissue paper
	30	.015	.006	.002	13.235	.159	Medicine packet with contents (vitamin B complex, piroxicam), shaving stick, cotton buds
	31	.000	.000	.000	6.110	.000	Medicine packet with residue (aspirin)
	32	.000	.000	.000	3.920	.000	Medicine packet with residue (piroxicam), bandage
	33	.000	.005	.000	2.840	.176	Medicine packet with residue (diclofenac sodium, Panadol), cotton bud, shaving stick
	34	.170	.005	.086	3.581	4.887	Medicine packet with content (metronidazole) and with residue (cyproheptadine, multi-vitamin capsules and syrup), soiled sanitary pads (3), used blade, cotton bud

	35	.005	.000	.000	9.140	.055	Medicine packet with residue (paracetamol, amlodipine)
	36	.010	.000	.106	1.575	.635	Medicine packet with residue (aluminium hydroxide, paracetamol, menthol), baby diaper, cotton bud
	37	.000	.000	.000	1.795	.000	Nil
	38	.001	.000	.001	3.400	.029	Medicine packet with residue (loperamide hydrochloride), cotton bud
	39	.010	.000	.055	6.635	.151	Medicine container with content (herbal tablets[“sharp-sharp”] and residue (analgesic: aspirin, caffeine & paracetamol), used sanitary pads (4)
	40	.004	.000	.557	11.341	.035	Medicine packet with residue (folic acid), baby diapers (3)
	41	.001	.000	.660	7.380	.014	Medicine packet with residue (paracetamol, amlodipine besilate), used blade, baby diapers (2)
D + E	42	.000	.000	.000	1.275	.000	Nil
	43	.001	.000	.000	1.440	.069	Medicine packet with residue (analgesic: [paracetamol, ibuprofen, caffeine])
	44	.054	.000	.000	18.350	.294	Infusion bag with content (0.9% saline infusion), medicine packets with residue (paracetamol, acetaminophen suppositories, analgesic [EFPAC], used blade
	45	.000	.000	.000	7.995	.000	Nil

46	.070	.000	.220	17.425	.402	Medicine container with content (dietary supplement[garlic capsules], herbal capsules, diclofenac sodium) and residue (albendazole, cyproheptadine syrup), baby diaper
47	.000	.000	.000	10.345	.000	Nil
48	.002	.000	.174	12.372	.016	Medicine packet with residue (loperamide hydrochloride), baby diaper
49	.009	.000	.001	19.768	.046	Medicine packet with residue (sulphadoxine-pyrimethamine, haematinic [iron], cotton bud
51	.161	.000	.010	3.086	5.217	Medicine packet with content (cough syrup[menthol, eucalyptus oil]), and residue (diclofenac sodium (2), paracetamol)
52	.002	.000	.195	5.920	.034	Medicine packet with content (folic acid, diclofenac sodium) and with residue (citric acid, analgesic), diaper, plaster
53	.135	.000	.000	4.565	2.957	Medicine packet with residue (Kwik action [caffeine, paracetamol, ephedrine hydrochloride], artemether-lumefantrine, paracetamol, amoxicillin with clavulanic acid, cough syrup [dextromethorphan, bromhexine, menthol, ammonium chloride]
54	.010	.000	.900	7.565	.132	Medicine packet with content (EFPAC[acetaminophen, acetylcylic acid,

						caffeine]), baby diapers (8)
55	.001	.001	.000	2.885	.069	Medicine packet with residue (penicillin V), used blade
56	.110	.001	.000	17.776	.624	Medicine container with residue (cough syrup [guaiphenesin, diphenhydramine hydrochloride, sodium citrate, menthol], Kwik-action (analgesic), metronidazole, penicillin V, multivitamins, used blade
57	.000	.000	2.015	3.620	.000	Baby diapers (9)
58	.001	.000	.000	8.125	.012	Medicine packet with residue (paracetamol)
59	.000	.000	.000	12.390	.000	Nil

Appendix 16. Solid medical waste and offensive waste collected from households in Week 5 (n=59 households)

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
A + B	1	.005	.000	.000	.550	.909	Medicine packet with residue (albendazole, paracetamol)
	2	.001	.000	.000	.660	.152	Medicine packets residue (ibuprofen, paracetamol)
	3	.000	.000	2.460	16.350	.000	Baby diapers (13)
	4	.011	.000	.000	1.710	.643	Medicine packet with content (diclofenac sodium) and residue (multivitamin, sodium cromoglycate (eye drops), paracetamol)
	5	.000	.000	.000	.395	.000	Nil
	6	.255	.005	1.310	8.940	2.908	Medicine containers with content (amoxicillin syrup, amodiaquine syrup) and with residue (sulphathiazole, ascorbic acid, ibuprofen & paracetamol, haematinic [syrup: iron (III) hydroxide & multivitamins], shaving stick
	7	.000	.000	.000	6.930	.000	Nil
	8	.000	.000	.000	1.235	.000	Nil
	9	.005	.000	.000	17.665	.028	Medicine packet with content (paracetamol)
	10	.000	.000	.000	1.570	.000	Nil
	11	.005	.005	.282	11.125	.090	Medicine packet with residue (loperamide hydrochloride [2]), baby diapers (2), sanitary pad plastic, cotton bud, shaving stick

	12	.001	.000	.000	13.990	.007	Medicine packet with residue (sulphathiazole)
	13	.000	.000	.000	12.305	.000	Nil
	14	.001	.000	.000	10.865	.009	Medicine with residue (nifedipine)
	15	.000	.010	.850	2.370	.422	Baby diapers (6), shaving sticks (2)
	16	.005	.000	.010	1.895	.264	Medicine packet with residue (analgesics [aspirin, paracetamol] (2), [diclofenac sodium, paracetamol], sanitary pad plastics
	17	.001	.000	.001	7.670	.013	Medicine packet with residue (folic acid), cotton bud
	18	.485	.001	1.880	6.170	7.877	Medicine container with content (multivitamin syrup, amoxicillin trihydrate, amoxicillin syrup) and with residue (paracetamol syrup), baby diapers (5), used blade
	19	.000	.000	.445	5.230	.000	Baby diapers (4)
	20	.001	.005	.000	15.246	.039	Medicine packet with residue (paracetamol, diclofenac sodium), shaving stick
	21	.005	.000	.835	8.530	.059	Medicine packet with residue (ampicillin trihydrate, acetaminophen and acetylsalicylic acid), baby diapers (5)
C	22	.000	.001	.000	4.340	.023	Used blade
	23	.006	.000	.000	11.115	.054	Medicine packets with residue (paracetamol, artemether-lumefantrine)
	24	.000	.005	.000	12.635	.040	Shaving stick

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
C	22	.000	.001	.000	4.340	.023	Used blade
	23	.006	.000	.000	11.115	.054	Medicine packets with residue (paracetamol, artemether-lumefantrine)
	24	.000	.005	.000	12.635	.040	Shaving stick
	25	.165	.000	.000	9.230	1.788	Medicine container with content (amoxicillin trihydrate syrup)
	26	.005	.000	.005	6.485	.077	Medicine packet with residue (albendazole [3], griseofulvin), sanitary pad plastics
	27	.095	.000	.260	7.135	1.331	Medicine container with content (cough syrup [ammonium chloride, menthol, tinctures], blood soaked tissue and cloth
	28	.000	.000	.265	12.315	.000	Baby diapers (2)
	29	.110	.000	.375	12.585	.874	Medicine packet with residue (albendazole, paracetamol, syrup [diphenhydramine hydrochloride]), baby diapers (2)
	30	.001	.000	.000	2.516	.040	Medicine packet with residue (analgesic[paracetamol & anhydrous caffeine])
	31	.000	.000	.025	4.660	.000	Soiled sanitary pad
	32	.100	.005	.000	4.010	2.618	Medicine container with content (syrup:[diphenhydramine hydrochloride, ammonium chloride]) and with residue (ascorbic acid), shaving stick

	33	.005	.001	.000	5.195	.115	Medicine packet with residue (cyproheptadine hydrochloride & multivitamins), used blade
	34	.000	.000	.000	3.605	.000	Nil
	35	.011	.015	.000	1.601	1.624	Medicine packet with content (prednisolone) and with residue (metronidazole (2), mebendazole, gentamycin injection vial (broken vials), syringes and needles (3)
	36	.000	.000	.266	5.285	.000	Baby diaper, cotton bud
	37	.001	.000	.001	15.775	.006	Medicine packet with content (paracetamol), cotton bud
	38	.100	.000	.140	3.640	2.747	Medicine container with residue (multivitamin syrup), baby diapers (2)
	39	.000	.000	.000	6.795	.000	Nil
	40	.160	.005	.000	17.000	.971	Medicine container with residue (antacid [magnesium hydroxide, simethicone]), shaving stick
	41	.016	.001	.000	9.475	.179	Medicine packet with residue (analgesic: [diclofenac sodium, paracetamol], benzyl penicillin G injection vial), used blade
D + E	42	.001	.000	.000	.600	.167	Medicine packet with residue (paracetamol)
	43	.005	.000	.000	1.575	.317	Medicine packet with residue (penicillin V, paracetamol)
	44	.000	.000	.000	12.335	.000	Nil

Zone	House ID	Medicinal waste (kg)	Sharps (kg)	Offensive waste (kg)	Household waste (kg)	Per cent SMW	Description
	45	.005	.001	.000	2.670	.225	Medicine packet residue (cyproheptadine & multivitamins (2), calcium pantothenate), used blade
	46	.001	.001	.000	15.490	.013	Medicine packet residue (analgesic: paracetamol, caffeine), used blade
	47	.000	.000	.000	2.705	.000	Nil
	48	.000	.000	.000	2.885	.000	Nil
	49	.000	.000	.195	13.610	.000	Baby diapers (2)
	50	.000	.000	.000	1.605	.000	Nil
	51	.001	.000	.190	6.725	.015	Medicine packet with residue (paracetamol), baby diaper
	52	.000	.000	.000	6.610	.000	Nil
	53	.000	.000	.000	5.695	.000	Nil
	54	.001	.000	.000	5.115	.020	Medicine packet with residue (Pack of lozenges: [menthol, eucalyptus oil, peppermint oil]
	55	.010	.005	.000	20.165	.074	Medicine packet with residue (penicillin V) and with content (Tramadol hydrochloride, artemether-lumefantrine, streptol: [menthol, eucalyptus oil, capricum oleoresin]), shaving stick
	56	.015	.001	3.100	21.190	.076	Medicine container with content (topical betamethasone diproprionate & gentamicin sulphate) and with residue (paracetamol, artesunate-amodiaquine), used blade, baby diapers (16)

57	.006	.001	.000	12.030	.058	Medicine packet with content (nicotinamide) and with residue (penicillin V), used blade
58	.000	.000	.000	15.160	.000	Nil
59	.120	.001	.000	14.180	.853	Medicine container with residue (syrup bottle: [paracetamol, polymaltose], artemether-lumefantrine), used blade

N. B.: Zones refer to administrative zones (also used for waste management) assigned by the Ga South Municipal Assembly and where the households that participated in the waste stream analysis were located

	
Plaster and gauze bandages soiled with serum	Faecally soiled baby diapers
	
Sanitary waste – tissue soiled with menstrual blood	A cartridge, most likely for pregnancy test
	
Condoms, cotton buds and packets of sildenafil and levornorgestrel	An intravenous infusion bag (0.9% normal saline)

Appendix 17. Photographs of offensive waste retrieved from household waste

Source: Field survey, 2014

Appendix 18. Statistical tests used in the study

1. **Kendall's tau** is a non-parametric measure of the **correlation among ranked data**. It often yields a lower value than the Spearman rho (another non-parametric correlation test). It has been suggested that it may be a better estimate of correlation in a given population than Spearman's statistic, and one can therefore generalize more accurately with the test. Used for a small data set containing many tied ranks.

2. **Kruskal-Wallis H test**: This test compares two or more groups of ordinal or quantitative data when the sample data violate the assumptions of normality. It is the non-parametric analogue of a **one-way analysis of variance (ANOVA)**. The null hypothesis assumes that the samples come from identical populations. It does not require that the samples be the same size.

3. **Regression analysis** is a method of predicting an outcome variable (Y_i) from one or more predictor variables (X_i). The subscript denotes the values corresponding to i^{th} respondent. The relationship between the variables is assumed to be linear. It is defined by its **gradient** or **slope** often denoted by β_1, and the point at which the slope crosses the y-axis (vertical axis) often represented as β_0 and known as the **intercept**. The parameters, β_1 and β_0 are referred to as regression coefficients. The model which depicts the relationship also contains an error term which is the difference between the predicted values of the model and the observed values. The following expression is often used to depict the model: $Y_i = (\beta_0 + \beta_1 X_i) + \varepsilon_i$. Here, the regression coefficient (β_1) represents the change in Y_i following a unit change in X_i. Two types of regression analysis were used in this study:

a. **Ordinary least squares regression**: This models the mean of a response variable recorded on an interval scale as a linear function of one or more explanatory variables as well as appropriately coded categorical explanatory variables. It demonstrates the average change in the response variable associated with a unit change in the explanatory variable, holding constant other explanatory variables in the model. R^2 is a measure that indicates the percentage of the variation in the response variable that is shared by the explanatory variable.

b. **Quantile regression**: This models the relationship between the explanatory variable, X_i and the conditional quantiles of the response variable, Y_i. Quantiles (percentiles) are used to describe the distribution of the response variable. The model is depicted by the expression:

$$Y_i = Xi.\beta q + ei,$$

Where βq represents the change in a specified quantile of the response variable produced by a unit change in the explanatory variables. Therefore the computed values of β are dependent on the quantiles selected.

5. **Sign test**: This is the non-parametric analogue of the **one-sample t-test**. It tests whether a sample has a hypothesized median, therefore the null hypothesis is that the sample is drawn from a population with a specific median value. Data in the sample are assigned classes above (+) and below (-) the hypothesized median. Therefore if the null hypothesis is true, there should be equal number of differences in each direction. The test used when the direction of the difference is to be ascertained, without regard for the size of the difference.

6. **Wilcoxon's rank-sum test**: This is the non-parametric analogue of the **independent t-test**. It is used to test differences between two conditions in which the participants are different. The null hypothesis states that the two groups have equal mean ranks. A p-value less than 0.05 indicates that the two groups are significantly different. It is reported using the test statistic, *W*, and the p-value (its significance value).

7. **Wilcoxon signed rank test**: This is the non-parametric analogue of the **repeated measures t-test**. It compares two-sample paired data (e.g. before and after observations, wet season and dry season weight measurements) by computing the differences of the paired observations and testing if the median of the differences equals zero. It does not assume normality.

Sources:

(Field, Miles, & Field, 2012; Boslaugh, 2013b; Field, 2013a, 2013b)

www.biostathandbook.com/wilcoxonsignedrank.html cited on 6th March, 2015

www.biostathandbook.com/exactgof.html#signtest cited on 6th March, 2015

Appendix 19. Descriptive statistics of wet waste measurements of solid medical waste by income groups and total sample, with 95% confidence intervals

	Per household/day **(x 10^{-3}kg/day)**			
Income groups	Low	Middle	High	Total
No. of households	29	16	15	60
Mean	9.651	4.736	5.326	7.259
S.E.	2.961	1.000	1.049	1.495
95% CI	3.585 - 15.716	2.604 – 6.868	3.076 – 7.577	4.267 – 10.251
No. of households	27	16	15	58*
Mean	5.575	4.736	5.326	5.279
S.E.	0.777	1.000	1.049	0.522
95% CI	3.978 – 7.173	2.604 – 6.868	3.076 – 7.577	4.233 – 6.326
	Per capita/day (x 10^{-3}kg/person/day)			
No. of households	29	16	15	60
Mean	2.427	0.942	1.397	1.774
S.E.	0.662	0.189	0.319	0.341
95% CI	1.071 – 3.784	0.538 – 1.346	0.712 – 2.081	1.091 – 2.456
No. of households	27	16	15	58*
Mean	1.547	0.942	1.397	1.341
S.E.	0.273	0.189	0.319	0.161
95% CI	0.986 – 2.108	0.538 – 1.346	0.712 – 2.081	1.018 – 1.665

*S.E. = standard error, 95% CI = 95% confidence interval, N = number of households; * sample without outliers i.e. 2 households (ID. No. 18/20 and 09/02 with household generation rates of 54.85 x 10^{-3} kg/household/day and 74.48 x 10^{-3} kg/household/day respectively).*

Appendix 20. Discussion Tool used for focus group discussions

Appendix 21. Handbill on solid medical waste in households (template)

Adapted from: http://dhhs.ne.gov/publichealth/Documents/01-07-13%20DEQ%20household%20medical%20waste.pdf. Retrieved 3rd July, 2015