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Assessing Clinical Solid Waste Management Strategies in Sunyani Municipality, Ghana– Evidence from Three Healthcare Facilities

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ABSTRACT: *The study investigated clinical waste management (CWM) strategies used by the three healthcare facilities in Ghana. Specifically, the study sought to; determine the amount of different kinds of solid waste; evaluate the existing methods for managing clinical solid waste in health facilities; and recommend possible remedial measures to be implemented. The study collected data through field data collection; observation and structured interview. Document analysis was used to triangulate the information collected through observation and structured interviews. The results revealed varying quantities of clinical waste generated and clinical waste compositions. CWM standards and best practices were inappropriately applied for clinical waste transportation, treatment, storage and disposal in two hospitals. Recycling strategy is non-existent. Reasons such as apathy of hospital administrators and waste collectors are attributed to poor CWM in the hospitals. The study recommends adoption of recycling strategy and creation of staff awareness and training on health implications of poor CWM.*

KEYWORDS: Clinical waste management (CWM), solid waste strategy, Healthcare workers, Sunyani Municipality

INTRODUCTION

Globally, there is a great concern on control and safe handling of clinical solid waste in and around the healthcare facilities setting due to its potential health implication on human and its surroundings (Hossain et al., 2013). Clinical solid waste defined by the Health and Safety Commission London as in Collins, (1991). is 'waste generated from medical, nursing, dental, veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research which by nature of its toxic, infectious or dangerous content may prove a hazard or give offence unless previously rendered safe and inoffensive'. The term clinical solid waste includes syringes, live vaccines, blood and other waste contaminated with bodily fluids, culture dishes, sharp objects, discarded surgical gloves, discarded surgical instruments *etc* (WHO, 2014). The collection, segregation and disposal of clinical solid waste entails labour intensive operations, involving many possibilities of direct contact with the waste increasing the risk of infections to the waste handlers (Abor & Bouwer, 2008; Udofia & Nriagu, 2013).

Past literatures have showed that the clinical waste management (CWM) at healthcare facilities is lagging in developing nations as compared to developed (Awad et al., 2004; Hamoda et al.,

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2005; Da Silva et al., 2005). Unlike the developed countries, most developing nations tend to have both clinical and non-clinical wastes handled and disposed off together (Da Silva et al., 2005) thereby breaching the CWM standards and best practices (WHO, 2014). The African continent alone has over 67,000 healthcare facilities that generates over 283, 000 tonnes of clinical wastes annually (Udofia & Nriagu, 2013). A WHO survey in 22 developing nations found that about 18% to 64% of healthcare centres' use inappropriate clinical waste treatment and disposal technologies (WHO, 2005a). This phenomenon poses public health risk due to the infectious nature of clinical waste (Alhumoud, & Alhumoud, 2007; Da Silva et al., 2005). Mostly, the first group of people at risk are the healthcare staffs who are prevalently exposed to common diseases such as cholera, tuberculosis, hepatitis, skin infections, and food poisoning, *etc*., in either epidemic or even endemic form (Marinkovic´ et al., 2008; Bdour et al., 2007). Consequently, studies conducted by (Alhumoud, & Alhumoud, 2007; Marinkovic´ et al., 2008) revealed waste handlers as the prevalently exposed as compared to other healthcare workers. Due to their occupational job functions, waste handler's general exposure to clinical waste could result in an infection during waste handling process mostly through punctures, cuts, inhalation or dermal contact (Hossain et al., 2013). Therefore, clinical solid waste is perceived as hazardous or infectious, and requires steps to control and safely handling to minimize occupational incidents and environmental contamination (Cheng et al., 2009; Katoch & Kumar, 2008).

Many studies have proposed different appropriate CWM practice in the view of reducing health hazards and its associate environmental contamination (Da Silva et al., 2005; Suwannee, 2002). However, reasons such as non-existence of comprehensive waste management strategies coupled with lack of awareness of the healthcare workers regarding the infectious risk of clinical solid waste are attributed to the mismanagement of clinical solid waste in many healthcare facilities of developing countries (Agarwal, 1998; Nema et al., 2011).

Prior to 1992, Ghana had no well defined clinical solid waste management practices in the healthcare facilities. So the Waste Management Department of the Accra Metropolitan Assembly and the Ministry of Health following the United Nations Conference on Environment and Development (UNCED) in Rio de Janerio in June 1992 developed a clinical waste management manual for healthcare centres on how safe handling and disposal of both clinical and non-clinical waste generated. The outcome of the UNCED conference suggested to countries to establish waste treatment and disposal criteria, and develop the ability to monitor the environmental impact of wastes by the year 2025 (Abor and Bouwer, 2008; Nema et al., 2011). However, there is growing concern over poor management practices and improper precautions taken by most clinical waste workers during the solid waste management process in Ghana. The research problem is that little studies have assessed the clinical solid waste management strategies adopted by the healthcare centres in Ghana. This study evaluates the challenges and opportunities in Ghana's healthcare facilities in managing clinical solid waste. The study explored within the Sunyani Municipality how clinical solid waste management process from generation, segregation, collection, handling, treatment, storage and disposal in three selected hospitals in the Sunyani municipality.

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Objectives of the Study

The study objective is to investigate the clinical waste management (CWM) strategies used by the hospitals in Sunyani municipality.

Specifically, the study seeks to

- To determine the amount of different kinds of solid waste generated in hospitals within the municipality
- To evaluate the existing methods used in managing clinical waste in hospitals within the municipality
- To recommend possible remedial measures to be implemented in Sunyani Municipality, Ghana.

Research Questions

1. What is the quantity of solid waste generated in hospitals within the municipality?
2. Is the existing CWM methods employed prior to disposal in the Sunyani Municipality in accordance to best practices?
3. What possible remedial measures can be implemented to improve CWM practices in the municipality?

LITERATURE REVIEW

Concept of clinical waste management (CWM)

Definition of clinical waste

For many years, health workers, hospital administrators, and other health related professionals have realized the necessity to protect themselves and the general public from exposure to clinical solid wastes (Abor & Bouwer 2008). Clinical waste has often been defined differently by different countries, research scientist, international NGOs and other global institutions (Nema et al., 2011). However, this study adopts the definition of clinical solid waste by Health and Safety Commission London as ‘waste arising from medical, nursing, dental, veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research which by nature of its toxic, infectious or dangerous content may prove a hazard or give offence unless previously rendered safe and inoffensive. Such waste includes human or animal tissue or excretions, drug and medical products, swabs and dressings, instruments or similar substance or materials (cited in Collins, 1991).

Source classification of waste

Clinical waste can be classified as major or minor sources according to the waste quantities produced. The major source of clinical waste are generated at major hospitals (e.g. university teaching hospital, general and districts hospitals) and other health centers (i.e. emergency medical care services, health care centre and dispensaries etc.) (Cheng et al., 2009; Katoch & Kumar, 2008) The minor sources of clinical waste are generated at small health care

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establishment (such as physicians officer, dental clinics, acupunctures, chiropractors etc.) and non-health activities involving intravenous or subcutaneous interventions basically with low waste generation (Katoch & Kumar, 2008).

Clinical waste generation estimates

Few studies have determined daily clinical solid waste generation rate for developed and developing countries. For example, Alvim Ferraz et al (2000)) estimated that in Portugal, the daily hospital waste generation rate is 3.8 kg/bed/day and 1 kg/bed/day is generated in Thailand (Kerdsuwan, 2000), 2.07kg/bed/day in El-Beheira in Egypt (Abd El-Salam, 2010), 0.5-2.2kg/bed/day in Jordan (Abdulla *et al.* 2008), in Bangladesh 1.28kg/bed/day (Alam *et al.*, 2008), 2.79- 3.86kg/bed/day was reported in Taiwan (Gluszynski, 1999), 0.48 kg/bed/day in Korea (Jang *et al.* 2006), 0.6kg/patient/day in South Africa (Nemathaga *et al.*, 2008), 0.7-1.22kg/bed/day in Algeria (Bendjoudi *et al.,* 2009), 0.255kg per patient per day in Dar es Salaam, Tanzania (Mato and Kassenga, 1997) and 1.3kg/patient/day in Libya (Sawalem *et al.*, 2009). Canada and USA were reported to have high generation rates that range from 4.3-5.8kg per bed per day (Hossain *et al.* 2011).

However, according to the WHO estimates about 80% of clinical wastes are non-hazardous (comparable to domestic waste), 15% are infectious (from cultures and stocks of infectious agents, wastes from infected patients, wastes contaminated with blood and its derivatives, discarded diagnostic samples) and anatomic (recognizable body parts and carcasses of animals) wastes and the remaining 5% is made-up of sharps (1%), toxic chemicals and pharmaceuticals (3%) and radioactive waste (1%) (WHO, 2007). This traditional estimate, according to a study by Azage & Kumie (2010) varies across many developing countries. Azage & Kumie (2010) estimated that 25% of clinical waste produced in Pakistan is hazardous, 26.5% in Nigeria and 2-10% in other sub-Saharan Africa countries. Similar a study by Manyela & Lyasenga (2010) in Tanzania estimated that 50% of the country's clinical waste is hazardous. Again, in Bangladesh, Sarkar et al (2006) estimated that 36.03% of clinical wastes as hazardous.

Solid Waste Categorization

The following clinical and non-clinical wastes are the two types of solid wastes that are generated at the health facilities:

Nonclinical waste or General waste: General/domestic waste which constitute about 75%-90% of the total waste that are generated include food surplus from the hospital`s kitchen, papers, cardboards, plastics, rubbers, etc (WHO, 2005a).

Clinical waste or Medical waste: Medical or clinical waste comprises surgical and pharmaceutical wastes (WHO, 2007);

a. Surgical waste can be group under infectious waste and pathological wastes and constitutes 10%-25% includes syringes, sharp instruments, platelets, placenta, body parts, feotus, etc.

b. Pharmaceutical waste which also constitutes less than 1% includes expired drugs and vaccines, left over drugs, etc (Katoch & Kumar, 2008; WHO, 2007).

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Clinical waste management process

WHO (2014) stipulate that the objective of any effective CWM program should be able to provide protection to human health and the environment from hazards posed by the waste. Thus proper management ensures that infectious waste is handled in accordance with established procedures from the point of generation through to treatment of the waste and its final disposal stage. Studies show that different countries have designed different strategies of handling its waste. However, a CWM generally follows these important elements (Marinkovic et al. 2008); Pruss et al, 1999).

1. Identification of waste
2. Segregation and packing
3. Labeling and documentation
4. Internal and external transportation
5. Temporary storage
6. Treatment technique
7. Disposal of treated clinical waste
8. Landfill/ Dumps

Identification of Waste: Waste is identified in hospital depending on its sources and level of hazards. The health-care workers must identify each waste and separate it. The reason is because every waste needs to be disposed in different ways (Berger et al., 2000)

Segregation: Segregation aids in wastes minimization. Segregation is the separation of wastes into different categories usually at the time the waste is produced (Sagoe-Moses et al, 2001).

Packing: Clinical wastes are packaged in order to protect waste handlers and the public possible injury and disease that may result from exposure to the waste. For example, plastic bags for many types of solid or semi-solid waste and puncture-resistant containers for sharps (Sawalem et al 2008).

Labeling: Labeling are done in a number of ways such as writing the information on the bag or container, using pre-printed self-adhesive address labels supplied on a peel-off roll, tie-on tag label and self-locking plastics tags (Coker et al., 2009).

Documentation: Proper documentation and record is important in order to comply with environmental regulation. An inventory provides an accurate and up-to-date record of quantities and categories of clinical waste being generated, treated and disposed of (Marinkovic et al., 2008).

Transportation: Transportation of clinical waste in healthcare centers is in two stages; the first is from the source of generation to an on-site treatment facility while the second involves removal from on-site temporal storage facility to an off-site treatment and disposal facility Coker et al, (2009). Different countries have devised various means of transporting clinical waste from source of generation to on-site treatment facility and finally to disposal facility. For example, in Libya, on-site clinical waste are transported in uncovered trolley in surveyed

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healthcare facilities (Sawalem et al 2008) while in Nigeria, clinical waste are transported on shoulders with bare hands in some healthcare facilities (Coker et al., 2009). Off-site transportation of clinical waste according to Luttrell et al (2003) takes place on land using vehicles, even though there is a likely risk of accidental release of hazardous materials in to the environment.

Temporal Storage: Temporal storage refers to the interim period between generation and transportation either to an on-site treatment facility or to an off-site location (Luttrell et al (2003) properly marked and accessible only to authorized personnel (Marinkovic et al (2008). Past studies have not shown yet a universally accepted standard period of time that the waste can be stored prior to treatment and disposal, however, WHO recommends that time for holding clinical waste be kept as short as possible

Treatment Technique: Treatment of wastes mainly aims at rendering direct exposure to the wastes as less dangerous to human, to recover recyclable materials, and to protect the environment. Treatment alternates the characteristic of the waste and is carried out according to regulations and procedures set by the Environmental Protection Agency (EPA). Treatment technique is any method, technique, or process designed to change the biological character or composition of waste (Marinkovic et al (2008). An example of treatment for clinical waste is incineration. Incineration is the combustion of waste in a controlled way in order to destroy it or transform it into less hazardous, less bulky or more controllable constituents. Incineration continues to be a preferred treatment process for clinical waste management (Marinkovic et al., 2008; Pruss et al., 1999).

Disposal of Treated Waste: Disposal refers to the final placement of treated waste on the land, using a sanitary landfill or any other environmentally acceptable method of final storage appropriate to the local conditions. Waste disposal are important for sharps, waste-requiring incineration, waste that cannot be incinerated and radioactive waste (Pruss et al., 1999).

Health impacts of clinical waste

Sagoe-Moses et al, (2001) survey found protecting healthcare workers in developing countries as a challenge. According to Sagoe-Moses et al, (2001) both health care workers and individuals such as children outside the health care environment to be at risk. Pruss et al (1999) survey also found healthcare workers (within the health care environment such as doctors, nurses, healthcare personnel, patients etc) to be potentially at risk. Pruss et al (1999) further found infectious components in clinical waste such as contaminated sharps and syringes pose the biggest health risks due to potentials for direct exposure to pathogens in blood and other fluid from patients through a cut in the skin. Jahan (2005) identified 73 injuries from needles and other sharp objects in a retrospective survey of all self-reported documents in Buraidah Central Hospital, Saudi Arabia. According to the author, nurses, physicians, technicians and non-clinical support staff were involved in 66%, 19%, 10% and 5.5% of the instances respectively. Pruss-Ustun et al (2005) estimated that more than three million health care workers experience the stressful event of percuteneous injuries with a contaminated sharp object each year.

Berger et al (2000) identified that the risk of occupationally acquired infection with hepatitis B and hepatitis C due to frequency of needle stick injuries with patient blood contact. In a similar study by Talaat et al (2003), out of 1485 health care workers interviewed in Egypt, 529 (35.6%) have been exposed to at least 1 needle stick injury during the past 3 months with an estimated

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annual number of 4.9 needle sticks per worker. According to Talaat et al (2003), 15.8% of health care workers have received 3 doses of hepatitis B vaccine, with vaccination coverage highest among professional staff (38%) and lowest among housekeeping staff (3.5%). Another study in the US, by Simard et al (2007) found health care workers at risk and reported that 75% had received 3 or more doses of the hepatitis B vaccine, corresponding to an estimated 2.5 million vaccinated hospital-based health care workers.

Pruss-Ustun et al (2005) suggested that strategies such as education of health care workers on the risks and precautions, reduction of invasive procedures, use of safer devices, and procedure and management of exposures are available to prevent infections due to sharps injuries. According to Pruss-Ustun et al (2005) advocated for surveillance and monitoring systems in developing countries.

Empirical Studies of Clinical Waste

Suwannee (2002) surveyed CWM in Phitsanulok province, Thailand to classify the characteristics of waste and estimate average daily waste generated from hospital and clinics. The study attempted to find the average daily waste generated from hospital and clinics. The author found factors such as type of hospital, specialization, proportion of reusable items, and waste management plan impacted on waste generation assessment.

Askarian et al. (2004) attempted to estimate the amount of different kinds of waste produced at hospitals and determine the relationship between the weight of the waste generated and several factors such as number of bed, economic, social and cultural status of the patients and the general condition of the area where the hospital was situated. However, the results of the study did not confirm a statistically significant correlation between types of health services provided.

Awad et al. (2004) used mathematical-statistical models to predict quantity of waste generated at hospitals in Irbid, Jordan. The generation rates were evaluated on the basis of kilogram per patient/per day and kilogram per bed/per day. In their model, they observed that the significant factors including the number of patients, number of beds and type of hospital affect on weight of generated waste. They showed that there is a linear relationship between the waste quantities and number of beds occupied. Hamoda et al. (2005) determined hazardous and nonhazardous waste generation rates at two public hospitals in Kuwait. Some important factors such as the number of patients, number of beds and the type of activity were identified in relation to the generation rates. The results indicated that the calculation of generation rates based on number of patients was more applicable than the number of beds. Da Silva et al. (2005) evaluated CWM practices in the south of Brazil and reported the amount of clinical waste depend upon several factor such as the type of healthcare facility, status, capacity, level of instrumentation, and location of the facility.

A study was conducted by Alhumoud and Alhumoud, (2007) to determine the amount of different kinds of clinical solid wastes and assess the obstacles in the existing hospital's CWM system in government hospitals of Kuwait. The results found that waste generation rates depend on several factors such as established waste management methods, type of health-care establishment, hospital specializations, proportion of reusable items employed in health care and proportion of patients treated on a day-care basis. Bdour et al. (2007) conducted a survey on all existing methods for handling and management of clinical waste disposal. The authors used statistical methods to develop mathematical models for prediction of hospital waste

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quantities. Moreover, important factors including the number of patients, number of beds, and hospital type which are effective in waste management were investigated.

In Croatia, Marinkovic et al. (2008) found that the quantity of clinical waste generation depends on the size and the type of healthcare institution, but also based on national income and level of development and concluded that quantity of clinical waste differs from country to country. In the survey by Sanida et al. (2010) and Komilis et al. (2012), the amounts of infectious clinical waste generated daily and average generation indexes were determined in relation to several parameters factors at public hospital in Central Macedonia, Greece. The authors found parameters such as number of beds, type of hospital, bed coverage and the difference in hospital divisions and wards and the number of operations and laboratory test performed to influence waste generation.

In India, Katoch and Kumar (2008) presented a technique to develop mathematical model in clinical waste generation in three major hospitals in Shimla town, India. Their proposed model correlated the waste generation rate as function of bed occupancy and type of ailment in terms of seasonal changes. A similar study by Taghipour & Mosaferi (2009) determined the characteristics of medical waste such as quantity, quality, composition and medical waste generation rate at different hospitals. The results showed the effect of many factors such as medical waste management methods, type of hospital (i.e., governmental, educational, university, private, NGO and military), type of specializations, ratio of reusable items, the general condition of the place where the hospital is located, number of patents per day and their economic, social and cultural conditions in generation rate among hospitals. Another study in China, by Yong et al. (2009) evaluated medical waste management aspects in some selected hospitals and concluded that factors such as hospital size, hospital location, beds occupancy percentage, medical waste segregation program, type of hospital and type of services affect the medical waste generation rate. Razali & Ishak (2010) evaluated the management of clinical waste and its obstacles in Selangor 'hospital in Malaysia the results show that the quantity of clinical waste depends upon the hospital size, the segregation program and the medical activities.

In Lydia, Sawalem et al. (2009) evaluated CWM in Libya and found that several factors such as the type of healthcare establishment, level of instrumentation and location affect waste generation rates. The result showed that the highest generation rates at Tripoli Medical Centre are attributed to larger number of patients due to being in the capital of Libya. Azage & Kumie (2010) evaluated waste management system and assessed the rate of waste generation at ten public health centres in Ethiopia. A cross-sectional survey was conducted to estimate waste generation rate. Study reported that numerous factors such as established methods of waste management, type of healthcare establishment, degree of healthcare facility specializations, reusable items employed in health care, seasonal variation and patient work load affect on characteristics of waste generation. In Istanbul, Turkey, Eker & Bilgili (2011) determined waste was generated from healthcare services using statistical analysis to evaluate the relationship between the amounts of various clinical wastes. the bed capacities, number of patients. The authors concluded that except for recyclable and hazardous waste, evaluation of waste generation in accordance with the bed capacity is reasonable. The results indicated that only the amount of sharps and clinical waste can be evaluated using number of inpatients.

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RESEARCH METHODOLOGY

The study was conducted in Sunyani Municipality in the Brong Ahafo Region of Ghana located geographically on longitude 2°10'W-2°30'W and latitude 7°05'N-7°20'N (Figure 1). The district stretches over an area of about 829.3 km^2 and has population of over 101,145 with a growth rate of 3.8% (GSS, 2014). It has a tropical and wet semi-equatorial climate with annual average temperatures ranging from 23°C in August to 33°C in March. The mean monthly rainfall is 88.9mm, with high relative humidity. The district falls within the forest-dissected plateau terrain region of Ghana. The terrain is flat to undulating, with an elevation of 376m above sea level.

The study used purposive sampling to select of 3 health facilities (Figure 1). Two hospitals are publically owned and the third hospital is privately owned. The private hospital is the Seventh Day Adventist (S.D.A) hospital geographically located on longitude 2°20'33.92''W and latitude 7°20'44.19''N. The other government owned ones are as follows; Municipal hospital (MH) geographically located on longitude 2°19'43.42''W and latitude 7°20'19.43''N & Regional Hospital (RH) geographically located on longitude 2°18'51.60''W and latitude 7°20'39.20''N all in the Sunyani municipality. The three hospitals were selected based on the following factors such as hospital size, hospital location, type of health services and distance between them (Figure 1).

Structured interview and field observation were primarily used to collect data. Field observation was used as cross check on the data collected. The source population for this study was healthcare workers such as doctors, nurses, pharmacists and other auxiliary health care workers. The structured interview was prepared and administered by a face-to-face interview method. The designed questions were clearly written and given to the interviewee prior to the interview. This was to help the interviewee to acquit himself/herself with the questions to give accurate answers to the researcher. Ethical clearance was obtained from selected hospitals and Ghana Ministry of Health. For the purpose of facilitating field work, the study through a written consent, requested participants for their willingness to participate to this study. They were also informed that they have a right to withdraw at any time during the data collection and at the same time assured that their responses will be kept confidential and be used only for this study purpose.

The study used unobtrusive field observation (Yin, 2009) where the researcher was not directly involved in the activities observed. This prevented the researcher from being bias (Yin, 2009). The researcher observed types of clinical waste generated in the selected healthcare facilities, places where clinical waste is stored and authorized waste collection points. Observations were done through monitoring and through spot checks. Places such as operating theater rooms, consulting rooms, pharmacy, laboratories, clinical waste storage and treatment rooms within the selected healthcare centers' were considered. According Crewell's (2008) and Yin (2009) observation aids to reveal habits the subjects are unaware of and can help place behaviour in context. The time duration for the study was 7 days at each healthcare facility, observing the clinical waste process daily from the source of generation to incinerators and landfill where finally clinical waste is treated and disposed of. The reasons for observations were to see whether segregation, handling, collection, treatment and storage were done according to standards or best practice and if clinical waste receptacle were provided, waste deposited in appropriate containers, transported appropriately, incinerated according to the manufacturer's

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instruction and disposed of in a safe manner per Ghana Health Sanitation Act/WHO procedure for incineration and disposal.

Field measurement was undertaken to measure the quantity of clinical waste generated and the number of patients who visited the selected healthcare facilities per day. To measure waste generated, the researcher ensured that the waste type generated was put into pre-weighed separate bags for example red plastics for infectious waste and yellow containers for sharps. A digital weighing scale was used to measure clinical waste at all sampled healthcare facilities. The researcher asked for the assistance from waste handling operatives to help with measuring of clinical waste. A camera was used to collect primary data from observations in the field of study. A measurement/observation sheet was used to record data obtained. Document analysis was performed using data from existing records such as administrative procedures and policy framework of CWM processes and strategies. The purpose of this procedure was to aid the researcher with background information of work done and clinical waste management practices.

Data collected from the field was checked for consistency and completeness before subsequent analysis. The results were presented in Tables and Figures.

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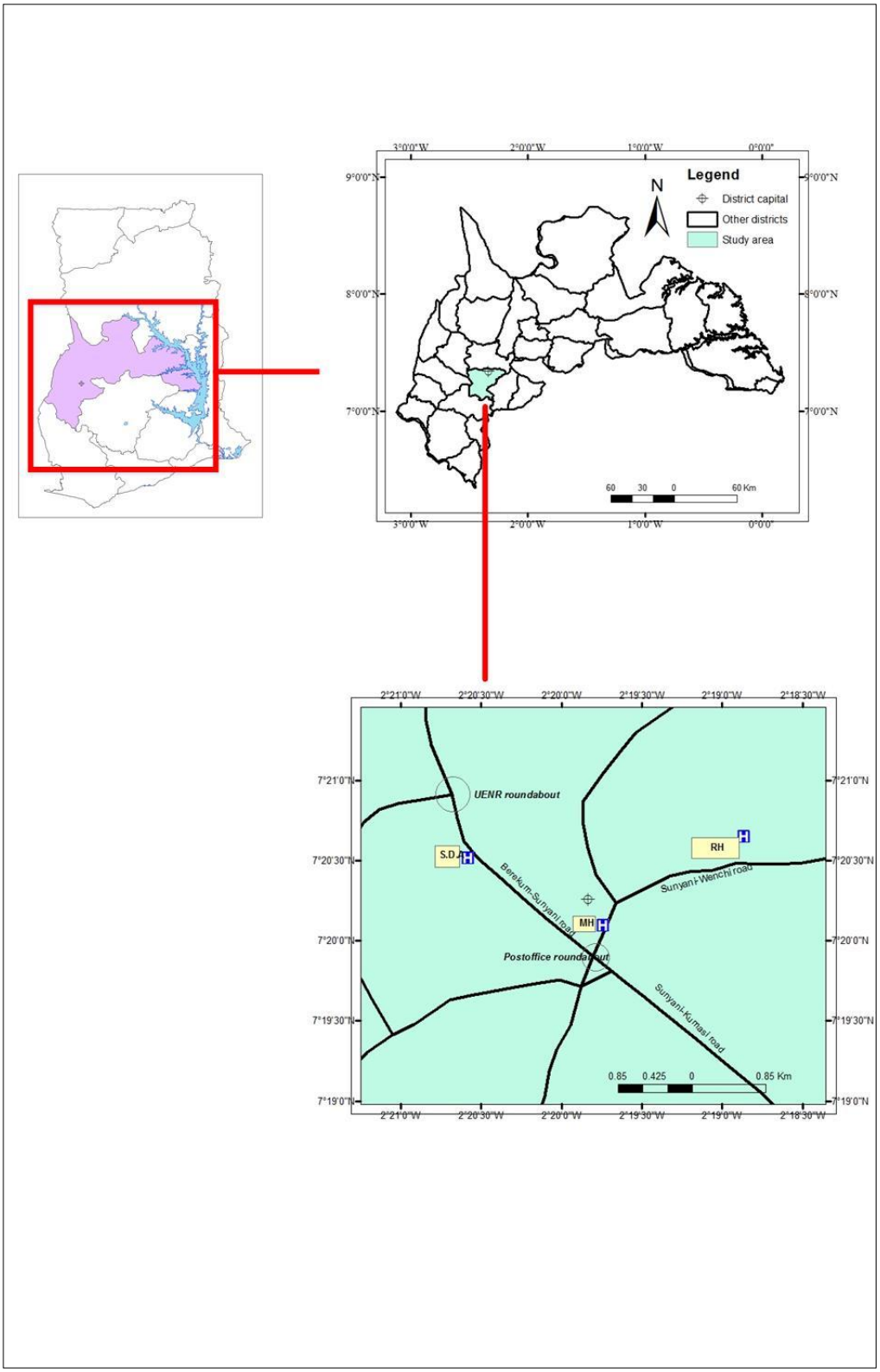

Figure 1: The study area in the Brong Ahafo region of Ghana shown as a green with selected hospital locations Source: (Authors, 2014)

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RESULTS

Solid Waste Generation in the Health Care Facilities

The findings revealed that similar solid wastes (i.e. clinical and non-clinical) were generated in the three (3) selected healthcare facilities in the Sunyani Municipality. The results revealed that clinical wastes are generated mostly in the wards, theatres, laboratories, pharmacy, mortuary, the clinics while non-clinical wastes are generated at the laundry, kitchen, out-patient department (OPD) by patients and visitors.

The generation rate of clinical waste generated was computed to be 0.26kg/patient/day at RH, 0.39kg/patient/day at MH and 0.58/patient/day at S.D.A hospital. This resulted in an average of 238.7kg per day for the three healthcare centres (Table 1). From the results in Table 1 the highest generation rate on average basis was found at RH with 141.8kg/day, 52.6kg/day was found at MH and S.D.A had the lowest generation rate of 44.3kg/day. The results suggest that quantities of waste generation rate in surveyed hospitals depend on type and size of the healthcare facility, number of patients who visit the hospitals and type of services provided. For instance, the study found that the RH runs the followings services; pharmacy, laboratory, theatre, mortuary, allied department (i.e. X-ray). It has a clinic that operates daily and is open for 24 hours, thus many people visit the clinic because of its operating hours which are flexible and convenient. Also, the RH has 413 bed capacity and an average of 550 people visiting daily. The RH serves as a teaching facility as well as referral hospital from other healthcare centres in Sunyani Municipality and surrounding districts. This could have a significant effect on the generation rate. Thus, explains why RH generates the highest clinical waste in the Sunyani Municipality followed by MH with services such as; pharmacy, laboratory, theatre, mortuary, birth & death registry with bed capacity of 63 and a clinic. An average of 135 people visits Municipal hospital daily. Also, MH has a clinic that contributed to the amount of waste produced. The S.D.A. hospital has a pharmacy, laboratory, theatre and allied department (i.e. X-ray). It has a bed capacity 38 bed capacities. An average of 76 people visits S.D.A hospital daily. The results showed that clinical waste generated is proportional to the number of people and beds who visit each healthcare facility. These factors could explain the highest and lowest clinical waste generation rate recorded among the three healthcare facilities.

The results from Table 2 show that greater proportion of solid wastes (both clinical & non-clinical) generated in the wards of the study hospitals. The findings showed that RH generates the highest waste from wards followed by MH and S.D.A. hospital respectively. This finding is corroborated by the size of the hospitals which revealed that RH, MH and S.D.A hospitals have 413, 63 and 38 bed capacities respectively. The operating theatre where surgical operation in the health care facility takes place generates 15 kg/day and 10 kg/day of clinical solid waste from RH and MH respectively whilst S.D.A. hospital has no operation theater. The laboratory generates 10 kg/day, 3.8 kg/day and 3 kg/day of clinical waste at RH, MH and S.D.A. hospitals respectively. The pharmacy (RH=22.5kg/day; MH=15kg/day and S.D.A=3.8kg/day) and the Mortuary (RH=5kg/day and MH=10kg) departments generate only non-clinical solid waste. The results from clinics revealed that S.D.A. hospital generates 10kg clinical waste daily whilst RH and MH generate 10kg and 3kg non-clinical solid waste daily.

ISSN 2056-7537(print), ISSN 2056-7545(online)

Table 1: Solid Waste generation rate for sampled hospital

Sampled Hospital	Clinical waste (kg)/day	Non-clinical waste(kg)/ day	Total (kg)/ day	Number of beds	Average Number of patients/ day	Generation rate (kg/patients / day)	Generation rate *Clinical waste*) (kg/patients/day)	Generation rate *Clinical waste*) (kg/bed/ day)
Regional Hospital	141.8	132.5	274.3	413	550	0.50	0.26	0.34
Municipal Hospital	52.6	104.8	157.4	63	135	1.20	0.39	0.84
S.D.A Hospital	44.3	14.3	58.6	38	76	0.77	0.58	1.17

Source: Field data computation (2014)

Table 2: Solid Waste generation rate in the Regional Hospital

Department	Clinical waste(kg)/day			Non-clinical Waste(kg)/day		
	RH	MH	S.D.A	RH	MH	S.D.A
Pharmacy	-	-	-	22.5	15	3.8
Laboratory	10	3.8	3	8.75	3.8	-
Wards	116.75	48.8	31.3	52.5	43	3.0
Clinics	-	-	10	10	3	-
Theatre	15	10	-	-	-	-
Mortuary	-	-	-	5	10	-
Allied Dept.	-	-	-	33.75	30	7.3
Total	**141.8**	**52.6**	**44.3**	**132.5**	**104.8**	**14.3**

Source: Field data computation (2014)

Process of Clinical Waste Management

Identification and segregation of clinical solid waste

Table 4 presents results of clinical solid waste categorization and corresponding waste composition in Sunyani Municipality. The results of waste identification from interview and observation revealed that clinical solid waste in the health care facilities were grouped into six categories, namely, contaminated sharps, laboratory waste, human and animal tissue, infectious waste, surgical waste, pharmaceutical waste. The result showed that the selected hospital practiced and adheres to waste segregation procedures. The findings from the interview and observation revealed that the health facilities used for colour-coding for managing solid waste.

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The practice of colour-coding for managing solid waste in MH and S.D.A hospital was yellow plastic bags and yellow 15kg wheeled plastic bins for taking clinical solid waste and black plastic bags and black 15kg bins for non-clinical waste. The RH used yellow plastic bags and 15kg wheeled plastic bins for taking clinical solid waste and green plastic bags and green 15kg bins for non-clinical waste. The result indicates strong adherence to solid waste segregation and this may be linked to internal administrative practice by medical staff. The location of the equipment is different depending on demand and suitability. The segregation starts at the beginning of clinical waste generation and health care staff such as the nurses, doctors and health workers are to ensure that capacity of each plastic bags are three quarter full and clinical solid waste are separated from general waste and only disposed in the yellow plastic bags or containers provided.

Table 3: Clinical solid waste categorization and composition in Sunyani municipality

Category	Composition	Percent
Contaminated Sharps	Syringes, needles, cartridges, ampoules and other sharp instruments.	25
Laboratory Waste	Unsterilized laboratory stock cultures, or cultures, of infectious agents and potentially infectious waste with significant health risk from dental, medical, veterinary or pathological laboratories.	6
Human and Animal Tissue	All human and animal tissues, organs and body parts, and dead animals.	5
Infectious Material	Infectious materials from patients with the following pathogens – HIV/AIDS, Hepatitis, Tuberculosis etc.	3
Surgical Dressings	Surgical dressings, swabs and all other wastes dribbling with blood, caked with blood or containing free-flowing blood.	45
Pharmaceutical Waste	Expired drugs from repacking	10

Source: Field data computation (2014)

Solid waste collection and handling

The study results revealed the mode of solid waste collection is similar among the three hospitals. The findings revealed through interview and observation that generally the hospitals solid waste collection are performed by waste pickers called porters. These porters are permanently employed by the hospitals to collect both clinical and non-clinical waste. The porters collect and transfer solid waste from plastics bags and 15kg bins from the hospitals wards. The findings revealed that in all three surveyed hospitals, doctors, nurses and other healthcare assistance put on nose mask, gloves before coming into contact with the clinical solid waste. The health cleaners and waste collectors (porters) wear facemask, apron, gloves and safety boots before handling the solid waste. The results show that the RH has employed 28 (i.e. males=15; females=13) healthcare workers engaged for waste collection. The S.D.A Hospital has 6 porters (i.e. males=2; females= 4) whilst the MH has employed 8 porters (i.e. males=3; females=5). The porters start their duty by entering every ward or clinic according to their duty rosters.

ISSN 2056-7537(print), ISSN 2056-7545(online)

Internal transportation and temporary storage area

The internal transportation of the solid waste to the hospital temporary storage area varies across the three hospitals. The RH use donkey attached to a trolley to internally transport to the hospital's temporary storage area. The MH and the S.D.A hospital uses wheelbarrow and manually carried the 15kg bin to the temporary storage area respectively. This result suggests that size of the hospital and location of the temporal storage facility determines the mode of waste transportation. The purpose of providing temporary storage in managing clinical solid waste is to create a place where the waste can be stored temporarily for treatment and disposal safely. The storage areas of the three (3) hospitals are located far from canteen, public passages and other stores.

Treatment and disposal of solid waste

The findings revealed that RH treats and dispose their own clinical solid waste. The observation results revealed that only the RH uses a gated building as temporal storage area for holding the clinical solid waste and a covered metallic container placed near their treatment area for holding the non-clinical waste. At the temporary storage area, the clinical sold waste is sorted and transferred to the waste depot for safe keeping and later incinerated. The RH provides incinerator for treatment of clinical solid waste. The results from observation showed that the type of incinerator used in the RH is 'Rotary Kiln Incinerator' and controlled automatically with combustion capacity of 75 kg/hr. or 1.8 ton/day and operation temperature 1200^{o}C. The incinerator works twice a week with four workers employed to operate it, where the operators start working from 6am to 7pm when on duty. After incineration the all the residues or the ashes are buried in dug pit together with expired drugs from the hospital's pharmacies under strict supervision by representatives each from authorities such as Environmental Protection Agency (EPA), Food and Drugs Board, Audit and Regional Stores.

Both MH and S.D.A have an uncovered metallic container for holding non-clinical waste whilst the clinical waste such as sharps and pharmaceuticals waste are held in paper boxes before transferred to the waste depot for open pit burning. The open burning is done in a dug two rectangular pits of about 100mm × 400mm × 250mm in dimension. The findings from the staff interview revealed that some of the clinical wastes which are less deleterious or hazardous are burnt in the pit and the residues or the resulting ashes are buried in the same pit. The surveyed hospitals have engaged private solid waste management companies to collect and transfer non-clinical waste from the waste depot to the final waste disposal site. The RH and MH engaged Zoomlion Ghana Limited while S.D.A engaged Alhaji Issaka Issah Waste Company Limited with a collection frequency of twice every week for the RH/MH and once a week for S.D.A hospital. Recycling of waste, a strategy of managing clinical solid waste after a careful process of rendering it infectious to reduce waste generation rate in the health care facilities is not practiced in all three hospitals.

DISCUSSION

From the study, quantities of waste generation rate in the three surveyed hospitals depend on type and size of the hospital, number of patients and type of services rendered. These factors could have a significant effect on the generation rate. Results of the study are confirmed by numerous past studies in similar healthcare facilities globally. For example, result of clinical

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waste generation rate is consistent with a study by Cheng *et al.* (2009), Abd El-Salam (2010) and Abdulla *et al.* (2008) where their findings linked the quantity of clinical waste generated from healthcare facilities with the type or size of the institution.

RH generates the highest clinical solid waste than the other surveyed hospitals because it admits the biggest number of patients as compared to the two other hospitals (Gluszynski, 1999; Jang *et al.* 2006). The RH serves as a teaching facility as well as referral hospital which receive a lot of patients from other healthcare facilities in Sunyani Municipality and surrounding districts. This result is consistent with Abd El-Salam (2010), who revealed that in El-Beheira in Egypt, the hospital with the highest generate rate of 2.07kg/bed/day was found to be produced from the hospitals which had a large number of beds (590) and services (26 departments). The daily clinical waste generation rates for the three hospitals were consistent with past studies for developing countries although much greater than results obtained for this study. For example, in a similar study in Jordan, Abdulla *et al.* (2008) revealed that at surveyed hospitals waste generation ranged from 0.5-2.2kg/bed/day and in Bangladesh 1.28kg/bed/day (Alam *et al.,* 2008). Nemathaga *et al.,* (2008) reported a low generation rate of 0.6kg/patient/day in South Africa, 0.7-1.22kg/bed/day in Algeria (Bendjoudi *et al.,* 2009), 0.255kg per patient per day in Dar es Salaam, Tanzania (Mato & Kassenga, 1997) and 1.3kg/patient/day in Libya (Sawalem *et al.,* 2009). The average clinical waste generation rate of 2.79- 3.86kg/bed/day was reported in Taiwan. The reason for this low generation rate as compared to developed countries could be linked lack of modern healthcare facilities Nemathaga *et al.* (2008). Developed nation such as Canada and USA were reported to have high generation rates that range from 4.3-5.8kg per bed per day. This is because developed nations have modern facilities and good services (Hossain *et al.* 2011).

One of the specific aims of this study was to identify the current clinical SWM strategies used by health facilities in Sunyani Municipality, Ghana. The result of waste segregation and collection practice in the selected hospitals were within Ghana Health Service and WHO standards as well as recommended best practice worldwide. The hospitals kept data of stock of the colour-coded storage polytene and bin containers for different categories of waste generated. The CWM segregation and collection methods practice in all three selected hospitals were efficient and could be linked to strong internal administrative policy. This result is contrary to similar study by Oke (2008) in Nigeria, Ketlogetswe et al, (2004) in Botswana, Taghipour & Mosaferi, (2009) in Iran and Patil & Shekdar (2001) in India where segregation practice is weak. According to the authors, it was common practice for both clinical and non-clinical solid waste mixed together before initial collection. Despite the efficiency in current CWM practices for solid waste segregation and collection in the surveyed hospitals, some problem areas remain significantly the same along the other stages of CWM process. The short-comings were associated with transportation, temporal storage and treatment and disposal. This finding is consistent with findings from Tsakona, (2007) where hospital administrators are much concerned about safeness of the internal hospitals environment. For instance internal transportation of solid waste in three surveyed hospitals used wheeled trolleys pulled by donkey, wheeled barrow and manual carrying of waste bins to the storage site in RH, MH and S.D.A respectively. This result is common practice and consistent with previous studies conducted in other developing countries(Abor (2013; Ketlogetswe et al, 2004; Ndiaye et al., 2012; Muluken et al., 2013; Oke 2008; Patil & Shekdar, 2001; Taghipour & Mosaferi, 2009). Abor (2013) and Ndiaye et al., (2012) reported of hospitals where similar wheeled carts, trolleys and wheeled barrow for conveying solid waste as revealed in the Regional and Municipal hospitals. Muluken et al., (2013) reported of manual lifting of receptacles by hospital

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cleaners and waste collectors as revealed in the S.D.A hospital. Nonetheless, WHO (1999) has recommends dedicated vehicles be used for on-site collections. According to Taru & Kuvarega, (2005), a small vehicle with a carrying capacity of up to 14 bins was used in Zimbabwe to convey solid waste from hospital corridors to storage site. The study recorded an estimated average of 124 bins daily.

Only RH out of the three surveyed has a storage area that meets CWM standards and practices. RH solid wastes are separated according to clinical and non-clinical waste. The clinical waste are treated and kept in a protected area for safe keeping before incineration conformation with the standards of Environmental Protection Agency (EPA), Ghana Health Service and Sanitation Act. The status of the RH to referral and teaching healthcare facility in the region could account for this strict adherence. Numerous developing countries have reported healthcare facilities where disposal is done on-site, open burning in pits (Abah & Ohimain, 2011; Majara & Luduka, 2009) as revealed in MH and S.D.A hospitals. Similar study by Patil & Shekdar (2001) identified short-comings in the existing CWM system in India where few healthcare centres contain separate systems for disposal of clinical waste and others mixed different waste category open burning.

Abor & Bouwer, (2008) identified the problem of lack of effective CWM in developing countries to insufficient resource allocation, lack of training and appropriate skills, risk awareness, public apprehensions and misguided information on exposure, incinerator capacity and the increasing need for a solid and sustainable national health care strategy (Abor & Bouwer, 2008). These problems arise according to Tsakona, (2007) as a result of absence of trained healthcare workers available issues on efficient clinical waste management and the hazards that might emerge from their inappropriate handling. These challenges were observed in the MH and S.D.A hospitals respectively. Thus, little supervision is given to these porters after the waste leaves the premises of the hospitals. The existing system in the surveyed hospitals is that waste collectors or porters are jobs mostly given to the uneducated but poor citizens whose knowledge about integrated solid waste management is limited. Abor & Bouwer, (2008) reported similar findings and linked it to lack of sufficient attention to management of solid waste.

Generally, the government of Ghana has acknowledge poor waste management in the country and taken some steps to improve the current situation of solid waste management. For example; a national strategy on solid waste management elaborated by the Ministry of Local Governments and Rural Development is the national sanitation programme where every first Saturday of the month is reserved for officers, managers of facilities or installation, commercial and domestic properties to monitor, evaluate their solid waste management performance.

Implication to Research and Practice

Clinical Waste Management (CWM) remains a therefore, appropriate CWM is a crucial issue for maintaining human and public health.

A basic and essential step is any waste management process is that the integrated solid waste management practices cover all processes from the point of identification the wastes, to the place it is incinerated in the case clinical waste or disposed in the case of non-clinical waste (Nema et al., 2011). This is not the case found in two out three surveyed hospitals as both hospital administrators and healthcare professionals ignore the waste management chain after the solid waste leaves the healthcare premises brings the integrity of hospital policy on CWM

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to question. These study findings suggests that a holistic approach needs to be adopted to successfully manage clinical waste in developing countries. Another managerial implication of this research is that due to the potential health hazards of clinical solid waste to the general public, animals and the environment, interim remedial measure has to be adopted and implemented to avert an epidemic. The medium-long term managerial solution is that political and financial power needs to be focussed on training and awareness programs as well as monitoring and evaluation intensified to reverse the negative trend of managing solid waste in Ghana.

CONCLUSIONS

Regardless of the potential health implication of poor handling, treatment and disposal of clinical waste poses to humanity and environmental at large the study identified shortcomings associated with the current clinical waste management process in three selected hospitals in the Sunyani Municipal Assembly of Ghana. The shortcomings basically are found in lack of compliance to standards outlined in WHO and Ghana Health Service Sanitation Act by hospital administrators and waste collectors. This could partly be attributed to insufficient training of health implication associated with poor management of clinical as well as apathy shown by hospital administrators and healthcare workers.

CWM standards and best practices were inappropriately applied for clinical waste collection, handling, treatment and disposal at study hospitals. Wheeled carts, wheelbarrow and manual handling of waste, open dump, open pit burning of clinical waste were common practices in two out of the three hospitals. The waste management system needs improvements during collection, transportation, temporal storage and treatment and disposal in two out of the three hospitals. One internationally recognized strategies such as recycling are not being used by the hospitals. Recycling of waste should also be looked at as another strategy of managing clinical solid waste after a careful process of rendering it infectious to reduce waste generation rate in the health care facilities. In order to minimize potential health hazards of clinical solid waste, there should be training programmes and workshops conducted periodically for all relevant health personnel. Transportation of clinical solid waste should be supervised by trained operational personnel to ensure that the waste is handled safely and properly.

FUTURE RESEARCH

The sample size was relatively small and coverage was limited to Suniyani Municipality and thus could not be generalise to the entire healthcare facilities in Ghana. The study recommends further studies to increase sample size and coverage to include other public and private hospitals where infrastructural facilities and certain differ. Also, a further research should be conducted to ascertain clinical solid waste hazards to the environment.

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