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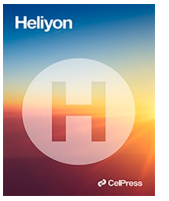

Research article

Health-care waste management practices: The case of Ho Teaching Hospital in Ghana

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ABSTRACT

Approximately 15% of wastes generated in hospitals is hazardous. Improper handling of this waste renders the remaining fraction infectious which is perilous to the health of hospital workers, patients, visitors and even communities. Sufficient data on medical waste management practices particularly in low-income countries such as Ghana is required for effective monitoring and policy making. This study sought to assess the waste generation rates, waste management practices, frequency of sharp injuries and the knowledge of health-care workers on waste management guidelines in Ho Teaching Hospital in Ghana. Data was collected through observations and questionnaire administration from 100 health-care workers. The results revealed that the total amount of wastes generated was 1.70kg/patient/day (490.62 kg/day) comprising of 57.48%, 33.98% and 8.54% of general, infectious and hazardous wastes respectively. Further investigations showed that 52% of the health-care workers knew about the existence of a hospital waste management policy and 89% attested that they had received training on medical waste management. The existing waste management committee was however, non-functional. Waste segregation at source and the use of color-coded waste receptacles were not strictly followed. Contaminated general wastes were landfilled whiles hazardous wastes were either incinerated or buried. Only 11% of the waste handlers were always completely dressed in personal protective equipment and about 77% of the waste handlers always sustained sharp injuries. Incentivizing the waste management team to ensure strict adherence to a waste management plan would improve waste management at the hospital.

1. Introduction

As crucial as hospitals are in saving human lives, wastes generated in hospital settings have perilous consequences if not well managed [1]. Health-care wastes, also termed as medical wastes are categorized into general, infectious and hazardous wastes [2]. While general wastes encompass waste materials uncontaminated with blood, harmful chemicals or body fluids such as food residues, packaging boxes, fabrics and sweepings, infectious wastes comprise sharps, body tissues and blood-stained materials including cloths, bandages [3] and gauzes [4]. Other types of wastes such as vaccines, x-ray photographic films, radioactive wastes, expired drugs, acids, heavy metals and solvents are categorized as hazardous wastes [2].

According to Ref. [5], general wastes form approximately 85% of the total medical wastes generated in hospitals. The remaining

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15% constitutes the hazardous category and is highly detrimental to public and environmental health. Improper management of the hazardous wastes puts doctors, nurses, patients, visitors, hospital laundry workers, waste handlers and scavengers at risk [6]. The health risks span from radiation burns, poisoning, and explosion to deadly infections. Exposure to hazardous wastes such as mercury and expired drugs particularly, cytotoxic, cytostatic and antibiotic drugs may lead to cancer, mutation, teratogenic effects ocular, respiratory and skin infections [7]. Injuries from contaminated sharps such as needles, pipettes, broken glasses and scalpels are, the most prevalent health risks among health care workers [8]. Globally, about 16×10^9 injections are administered annually and most of these needles and syringes are unsafely disposed of posing risk of reuse, injuries and infections. Sharps-inflicted injuries often result in acute infections such as Human Immunodeficiency Virus (HIV), tetanus, hepatitis B and C [6]. A study conducted by Ref. [8] in 2010 indicated that 1.7×10^6 Hepatitis B virus infections, 3.15×10^5 Hepatitis C virus infections and 3.38×10^4 new HIV infections resulted from the reuse of unsterilized needles and syringes. In a study conducted by Ref. [9], 92.5% of injuries among waste handlers were caused by poor collection methods of hypodermic needles in hospitals.

Improper disposal of medical wastes including indiscriminate dumping or burying of the wastes can impair the quality of drinking water sources from ground and surface water bodies [10]. Soils and atmospheric air at hospital dumpsites may also bear high bacterial and fungal counts as well as heavy metals including chromium, arsenic and lead [11]. Dioxins and furans, waste gases produced during incineration and open burning of wastes are also carcinogenic and endocrine disruptors capable of suppressing the immune system and the fertility of living organisms [12].

It has been estimated globally that one in every three health-care facilities do not practice safe medical waste management [13]. In combatting these dangerous repercussions associated with mismanagement of hospital wastes, efforts have been made by various countries in developing national health care management policies. Strict adherence to these policies in most developed nations have resulted in minimizing the menace associated with this hazardous waste. In Ghana and most other developing countries, much needs to be done despite the existence of these policies [14]. However, to attain sustainable management of sanitation for all as envisioned in the Sustainable Development Goal 6 by 2030, it is imperative that health-care waste is appropriately managed. This can be achieved by gathering sufficient data on the different types of wastes generated and the waste management practices adopted in health-care facilities. Although a significant number of researches has been conducted on management of hospital wastes globally, few of such studies have been carried out in Ghana [15]. Most of these studies investigated into the generation rate of medical wastes and the waste management practices in health-care facilities located in different regions in Ghana [15–17]. Presently, there is no documentation on medical waste management in the Volta Region of Ghana which is one of the sixteen [16] administrative regions of the country. Bridging this gap is essential as it will serve as a first-hand information source in aiding the WHO/UNICEF Joint Monitoring Program in carrying out its role in monitoring and reporting on sanitation issues in health-care facilities. In addition to bridging this gap, this study makes in-depth comparison between the medical waste management practices adopted in one of the hospitals in the Volta Region and the guidelines recommended by the Ministry of Health in Ghana.

In the light of this, the objective of this study was to quantify the various types of medical wastes generated in Ho Teaching Hospital, Ghana's fifth public teaching hospital [19] and to investigate into the current waste management practices regarding segregation, storage, transportation, treatment and disposal of waste in the hospital.

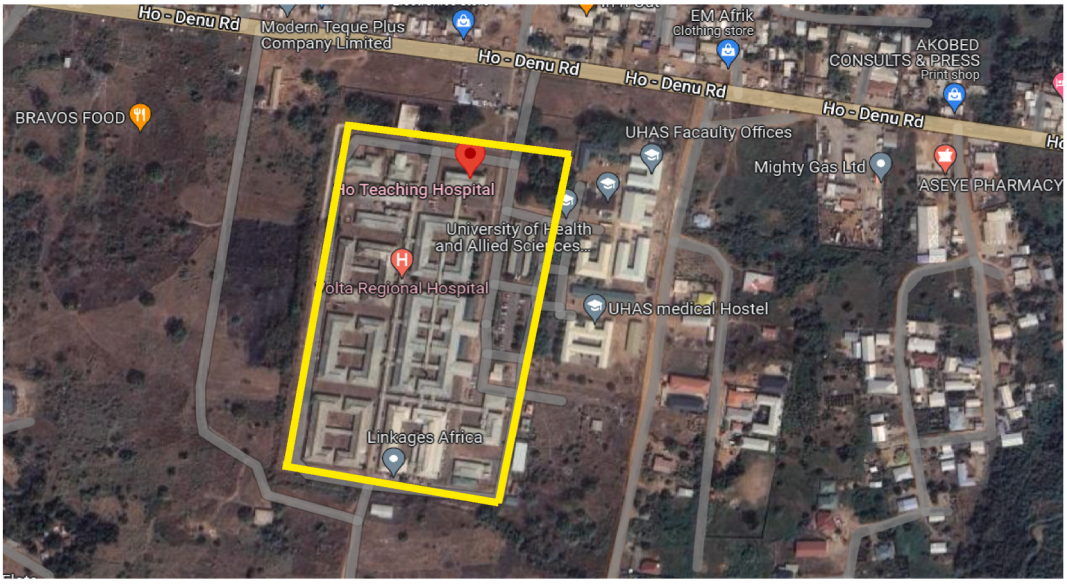


Fig. 1. Location of Ho teaching hospital in Ho municipality.

2. Materials and methods

2.1. Study area

Ho Teaching Hospital (HTH), the study site of this research is located in Ho municipality, the capital city of the Volta Region in Ghana. The municipality which is located on latitudes 6° 207′N and 6° 55′N and longitudes 0° 127′ E and 0° 53′ E is bounded on the east by the Republic of Togo, with Ho West District on the west, Hohoe municipality to the north and Agotime-Ziope on the south. The estimated population of the municipality is 218,948 with 49.18% being males and the remaining 50.82% representing females. Having a bimodal rainfall pattern, agriculture production has been the source of livelihood for most of the residents in the municipality [20]. Ho Teaching Hospital was constructed in November 1998 and in April 1999 health-care operations commenced in the facility. With a total working population of 320 people, the hospital does not only serve clients from the municipality but also extends its services to client from other countries including Benin, Nigeria and Togo [19]. The location of the hospital is shown in Fig. 1. The hospital has nine [9] different departments namely, F-Block, G-Block, Maternity Ward, Accident and Emergency Unit, Intensive Care Unit, Neonatal Intensive Care Unit, Isolated Ward, Psychological Ward and the Special Ward. The F-Block constitutes the female, male, children and babies' wards whilst the G-Block is made up the female and male surgical wards as well as the gynecology and urological wards.

2.2. Sample size and sampling technique

This research is a descriptive, cross-sectional study. Yamane's formula [21] as presented in Eq [1] was used in computing the sample size for the study.

$$n = \frac{N}{1 + N(e)^2} \tag{1}$$

where n is the sample size, N is the total population size (320) and e is the level of precision (0.1).

Based on the above formula, the sample size was computed as:

$$n = \frac{320}{1 + 320(0.1)^2} = 76.19 \tag{2}$$

For the total population of 320 workers in the hospital, a sample size of seventy-six (76) respondents was attained at a precision of ±10% and a confidence level of 90% [Eq. [2]]. Due to the willingness of the people to engage in the questionnaire administration, the sample size was increased to a hundred (100). These hundred respondents included twenty [20] Administrators and Heads of Units in the hospital, fifty (50) other health workers and thirty [30] waste collectors. The hospital administrators and Heads of Units encompassed the General Administrator, Medical Superintendents, Head of Pharmacy, Head of Radiology, Head of Laboratory units, Ward-in-Charges and Hospital Matrons. The fifty other health workers comprised staff nurses, auxiliary nurses, medical officers, laboratory technicians, radiologists and pharmacists. The waste collectors were the orderlies who handled the wastes in the various units of the hospital. The participants of the study were selected based on the non-probability convenient sampling technique since the administration of the questionnaires was dependent on the availability and accessibility of participants at the time of data collection.

2.3. Data collection

2.3.1. Questionnaire administration and observational survey

Assessment of waste management practices at the hospital was done through the use of questionnaires. Semi-structured questionnaires were administered to the respondents (See supplementary material attached). The rules and regulations on waste management guidelines given by the Ministry of Health, Ghana was used as the criteria in assessing the waste management practices in the hospital. Based on the guidelines, information gathered bordered on the existence and knowledge on a national policy guiding health-care waste management in Ghana, organization of periodic training programs on waste management for staff, knowledge on waste segregation, the method of waste collection, storage, on-site and off-site transportation, treatment and disposal of the wastes as well as the occurrence of sharp-injuries among waste handlers.

A non-participatory observational survey was also conducted to ascertain the information collected through the semi-structured interviews. In accomplishing this unannounced visits to the hospital, the treatment and the final waste disposal sites were made five times within a week over a period of five months. Observations made were captured on camera and recorded in a portable note book.

2.3.2. Measurement of waste generated

Medical solid wastes generated in the nine different departments of the hospital were weighed and recorded daily over a period of five months. The wastes were segregated into general, infectious and hazardous wastes according to the different classification of medical waste given by the Ministry of Health in Ghana. The different types of wastes were placed in well-labelled waste receptacles stating the category of waste and section of the hospital where the waste were generated on the receptacles. To prevent nosocomial infections during handling of the wastes, appropriate protective clothing and devices including forceps, gloves, nose masks, overalls, goggles and boots were used. The segregated wastes were then weighed in kilograms using a hanging scale and the values recorded in a

notebook. The average weights of each category of waste was computed which represented the mean generation rate in kilogram per day (kg/day). The average generation rate in kilogram rate was divided by the average number of patient in each hospital unit to obtain the waste generation rate in kilogram of waste generated per patient per day (kg/patient/day). The number of patients in each ward on each day was obtained from the hospital records. A flow chart illustrating the stages involved in assessing the waste management practices at the hospital and the quantities of wastes is shown in Fig. 2(a and b).

2.4. Data analysis

The data obtained from the questionnaires and the measurements of the wastes were analyzed using IBM Statistical Package for Social Sciences (SPSS) version 20 (SPSS Inc. New York). Microsoft Excel was applied in the computation of the waste generation rates and also for the creation of graphs and tables.

3. Results and discussion

3.1. Demographic characteristics of respondents

The demographic characteristics of respondents regarding their age, sex, level of education, their respective departments at the hospital as well as the number of years of service at the hospital were assessed. The data obtained is presented in Table 1. The hundred (100) respondents were made up of 59% males and 41% females. Specifically, 20% of the respondents were administrators and heads of departmental units in the hospital. Fifty percent (50%) were other health workers namely, the medical doctors, nurses and midwives. The remaining 30% were the medical waste collectors. Regarding their ages, 38%, 45% and 15% were within the young adult [19–34], the early middle-aged adult (35–49) and the late middle-aged adult (50–65) groups respectively. Only two [2] of the respondents (2%) who were the specialists in their respective fields were above 65 years. The questionnaires also revealed that 47% of the respondents had been working at the facility for 6–10 years. Eighteen percent (18%) and 15% have had 1–5 years and 11–15 years working experience respectively. Eleven percent (11%) have worked less than a year and 9% had more than 15 years working experience. Majority (72%) of the respondents had completed tertiary education, 11% and 15% had secondary and basic education respectively while 2% had no formal education. The respondents who had received secondary education (87%) could answer the questionnaires with ease.

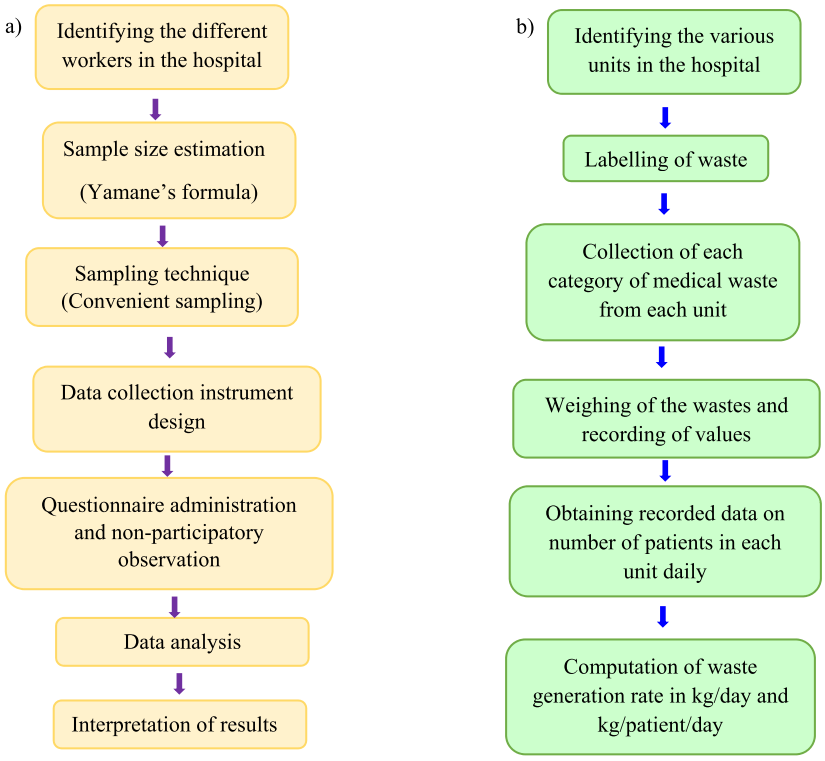


Fig. 2. Flow chart for methodology used in (a) assessing the waste management practices and (b) determining the waste generation rates at the hospital.

Table 1
Demographics of study population.

Variable	Percentage
Sex	
Male	59
Female	41
Working status	
Administrators and Heads of departmental units	20
Medical doctors, nurses and mid-wives	50
Medical waste collectors/handlers	30
Age (years)	
19–34	38
35–49	45
50–65	15
>65	2
Number of working years	
<1	11
1–5	18
6–10	47
11–15	15
>15	9
Educational status	
Basic education	15
Secondary education	11
Tertiary education	72
No formal education	2

3.2. Knowledge on the existence of a national health-care waste management policy

Existing legal documents in Ghana regarding health-care waste management include the Guidelines for Management of Health Care and Veterinary Waste [22], Health care Waste Management Policy and Guidelines [2] and the National Sanitation Policy [23]. Questionnaire results in assessing the knowledge of the respondents on the existence of these policies and guidelines revealed that about half of the respondents (52%) knew about their existence, 13% did not know about them whilst 35% were uncertain about their existence. These results prove that a higher number of the respondents were more knowledgeable about the existence of these policies than the 17.9% reported for health workers in Tanzania [24]. It is even more impressive in Botswana where it was reported that 70% of their health workers were familiar with their health care waste management policies [25]. The gap in awareness about these essential documents can adversely affect enforcement and compliance to these stipulated guidelines. To buttress the importance of knowing a health-care waste management guideline [13], found out that health workers who had read a waste management guideline were four times better in managing medical wastes than their counterparts who had not.

3.3. Existence of a medical waste management team

The guidelines outlined by the Ministry of Health [2] require each health institution in Ghana to form a medical waste management team. This team according to the guidelines is to be led by the head of the institution with the sole mandate to supervise, manage, advise and monitor compliance to the laid-out plans. From the interviews and personal observation, it was confirmed that a medical waste management team was in place. Further probing revealed that the committee was dormant and has therefore, laid back on enforcing the guidelines. While this is the case in Ho Teaching Hospital, the situation is worse in other hospitals. In their investigations [26], found out that waste management teams were entirely absent in three governmental hospitals in India. Additionally, only one out of the three hospitals in Ghana studied by Ref. [15] had an Environmental Unit responsible for waste management. The impact of this is that it can adversely affect compliance to health-care waste management guidelines which is likely to result in nosocomial infections at the hospital.

3.4. Provision of training on health care waste management

Training of health-care workers according to Ref. [27] is not only pivotal to efficient medical waste management practices but it also boosts the morale of the workers. According to the author training in medical waste management must be comprehensive, site-specific, task-specific and address the essential needs of a hospital. It must expose all the workers to the dangers of medical waste, the possibilities of worker exposure to these risks and the role of every worker in managing waste generated at medical facilities. Results from the administered questionnaires showed that most of the respondents (89%) including doctors, nurses, waste collectors and other staff of the hospital had received formal training and education on proper handling of medical solid waste and its associated health risks. This is contrary to the findings made by Ref. [24]. The authors asserted that approximately 90% of health-care workers in three leading hospitals in Tanzania have had no formal training on appropriate management of health-care wastes and were unaware of the risks involved. Frequent and comprehensive training programs may not only protect health-care workers from potential health

risks but also patients and visitors.

3.5. Generation rate of medical solid wastes

It is mandatory for every health facility according to the Health Policy developed by the Ministry of Health to keep records on the quantities of waste generated. However, from the interview, it came to bare that there was no record keeping on the different categories and amount of wastes generated in the hospital. Further investigations on the reason for non-quantification of the wastes indicated that, more than half of the respondents (64%) viewed waste quantification as unnecessary while 22% had the perception that it was a waste of time. The remaining 14% saw the waste as being too harmful to be handled.

The total quantity of waste generated in a day at the Ho Teaching Hospital was 490.18 kg consisting of about 56.3% of general wastes, 39.6% of infectious wastes and 4.1% of hazardous wastes (Table 2). These results are similar to that reported by Ref. [28] for hospitals in Ethiopia where the general wastes constituted about 58.69% of the total amount of wastes generated whiles the hazardous and infectious wastes comprised 41.31%. The general waste stream from HTH comprised kitchen wastes, wood, papers, cans, textiles, cardboard boxes as well as waste from landscaping and sweepings. General waste forms the majority of waste generated in most health-care facilities [5]. Infectious wastes, the second largest category of wastes generated at HTH, were made up of bandages and beddings, diapers, tubing, surgical gloves, nose masks, pathological wastes (internal body organs, placentas, fetuses and amputated human body parts and autopsy wastes), as well as gauzes, cotton wool, sanitary pads, swabs, gowns, dresses and towels stained with blood and other fluids. Finally, the hazardous wastes included the sharps (needles, syringes, surgical blades, and scalpels), radioactive materials, pharmaceuticals (particularly expired drugs) and heavy metals such as mercury contained in thermometers and fluorescent light tubes.

The highest amount of waste generated occurred at the G-Block (136.40 kg/day) which had four different wards (the female and male surgical wards as well as the gynecological and urological wards) and received about 32 patients daily. The least amount of waste (2.34 kg/day) was generated at the Intensive Care Unit possibly because it received averagely one patient each day.

3.6. Segregation and containment of medical solid wastes

Practice of waste segregation at source by the respondents was also sought in the study. The results proved that a relatively high number of the health workers (63%) claimed they segregated the waste at source whilst the remaining 37% admitted their lack of practice of source segregation of the waste. These results portray the lack of unison in the practice of waste segregation among the health care workers. Similar findings were reported by Ref. [17] for Tamale Teaching Hospital, Ghana and by Ref. [29] for hospitals in Dakar, Senegal.

To aid in accurate and easy segregation of waste and also to prevent careless handling of injurious wastes, the Ministry of Health has recommended the use of color-coded waste receptacles for the different types of medical waste. These include the use of black, yellow and brown receptacles for collection of general, infectious and hazardous wastes respectively. Based on this, the hospital had differently sized color-coded waste containers for temporal collection of waste generated at source. The sizes of these bins were 30, 120, 240 and 360 liter bins. The 360 L bin was specifically used at the mortuary. Some of these bins had lids whiles others did not. It must be mentioned that waste paper cartons were also used as receptacles for some type of wastes such as cotton wools. The waste containers were usually lined up with black polythene bags. Once the bins were emptied, they were washed thoroughly with laundry detergents to prevent contamination. The different color-coded receptacles present were the yellow and black colored bins and plastic bags. However, this color-coding system was not uniformly applied in the hospital as there were also blue and green colored bins; some of which were designated for collection of general wastes [Fig. 3(a and b)]. The use of color-coded polythene bags for waste collection was also not strictly adhered to as all types of wastes were collected primarily in black colored bags due to shortages in the yellow and brown bags. Most of these receptacles were unlabeled [Fig. 3(b)] which violates the WHO guidelines. According to Ref. [30], compliance to the color-coding scheme and labelling of waste receptacles enhance waste segregation.

Table 2
Quantities of medical wastes generated in each ward.

Ward/Unit	kg/patient/day				kg/day
	General	Infectious	Hazardous	Total	Total
F-Block	0.060 (±0.033)	0.049 (±0.018)	0.004 (±0.004)	0.113 (±0.05)	121.76 (±73.94)
G-Block	0.083 (±0.018)	0.056 (±0.005)	0.007 (±0.001)	0.145 (±0.021)	136.40 (±18.96)
Maternity ward	0.068 (±0.01)	0.041 (±0.022)	0.003 (±0.001)	0.112 (±0.025)	73.78 (±16.66)
Accident and Emergency	0.064 (±0.02)	0.052 (±0.018)	0.003 (±0.001)	0.119 (±0.039)	89.81 (±7.94)
Intensive Care Unit	0.162 (±0.149)	0.084 (±0.079)	0.036 (±0.033)	0.282 (±0.26)	2.34 (±2.82)
Neonatal Intensive Care	0.114 (±0.071)	0.051 (±0.029)	0.003 (±0.001)	0.168 (±0.088)	28.16 (±10.75)
Isolated Ward	0.298 (±0.173)	0.154 (±0.05)	0.048 (±0.047)	0.500 (±0.259)	10.53 (±6.13)
Psychological Ward	0.068 (±0.02)	0.043 ± 0.023	0.012 ± 0.004	0.123 ± 0.34	16.85 ± 6.33
Special Ward	0.060 (±0.076)	0.048 (±0.048)	0.030 (±0.042)	0.138 (±0.177)	10.99 (±12.83)
Total	0.978 (±0.079)	0.578 (±0.036)	0.145 (±0.017)	1.701 (±0.128)	490.62 (±51.85)

1The F-Block constitutes the female, male, children and babies' wards.
2The G-Block is made up the female and male surgical wards as well as the gynecology and urological wards.

(a) (b) (c)

Fig. 3. Different waste collection receptacles: (a) labelled bin for collection of general wastes (b) unlabeled waste bins (c) black polythene bag containing expired drugs in glass bottles.

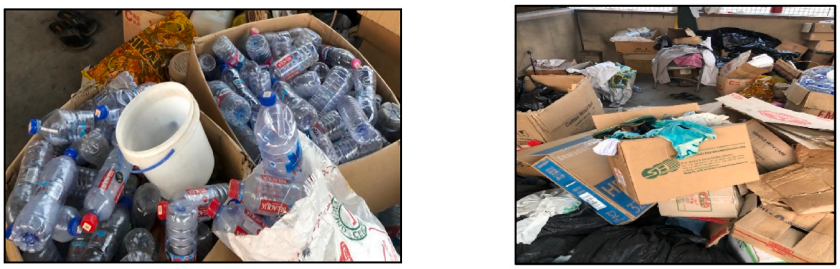
Despite the use of the different color-coded waste bins with some having specific labels on them, the wastes generated at source were not segregated as was claimed by some of the respondents. Generally, infectious and hazardous wastes were dumped together in the various color-coded bins which can potentially cause infections, injuries, and diseases. Not only does the unsegregated waste contaminate the general wastes but it also increases the volume and cost of treatment of the hazardous component of the waste [30]. For instance, expired drugs which should ideally be collected in brown bags were contained in black bags [Fig. 3(c)]. These observations are consistent with practices in other hospitals in Ethiopia [28], Senegal [29] and South Africa [31].

3.7. On-site transportation of medical solid wastes

Medical wastes in polythene bags and bins were carried from the points of generation whenever these receptacles were three-quarter full as recommended in the National Health Policy [2]. Ideally, on-site transportation of the wastes within hospitals must be done by means of wheeled trolleys, carts or containers that are meant solely for the conveyance of medical waste. Wheeled trolleys, carts or containers should be easy to load and unload with no sharp edges to cause damage to the bags [5,7]. However, at HTH, waste collectors moved the wastes from the various sections of the hospital either by carrying the waste bags or paper boxes or by wheeling the waste bins from the wards to a temporal storage facility. Waste plastic bags that were too bulky and heavy to be carried were dragged on the hospital floor to the storage site leading to wear and tear of these bags. In Abuja (Nigeria) waste bags are conveyed with the hands [32]. These practices pose risk of accidents and infections to waste collectors and others present at the hospital. It also contradicts practices in other healthcare facilities found in Kenya [33] and South Africa [34] where on-site transportation is done using trolleys and carts. Carriage of uncovered waste receptacles such as boxes is likely pose hazard to the waste handlers, the other health workers and patients in the hospital.

3.8. Temporal storage and sorting of medical solid wastes

Prior to treatment or final disposal of the medical wastes, the waste collected from the various sections of the hospital are kept temporarily in a shed on the hospital premise. Here, the wastes are sorted and some materials deemed relevant by the waste handlers such as plastic bottles and bags, cardboard boxes, old shoes and clothes [Fig. 4(a and b)] of patients and workers were separated from the heap for reuse. These materials which were taken from the mixed wastes were reused without treatment. Some of them were diverted into the public domain at the blind side of the hospital's management. The plastic bags and packaging cardboard boxes were reused for collection of health-care wastes at the facility. Similar practices occur in hospitals in India [35]. Even though the sorting and reuse of these materials is a good solid waste management practice, it is a perilous one since these sorted materials are likely to be infectious.



(a) (b)

Fig. 4. Wastes sorted for reuse (a) Plastic water bottles (b) Cardboard boxes.

3.9. Off-site transportation of wastes

Subsequent movement of the wastes from the storage facility to the treatment or disposal site by the waste handlers was done by trundling heaps of unlabeled wastes in uncovered wheel barrows. This practice is likely to expose waste handlers and other road users to injuries and infections [34]. reported a similar observation in a hospital in Southern Africa where piles of wastes being conveyed by small pickup trucks fall off onto road [32]. also narrated that medical wastes generated in hospitals in Abuja were carried by waste handlers to the disposal sites. These findings conflict with the regulations proposed by Ref. [30] which states that hospital wastes prior to transportation to treatment sites should be appropriately labelled and conveyed in designated closed vehicles to avoid spillage and spread of infectious diseases.

3.10. Treatment and disposal of medical solid wastes

At the treatment site, the wastes were separated into general, infectious and hazardous wastes by the waste collectors. The infectious and hazardous medical wastes are incinerated at the site by the waste handlers of HTH [Fig. 5(a and b)]. The hospital owns two functional incinerators (a Petroleum Gas (LPG) and a diesel-fired incinerator) for this purpose [Fig. 5(c and d)]. Incineration of the waste was executed daily at 4:30 in the morning until the close of day. The ashes from the incinerators were buried in a separate, unlined dug-out pit at the site even though the ashes are known to contain toxic chemicals which can adversely affect environmental and human health. Aside incineration, some of the infectious and hazardous wastes such as expired drugs, used syringes, swabs and gauzes soaked with blood were burnt in open, unlined pits at the treatment site. The pits that were filled due to incomplete burning of some of the wastes made of glass and plastics were covered with soil and new pits were dug at the site for burning other waste. According to Ref. [18], other hospitals in Ghana also burn medical wastes in pits. Incineration minimizes both the weight and volume of the wastes [7]. It is considered one of the best options of treatment for waste that are unrecyclable or cannot be landfilled [30]. Despite these merits, the lack of air pollution control equipment in the incinerators as well as burning of the wastes in pits releases toxic gases such as furans and dioxins directly into the atmosphere.

Anatomical wastes were stored at the morgue until a sufficient quantity was obtained. The wastes were disposed of at the cemetery of the municipality after acquiring a permit from the Waste Management Unit of the Ho Municipal Assembly. The anatomical wastes were acidified prior to burial to enhance degradation. In the past years, anatomical wastes including placentas, amputated body parts and fetuses from abortions were given back to owners or family members for burial according to their religion or as their custom demanded. In other hospitals such as Komfo Anokye Teaching Hospital in Ghana, anatomical wastes are incinerated [18]. The general wastes on the other hand, were added to the municipal solid waste in a communal skip container provided by Zoomlion Ghana Limited, the main private waste management company in the country. The wastes were transported and disposed of in a landfill by the waste management company.

The situation is even dire in health-care centers in Lusaka, Zambia where all the different categories of wastes are dumped in unlined pits and a few of them such as cotton swabs, expired drugs and sputum bottles were incinerated. Examination of ground water bodies surrounding these dumpsites which serve as drinking water sources indicated possible contamination from the leachates of these wastes [36].

3.11. Use of personal protective equipment among waste handlers

According to WHO guidelines, waste handlers are expected to be equipped with the appropriate Personal Protective Equipment (PPE) to guarantee their health and safety. The complete set of PPE comprises gloves, boots or closed shoes, nose masks and overalls [5]. The assessment made in the hospital portrayed that only 11% of the waste handlers always donned a complete set of PPE. Those who always put on gloves, nose masks, boots and overalls were 32%, 11%, 26% and 27% respectively (Fig. 6) depicting that gloves were the components of the PPE commonly worn by health workers whilst nose masks were rarely used. According to Ref. [37], 83.7% and 87.3% of the waste collectors in health-care facilities in Ethiopia wore heavy-duty gloves and aprons respectively. However, none

Fig. 5. (a) Wastes burnt in an open pit (b) Expired drugs and bottles burnt in the open (c) LPG incinerator and (d) Diesel-fired incinerator.

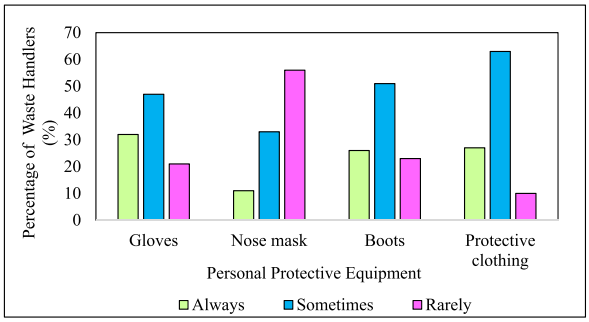


Fig. 6. Percentage of waste handlers who used each type of PPE.

of workers had ever used safety boots and only 12.7% used latex gloves during waste handling. According to Ref. [38], the factors that hinder the use of PPEs include weak policies, discomfort whiles working in PPEs, shortages and psychological perceptions of health workers.

3.12. Injuries from sharps during waste handling

Hospital waste handlers and other health workers are exposed to sharp injuries during handling of medical solid wastes. The frequency of injuries among the respondents was determined. The results illustrated that majority (58%) of the respondents particularly, nurses and doctors sometimes sustained various degree of injuries. A considerable number (23%) of the respondents specifically, 77% of the waste handlers were always afflicted by sharps. Nineteen percent (19%) of the respondents indicated that they rarely had any sharp injury and these were primarily, the administrators. In a study by Ref. [37], 30.9% of the health workers in Ethiopia admitted having sustained sharps and needle-stick injuries. In another study conducted by Ref. [39] 20% of the respondents which included health workers, four visitors and a patient in a teaching hospital in New York, United States of America had suffered from disposal-related sharp injuries. The prevalence of these accidents among health-care workers especially waste handlers may be attributed to the infrequent or inappropriate use of PPE, the adoption of thin-walled polythene bags for the collection of sharps and the dormancy of the waste management team, inadequate training of workers and lack of enforcement of relevant guidelines on waste management at the hospital.

3.13. The way forward

Based on the findings of this study, the following recommendations are being made to aid in improving healthcare waste management in the hospital to curb the spread of nosocomial infections.

a) The hospital must develop a health-care waste management plan to provide guidance and to ensure effective waste handling in the hospital. The plan should cover important details such as appropriate waste management technologies, financial commitments, institutional arrangements, operational plans and schedules on training programmes for staff.
b) Strategies to reduce the amount of waste generated and facilitate proper segregation of waste at source should be implemented.
c) The workers must be well educated on medical waste related-risks.
d) Informative posters on medical waste management practices must be pasted at essential places to educate and serve as reminders for both workers and clients of the hospital.
e) All workers at the hospital should be given adequate and periodic training on health-care waste management practices using designated health-care waste management manuals as well as the waste management plan of the hospital.
f) The waste management committee should be revived and incentivized to ensure a more transformational performance.
g) Financial support from the government or cooperative societies to the hospital for acquisition of:
    i) air pollution control devices to control release of greenhouse gases emitted from incinerators or to adopt greener solutions such as microwaving or autoclaving of the hazardous wastes;
    ii) adequate number of colour-coded, well-labelled waste collection receptacles which will be placed at designated points to enhance waste-segregation-at-source and;
    iii) personal protective clothing to minimise the cases in sharp-injuries;
    iv) on and off-site transportation vehicles for conveyance of hospital wastes.

3.14. Limitation of the study

This study has potential limitations. The research was limited to one teaching hospital in the municipality. Additionally, students and persons-with-disabilities were not included in the study. These limitations should be addressed in any further study conducted in the municipality. Even though these limitations can potentially affect the external validity of the results obtained in the study, the

outcomes of this study has brought to light the challenges impeding the appropriate management of health-care waste in the hospital and the strategies to adopt to enhance efficient waste management. Data on waste generation rates obtained in this study can be used in health-care waste management planning at the hospital.

4. Conclusion

This study investigated into the waste management practices at Ho Teaching Hospital. The total quantity of waste generation rate at the facility was 490628 kg/day. The methods of waste collection, segregation, storage, transportation, treatment and disposal practiced at the hospital breached the health-care waste management guidelines proposed by the Ministry of Health and the World Health Organization putting health-care workers, patients and visitors at risk. Infectious wastes were mixed with general wastes at the point of waste generation and later segregated by the waste handlers. It was therefore, not surprising that about 77% of the waste handlers always suffered sharp injuries. Hence, it is essential that a waste management plan which is in accordance to the national and international guidelines be developed and strictly adhered to. The waste management team should be revived to play its supervisory role in ensuring compliance to the guidelines. Each waste handler should be provided with a full set of PPE. Well-labelled color-coded waste receptacles should be provided and a proper record on the quantities of the different kinds of waste generated should be kept. Mandatory training on waste management must be organized frequently for health-care workers. Furthermore, air pollution control devices should be provided at the treatment site to curb the emission of air pollutants during incineration of the waste. Finally, an integrated medical waste management with concerted effort from the local government authority, private waste management companies and the Ministry of Health must be prioritized.

Author contribution statement

Clement Afesi-Dei: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data.
Miriam Appiah-Brempong: Analyzed and interpreted the data; Wrote the paper.
Esi Awuah: Conceived and designed the experiments; Wrote the paper.

Data availability statement

Data included in article/supplementary material/referenced in article.

Additional information

Supplementary content related to this article has been published online at [URL].

Ethical review and board approval

The Ghana Health Service Ethical Review Board gave ethical clearance before the inception of study. The administrator of the hospital also gave approval in a form of a letter for the survey and “non-participatory observation” in selected wards and units. Informed consent was also taken from all the respondents for voluntary participation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e15514.

References

[1] F. Nosheen, N. Malik, Z. Mehmood, F. Jabeen, A. Mahmood, M. Ibrahim, Biomedical waste management associated with infectious diseases among health care professionals in apex hospitals of a typical south asian city, Environ. Res. 215 (2022), 114240.

[2] MoH, Health Care Waste Management Policy, Accra, Ghana, 2006.
[3] F. Egbenyah, E.A. Udofia, J. Ayivor, M.M. Osei, J. Tetteh, P.B. Tetteh-Quarcoo, et al., Disposal habits and microbial load of solid medical waste in sub-district healthcare facilities and households in Yilo-Krobo municipality, Ghana, PLoS One [Internet] 16 (12) (2021) 1–16, https://doi.org/10.1371/journal.pone.0261211.
[4] C.W. Yoon, M.J. Kim, Y.S. Park, T.W. Jeon, M.Y. Lee, A review of medical waste management systems in the Republic of Korea for hospital and medical waste generated from the COVID-19 pandemic, Sustainability 14 (6) (2022) 1–25.
[5] WHO, in: Y. Chartier, J. Emmanuel, U. Pieper (Eds.), Safe management of Wastes from Health-Care Activities [Internet], second ed., WHO Press, Geneva, Switzerland, 2014, p. 329. Available from: http://www.who.int/water_sanitation_health/medicalwaste/wastemanag/en/.
[6] K.K. Padmanabhan, D. Barik, Health hazards of medical waste and its disposal, in: D. Barik (Ed.), Energy from Toxic Organic Waste for Heat and Power Generation [Internet], Elsevier Ltd., 2019, pp. 99–118, https://doi.org/10.1016/B978-0-08-102528-4.00008-0.
[7] ICRC, Medical Waste Management, 2011, pp. 1–164. Geneva, Switzerland.
[8] WHO, Safe Management of Wastes from Health - Care Activities: a Summary [Internet], 2017. Geneva, Switzerland, https://apps.who.int/iris/bitstream/handle/10665/259491/WHO-FWC-WSH-17.05-eng.pdf;jsessionid=BE197A8BAB73EC864CA3573E15D4F0E6?sequence=1.
[9] J. Pépin, C.N.A. Chakra, E. Pépin, V. Nault, L. Valiquette, Evolution of the global burden of viral infections from unsafe medical injections, 2000-2010, PLoS One 9 (6) (2014) 1–8.
[10] S. Kwikiriza, A.G. Stewart, B. Mutahunga, A.E. Dobson, E. Wilkinson, A whole systems approach to hospital waste management in rural Uganda, Front. Public Health 7 (136) (2019) 1–9.
[11] H.O. Stanley, V.N. Egbe, Impact of hospital waste from the university of port harcourt teaching hospital on the environment, South Asian J Res Microbiol 6 (4) (2020) 1–7.
[12] M. Zubair, A. Adrees, Dioxins and furans: emerging contaminants of air, in: J.D.R. Olvera (Ed.), Air Pollution - Monitoring, Quantification and Removal of Gases and Particles, 2019, pp. 111–125.
[13] D. Tilahun, D.O. Donacho, A. Zewdie, A.M. Kera, G. Haile, Healthcare waste management practice and its predictors among health workers in private health facilities in Ilu Aba Bor Zone, Oromia region, South West Ethiopia: a community-based cross-sectional study, BMJ Open 13 (2) (2023) 1–10.
[14] M. Ali, W. Wang, N. Chaudhry, Y. Geng, Hospital waste management in developing countries : a mini review, Waste Manag. Res. 1–12 (2017).
[15] W. Asare, P. Amedumey, G.B.H. Raphael, Solid waste management in hospitals: a comparative assessment in some selected hospitals in Obuasi Municipality of Ghana, Clean Waste Syst [Internet] (2022), https://doi.org/10.1016/j.clwas.2022.100025.
[16] S. Oduro-Kwarteng, R. Addai, H.M.K. Essandoh, Healthcare Waste Characteristics and Management in Kumasi, Ghana. Sci African [Internet], 2021, e00784, https://doi.org/10.1016/j.sciaf.2021.e00784.
[17] S.K. Abanyie, E.E.Y. Amuah, N.B. Douti, C.C. Amadu, M. Bayorbor, Healthcare waste management in the Tamale Central Hospital, northern Ghana. An assessment before the emergence of the COVID-19 pandemic in Ghana, Environ Challenges [Internet] (2021) 1–9, https://doi.org/10.1016/j.envc.2021.100320.
[18] R.O. Adu, S.F. Gyasi, D.K. Essumang, K.B. Otabil, Medical waste-sorting and management practices in five hospitals in Ghana, J Environ Public Health 2020 (2020) 1–14.
[19] Ho Teaching Hospital, Overview of Ho Teaching Hospital [Internet], 2023. https://www.hth.gov.gh/about-us/overview-2.
[20] Ho Municipal Assembly, Composite Budget for 2019-2020: Programme Based Budget Estimates for 2020, Ho Municipal Assembly, Ho, 2020.
[21] T. Yamane, Statistics: an Introductory Analysis, second ed., Harper and Row, New York, 1967.
[22] EPA, Guidelines for the Management of Health Care and Veterinary Waste in Ghana, Environmental Protection Agency, 2002, pp. 1–44.
[23] MLGRD, Environmental Sanitation Policy, second ed., 2010. Ghana.
[24] K. Kuchibanda, A.W. Mayo, Public health risks from mismanagement of healthcare wastes in Shinyanga municipality health facilities , Tanzania, Sci. World J. 2015 (2015) 1–11.
[25] B. Kudoma, An Evaluation of Clinical Waste Management in Gaborone City Council Health-Care Facilities, University of South Africa, 2013.
[26] S. Sharma, S.V.S. Chauhan, Assessment of bio-medical waste management in three apex government hospitals of Agra, J. Environ. Biol. 29 (2) (2008) 159–162.
[27] S.V. Manyele, Effects of improper hospital-waste management on occupational health and patient safety, Afr. Newsl. Occup. Health Saf. 14 (2004) 30–33.
[28] M.K. Debere, K.A. Gelaye, A.G. Alamdo, Z.M. Trifa, Assessment of the health care waste generation rates and its management system in hospitals of Addis Ababa, Ethiopia, 2011, BMC Publ. Health 13 (1) (2013) 1–9.
[29] C. Dieng, B. Mberu, Z.T. Dimbuene, C. Faye, D. Amugsi, I. Aboderin, Biomedical waste management in Dakar, Senegal: legal framework, health and environment issues; policy and program options, Cities Heal [Internet] 6 (1) (2022) 208–222, https://doi.org/10.1080/23748834.2020.1786228.
[30] A. Pruss, E. Giroult, P. Rushbrook, Safe Management of Wastes from Health-Care Activities, WHO, Geneva, Switzerland, 1999, pp. 1–230.
[31] F. Olaniyi, J. Ogola, T. Tshitangano, A review of medical waste management in South Africa, Open Environ. Sci. 10 (2018) 34–45.
[32] E.C. Okechukwu, A.C. Oparah, S.O. Aguora, J.S. Soni, Assessment of disposal practices among health workers in selected hospitals in Abuja, Texila Int J Public Heal 1–9 (2022).
[33] E.A. Othigo, J. Moronge, Hazardous biomedical waste management in a level four private hospital in Nairobi County, Kenya, J Sustain Environ Peace 3 (2) (2020) 34–40.
[34] P.A. Abor, Medical waste management practices in a Southern African hospital, J. Appl. Sci. Environ. Manag. 11 (3) (2007) 91–96.
[35] S.C. Joshi, V. Diwan, A.J. Tamhankar, R. Joshi, H. Shah, M. Sharma, et al., Staff perception on biomedical or health care waste management: a qualitative study in a rural tertiary care hospital in India, PLoS One 10 (5) (2015) 1–15.
[36] D. Nkhuwa, T. Kafula, A. Ahmed, A preliminary inventory of hazardous medical waste disposal systems and their influence on groundwater quality in Lusaka, Med. J. Zambia 35 (4) (2008) 129–138.
[37] T. Deress, M. Jemal, M. Girma, K. Adane, Knowledge, attitude, and practice of waste handlers about medical waste management in Debre Markos town healthcare facilities, northwest Ethiopia, BMC Res Notes [Internet] 12 (146) (2019) 1–7, https://doi.org/10.1186/s13104-019-4174-7.
[38] L. Cordeiro, J.R. Gnatta, C.L. Ciofi-Silva, A. Price, N.A. de Oliveira, R.M.A. Almeida, et al., Personal protective equipment implementation in healthcare: a scoping review, Am. J. Infect. Control 50 (8) (2022) 898–905.
[39] A.C. Weltman, L.J. Short, M.H. Mendelson, d. e. Lilienfeld, M. Rodriguez, Disposal-related sharps injuries at a New York city teaching hospital, Infect. Control Hosp. Epidemiol. 16 (5) (1995) 268–275.