

Assessing Biomedical Solid and Liquid Waste Management in University Hospital Centers (CHU) in Togo, 2021

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How to cite this paper: Gnaro, T., Ali, A., Adom, A., Abiassi, E.S., Degbey, C., Douti, Y., Messan, D.K., Sopoh, G.E. and Ekouevi, D.K. (2022) Assessing Biomedical Solid and Liquid Waste Management in University Hospital Centers (CHU) in Togo, 2021. *Open Journal of Epidemiology*, 12, 401-420. <https://doi.org/10.4236/ojepi.2022.124033>

Received: July 13, 2022

Accepted: October 29, 2022

Published: November 1, 2022

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Abstract

Introduction. Biomedical waste represents an environmental concern and a risk to healthcare workers, users of healthcare services, and the surrounding population. This study aimed to assess the management of solid and liquid biomedical waste in University Hospitals Centers (UHC) in Togo in 2021. **Methods.** This is a cross-sectional, evaluative and analytical study undertaken in 2021. It involved 3 UHCs, 25 departments, 340 care providers and departments randomly selected, 72 directors or deputies, supervisors and heads of departments, 27 collection and incineration agents selected by a reasoned choice technique, and 44 patients and attendants selected by an accidental choice technique. Data analysis was done using Pearson's Chi² statistical test for comparing proportions and logistic regression. **Results.** Solid and liquid waste management was "poor" due to non-use of waste management guidelines (ORa = 3.50; p = 0.0000), insufficient training of healthcare providers and collection agents (ORa = 6.55; p = 0.0000 and ORa = 6.08; p = 0.0000 respectively), insufficient user awareness sessions (ORa = 4.04; p = 0.0001), insufficient coordination of activities (ORa = 5.07; p = 0.0002), insufficient supervision of service providers and collection agents (ORa = 2.34; p = 0.0000), insufficient monitoring and follow-up of activities (ORa = 20.40; p = 0.0000). The sorting was not systematic (74.1%), and the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of the effluents were relatively high. **Conclusion.** Managing solid and liquid biomedical waste is insufficient in Togo's university hospitals and represents a potential risk to human health and the environment.

Keywords

Management, Biomedical Waste, Healthcare Providers and Services, University Hospitals, Togo

1. Introduction

The purpose of any health facility (HF) is to provide healthcare and services that will improve the health of the populations it serves. All over the world, health facilities provide care and services to populations while producing waste that should be properly managed to minimize health and environmental risks.

Biomedical waste, ordinary waste, excreta, and wastewater (WW) represent an environmental concern and a risk to healthcare workers, healthcare users, and surrounding populations. Healthcare waste with infectious risks (HCWI) is one of the most hazardous wastes in the world [1]. Biomedical waste, accounting for 10% - 25% of HF waste, poses a high infectious risk and its management should be of general concern [2] [3] [4]. Such waste includes general waste that can be assimilated into household waste (GHW) and waste from healthcare activities with infectious risks (HCWI). The latter is considered the second most dangerous waste in the world on top of radioactive waste [1] [5]. GHW includes solid wastes such as empty cardboard boxes, empty pharmaceutical packaging, paper leftovers from offices, food leftovers, liquid wastes such as WW from kitchen sinks, office sinks, showers and excreta from toilets (Water Closet). HCWI includes waste such as sharps, anatomical waste, bloody swabs, chemical waste, pharmaceutical waste, waste from the various departments, waste from the mortuary, and so on [1] [2] [6]. These wastes are mainly generated in larger quantities by university hospitals, due to their numerous departments. Quantities produced increase year by year with population growth, especially in developing countries, and with the single-use consumables concept [7] [8]. Waste water, sewage sludge, septic tank sludge or excreta containing about 95.5% water and 0.1% to 0.5% organic and inorganic materials are generated within the different sections of the hospital such as surgical units, intensive care, laboratories, outpatient departments, clinical departments, laundries, and so on, and have a fairly variable composition depending on activities performed [9]. The management of these liquid healthcare wastes is an often-neglected issue with negative consequences in terms of environmental damage as well as affecting the health of people. In most hospitals, there are no guidelines and standards, nor committees for the management of this liquid healthcare waste [10]. Therefore, the principle of the responsibility of these HFs in generating waste and in seeking safe management that respects the environment and health standards has become important [11]. Developed countries have regulations and standardized procedures to deal with the rational management of waste from HFs. However, in most developing country (DC) HFs, there are no plans or internal regulations

governing the management of biomedical, WW and other wastes, nor are there technical guidelines for their collection, transport, storage and treatment. There is also a lack of reliable data on the produced quantities [11] [12] [13] [14] [15]. There is an absence of incinerators or ones that do not meet the standards. Some incinerators are implemented without any environmental impact study and are sources of the nuisance. HCWI are often mixed with GHW and stored for several days without being destroyed. Similarly, storage and transport equipment are often defective and water treatment plants are almost non-existent. In several health facilities, especially in developing countries, poor waste management has been observed at several points in the management chain: poor sorting, overflowing of waste garbage cans, inappropriate transport and storage, and inadequate treatment [16] [17] [18] [19]. This situation has also been reported by a joint WHO and UNICEF assessment in 2015 in 24 countries where 42% of the health establishments, did not have adequate systems for the disposal of their waste [20]. Also, the quantities produced are not quantified nor documented [3] [21].

Togo, like other developing countries, is experiencing enormous difficulties in managing solid and liquid waste in its HFs. The situation seems to be more worrying in the UHC, where we note among other things the insufficiency in the sorting of waste, the release of biomedical WW into nature without any treatment, the insufficient training of staff in the management of hospital waste and on hospital hygiene [22] [23]. Thus, innovative approaches must be undertaken to find appropriate solutions for the management of HCWI. And to achieve this, it is necessary to conduct in-depth studies on waste management.

This research is part of the evaluation of the current situation of waste management in the university hospitals of Togo in view of proposing some approaches of solutions for proper management.

2. Study Methods

2.1. Study Framework

The study took place in Sylvanus Olympio University Hospital (UHC-SO) and Campus, located in Lomé, as well as Kara University Hospital in the city of Kara, 420 km from the capital. Their services include: internal medicine, hepato-gastroenterology, pediatrics, neurology, psychiatry and medical psychology, cardiology, gynecology-obstetrics, ENT, stomatology, clinical hematology, allergology, dermatology-venereology, ophthalmology, physiotherapy, pediatric surgery, traumatology, laboratories, radiology, pharmacy, speech therapy, vaccination, geriatrics, hygiene and sanitation. In addition to these services, UHC-SO had a hemodialysis service. The UHC-SO, Campus and Kara had respectively 1168, 457 and 375 staff in all fields and 833, 179 and 169 beds in 2020 [24] [25] [26].

2.2. Type of Study

This is a cross-sectional, evaluative, and analytical study undertaken from June 24, 2021 to August 28, 2021.

2.3. Targets

The main targets were the UHC-SO, Campus, and Kara, and the secondary targets were the medical and paramedical staff assigned to care and services (doctors, pharmacists, nurses, midwives, senior lab technicians, hygiene and sanitation technicians, senior anaesthesia and intensive care technicians, senior radiology technicians, lab technicians, orderlies), waste collection and incineration agents, patients and their attendants, hospital directors and deputies, and heads and supervisors of services. In addition, the waste management installations, the hospital environment, the storage and disposal sites were also included in our study.

2.4. Inclusion and Non-Inclusion Criteria

Here are the criteria used:

- were included in our study the medical and paramedical, administrative and support staff assigned to care and services in the UHC;
- medical, paramedical, administrative and support staff assigned to care and services not belonging to the UHC concerned and present on the day of the survey were not included.

2.5. Sampling Methods and Techniques

In each of the three UHCs, services were selected using a probabilistic method and a simple random technique after identification of the services concerned with waste management. Care providers and services have been selected by a probabilistic method and by a simple random technique, directors, heads of services, supervisors of services, maintenance agents, waste collection and incineration agents have been selected by a non-probabilistic method with a reasoned choice technique, patients and attendants by an accidental choice technique.

The total sample size was 483 including the providers and services calculate by the Schwartz formula ($n = Z^2 apq / i^2$); $p = 0.252$; $q = 1 - 0.252 = 0.748$; the accepted risk of error $\alpha = 0.05$; the accepted risk-reduced variance: $Z\alpha = 1.96$; $i =$ desired precision for our results = 0.05; the proportion (25.2%) of the hospital departments that practiced appropriate waste management [27].

2.6. Variables

The main component is waste management which took into consideration sorting, collection, storage, transportation, treatment of waste. Each item has sub-items and each is rated 1 if it is implemented according to the standard and 0 if not. The sum of the scores obtained is divided by the number of items or sub-items. When a university hospital has a score greater than or equal to 80%, it is classified as “**good management**”, *i.e.*, 1, and when a university hospital has a score of less than 80%, it is classified as “**poor management**”, *i.e.*, 0, according to the assessment scale adapted to that of Corlien M. VARKEVISSER [28] [29] [30]. The independent variables under study are human resources, material resources

(PPE, litter garbage cans, carts, containers, image boxes, etc.), infrastructure (incinerator, ash pit, treatment plant, waste storage sites, landfills, cesspools, septic tanks, latrines, showers, etc), financial resources (waste management budget, sources of funding), organizational resources (management plans, hospital hygiene management committees), waste management mechanism, policy documents and standards, waste management texts, existence of guidelines, etc.

2.7. Data Collection Techniques and Tools

The data collection techniques and tools by study target/source are listed in **Table 1**.

2.8. Organization of Data Collection

Data collection took place after a request for authorization to collect data was sent to the Minister of Health. Once the authorization was obtained, contact was made with the directors of the three university hospitals in order to present the authorization for data collection and also to explain the purpose of the research. A collection schedule was established at each university hospital. Interviewers were trained prior to the start of the data collection. A pretest of the collection tools was also carried out at the Kara regional hospital center (RHC), whose technical facilities are similar to those of the university hospitals. The investigators were supervised by us during the collection. Samples were taken at the septic tanks to assess the effectiveness of the treatment: temperature, pH, suspended solids (SS), Biochemical Oxygen Demand in 5 days (BOD_5), Chemical Oxygen Demand (COD) at the Laboratory of Applied Hydrology and Environment (LHAE) of the University of Lomé and biological (parasite research, total coliforms, thermo tolerant coliforms, yeasts and molds) at the Laboratory of Microbiology and Quality Control of Foodstuffs (LAMICODA) of the University of Lomé. The analysis methods used were: electrometry (temperature, pH); conductimetry (conductivity); filtering/drying/weighing (TSS); titrimetry by potassium dichromate (COD); respirometry (BOD_5).

Table 1. Data collection techniques and tools by target/source of study.

Targets/sources	Techniques	Tools
Service providers, maintenance and incineration agents	Survey by questionnaire	Questionnaire
Department Directors, Managers and Supervisors	Interview	Guide
Patients and attendants	Survey by questionnaire	Questionnaire
Infrastructure, service environment, waste storage, waste incineration, septic tanks, cesspools, latrines	Observation	Observation grid
Texts governing waste management	Literature review	Documentary exploitation sheet

2.9. Ethical and Deontological Concerns

Our research protocol was submitted to the Bioethics Committee for Health Research (CBRS) of the University of Lomé, whose favorable approval was obtained before the start of the collection (Opinion N°015/2021/CBRS/ of April 7, 2021). Authorizations were obtained from the Ministry in charge of health and the directors of the three university hospitals (N°058/2021/MSHPAUS/CAB/SG of June 15, 2021). The participants were included in the sample only if they gave their free and informed consent in writing. Data were collected and kept strictly confidential within the study team.

2.10. Data Analysis

After checking each form, data were entered using Epi Data software. They were analyzed using SPSS 24.0 software. A data description was made to assess the distribution of the central tendency and dispersion parameters. Logistic regression was performed to determine the relationships between waste management and the independent variables by calculating the Odds Ratio (OR) and their 95% confidence interval.

3. Results

3.1. Description of Respondents

The distribution of the respondents according to the UHC is presented in **Table 2**.

The providers surveyed were physicians (15.9%), State Registered Nurses (RN) (33.8%), State Midwives (SFE) (13.6%), laboratory technicians (biologist technician and engineer) (10.3%), Medical Assistants (MA) (4.1%), hygiene and sanitation technicians (hygiene assistant, technicians (0.9%), anesthesia and reanimation technicians (1.8%), physiotherapists (3.2%), auxiliary midwives (0.6%), auxiliary nurses (4.4%), orderlies (5.3%), others (ophthalmology technicians (0.8%), instrument technicians (1.9%), etc.). Their age in completed years of service ranged from 30 to 61 with a median of 7 years. Most of the managers and supervisors, 75% (54/72) were male and their ages ranged from 32 to 64 years with a median age of 40 years. For collection and incineration officers, the majority (16/27) were male and ranged in age from 32 to 62 with a median age of 54.

Table 2. Distribution of respondents according to UHC.

Respondents	University hospitals			Total
	Kara	Campus	SO	
Providers	75	90	175	340
Directors, Managers and Supervisors	20	21	31	72
Collection and incineration agents	4	3	20	27
Patients and attendants	9	10	25	44
Total	108	124	251	483

3.2. Resources and Organization for Waste Management

Several factors are related to the resources and organization in place for appropriate waste management in UHC among healthcare providers and services.

Univaried analysis, eight (08) variables were statistically associated with resources and organization. These were: sufficient hygiene officers, disbursement of planned financial resources, functional hygiene department, functional hygiene committee, waste management plan, waste management guides, waste collection route and knowledge of the organization in place. In addition, one variable had a p-value of less than 0.20, without being significantly associated, and was entered into the logistic regression model. This was the availability of conventional waste management garbage cans (**Table 3**).

Table 3. Univariate analysis of resources and organization for waste management in university hospitals in Togo (n = 340).

Resources/organization	Headcount	%	OR	CI _{95%}	p-value
Existence of a sufficient number of hygiene agents					
No	274	80.6	1	-	-
Yes	66	19.4	3.17	[2.07 - 6.42]	0.0000
Disbursement of planned financial resources					
No	230	67.6	1	-	-
Yes	110	32.4	4.27	[2.37 - 14.25]	0.0003
Availability of conventional waste garbage cans					
No	90	26.5	1	-	-
Yes	250	73.5	3.06	[0.48 - 5.13]	0.1377
Condition of the transport equipment					
Bad	180	52.9	1	-	-
Good	160	47.1	0.96	[0.77 - 2.03]	0.4106
Existence of a functional hygiene service					
No	21	6.2	1	-	-
Yes	319	93.8	6.43	[0.86 - 49.02]	0.0390
Existence of PPE providers and support agents					
No	49	14.4	1	-	-
Yes	291	85.6	1.06	[0.23 - 5.30]	0.6301
Existence of a functional hygiene committee					
No	226	66.5	1	-	-
Yes	114	33.5	2.08	[1.24 - 5.03]	0.0170
Availability of a waste management plan					
No	215	63.2	1	-	-
Yes	125	36.8	2.08	[1.37 - 4.43]	0.0018

Continued

Existence of waste management guides					
No	137	40.3	1	-	-
Yes	203	59.7	1.68	[1.30 - 2.90]	0.0420
Definition of a waste collection circuit					
No	63	18.5	1	-	-
Yes	277	81.5	5.4	[2.80 - 15.50]	0.0005
Organization set up for waste management					
No	117	34.4	1	-	-
Yes	223	67.6	2.49	[1.80 - 5.02]	0.0006

Multivaried analysis, seven (07) variables were statistically associated with poor waste management. These were: insufficient number of hygiene agents, insufficient disbursement of financial resources, absence of a functional hygiene committee, absence of a waste management plan, absence of waste management guides, failure to define a waste collection circuit and lack of knowledge of the existing organization. Thus, the risks of poor waste management were multiplied by:

- 3.83 by the lack of hygiene agents ($p = 0.0001$);
- 5.23 by insufficient disbursement of financial resources earmarked for waste management ($p = 0.0006$);
- 2.57 by the non-existence of waste management plans ($p = 0.0013$);
- 1.75 by the non-existence of waste management guides ($p = 0.0403$);
- 5.48 by not defining a waste collection circuit in hospitals ($p = 0.0004$);
- 2.16 by the absence of a hospital hygiene committee ($p = 0.0100$);
- and 2.83 by the lack of knowledge of the organization set up within the university hospitals for waste management ($p = 0.0004$) (**Table 4**).

For collection and incineration agents:

- the PPE provided is insufficient and defective (22/27);
- transport equipment is defective (17/27);
- waste management guides are not available (17/27).

For directors, supervisors and heads of departments (n = 72), they stated that:

- human and financial resources are insufficient (100%), waste garbage cans and other collection and transport materials are defective (58.33%);
- there is a committee in charge of hygiene aspects within the hospital (21.61%), but all acknowledged the fact it was not functioning;
- they are not aware of any policy documents and standards for waste management (84.72%) and guidelines (65.28%).

The 3 UHCs each had a type MP 100 incinerator.

3.3. Waste Management Process**Management of solid waste**

Table 4. Multivariate analysis of resources and organization for waste management in university hospitals in Togo.

Resources/organization	ORa	CI _{95%}	p-value
Existence of a sufficient number of hygiene agents			
No	1	-	-
Yes	3.83	[2.15 - 6.80]	0.0001
Disbursement of planned financial resources			
No	1	-	-
Yes	5.23	[2.21 - 12.34]	0.0006
Existence of a functional hygiene committee			
No	1	-	-
Yes	2.16	[1.19 - 3.90]	0.0100
Availability of a waste management plan			
No	1	-	-
Yes	2.57	[1.47 - 4.65]	0.0013
Existence of waste management guides			
No	1	-	-
Yes	1.75	[1.42 - 2.99]	0.0403
Definition of a waste collection circuit			
No	1	-	-
Yes	5.48	[1.92 - 15.60]	0.0004
Organization set up for waste management			
No	1	-	-
Yes	2.83	[1.57 - 5.10]	0.0004

Solid waste management involves the following steps: source separation, collection, storage, transportation and treatment.

With healthcare providers

In the univariate analysis, nine (09) variables were statistically associated with the solid waste management process. These were: sorting practice, use of guidelines, destruction of waste by incineration, training of service providers, on-the-job training of collection agents, sensitization of users on waste management, coordination of waste management activities, supervision of actors, and monitoring and evaluation of waste management activities. In addition, 02 variables (daily waste collection and transportation of waste in closed containers) with a p-value less than 0.20 were entered into the logistic regression model (**Table 5**).

On multivariate analysis, eight (08) variables were statistically associated with the solid waste management process. These were: sorting practice, use of guidelines, training of service providers, on-the-job training of collection agents,

Table 5. Univariate analysis of the solid waste management process in UHC (n = 340).

Management activities	Headcount	%	OR	CI _{95%}	p-value
Healthcare providers practice waste sorting					
No	88	25.9	1	-	-
Yes	252	74.1	3.76	[1.65 - 7.33]	0.0005
Providers use waste management guidelines					
No	177	52.1	1	-	-
Yes	163	47.9	3.32	[2.16 - 5.83]	0.0002
Collection from various departments daily					
No	82	24.1	1	-	-
Yes	258	75.9	2.12	[0.73 - 3.13]	0.0743
Waste storage time before destruction					
24 h and more	215	63.2	1	-	-
Less than 24 h	125	36.8	0.75	[0.29 - 2.87]	0.2310
Transported in closed containers					
No	157	46.2	1	-	-
Yes	183	53.8	4.27	[0.91 - 6.74]	0.0621
Destruction of waste by incineration					
No	52	15.3	1	-	-
Yes	288	84.7	0.34	[0.29 - 0.78]	0.0390
Training of service providers					
No	161	47.4	1	-	-
Yes	179	52.6	6.44	[3.63 - 11.99]	0.0001
On-the-job training for collection agents					
No	205	60.3	1	-	-
Yes	135	39.7	5.97	[3.35 - 10.59]	0.0002
Awareness raising of users on waste management					
No	181	53.2	1	-	-
Yes	159	46.8	4.07	[2.31 - 6.58]	0.0003
Coordination of waste management activities					
No	151	44.4	1	-	-
Yes	189	55.6	5.11	[4.71 - 8.38]	0.0001
Supervision of the actors during the activities					
No	202	59.4	1	-	-
Yes	138	40.6	2.41	[1.90 - 2.63]	0.0000
Monitoring and follow-up of activities					
Yes	135	39.7	1	-	-
No	205	60.3	20.10	[9.86 - 40.98]	0.0000

sensitization of users on waste management, coordination of waste management activities, supervision of actors and monitoring and evaluation of waste management activities. Thus, the risks of poor waste management were multiplied by:

- 3.92 by insufficient waste sorting ($p = 0.0003$);
- 3.50 by not using the guidelines ($p = 0.0000$);
- 6.55 by insufficient training of providers on waste management ($p = 0.0000$);
- 6.08 by insufficient training of collection agents on waste management ($p = 0.0000$);
- 4.04 by insufficient awareness-raising sessions for users on waste management ($p = 0.0001$);
- 5.07 by insufficient coordination of waste management activities ($p = 0.0002$);
- 2.34 by insufficient supervision of collection and incineration service providers and agents ($p = 0.0000$);
- 20.39 by insufficient monitoring and evaluation of waste management activities ($p = 0.0000$) (**Table 6**).

Table 6. Multivariate analysis relating to the solid waste management process in UHC.

Management activities	ORa	CI _{95%}	p-value
Healthcare providers practice waste sorting			
No	1	-	-
Yes	3.92	[1.80 - 8.53]	0.0003
Providers use waste management guidelines			
No	1	-	-
Yes	3.5	[2.03 - 6.04]	0.0000
Providers are trained			
No	1	-	-
Yes	6.55	[3.58 - 11.97]	0.0000
On-the-job training for collection agents			
No	1	-	-
Yes	6.08	[3.48 - 10.63]	0.0000
User awareness on waste management			
No	1	-	-
Yes	4.04	[2.33 - 7.01]	0.0001
Coordination of waste management activities			
No	1	-	-
Yes	5.07	[4.84 - 8.53]	0.0002
Supervision of actors during activities			
No	1	-	-
Yes	2.34	[1.93 - 2.84]	0.0000
Monitoring and follow-up of activities			
No	1	-	-
Yes	20.40	[9.93 - 41.86]	0.0000

Collection and incineration workers, reported that:

- they received on-the-job training before starting their activities (12/27) and in-service training (14/27);
- care and service providers do not sort waste at source (27/27);
- waste was stored for more than 24 hours on the wards (12/27);
- toilet maintenance is done at times but is not at all easy (21/27);
- incineration of HCWI is practiced (27/27), burning of GHW within the hospital (18/27) and evacuated by a private company outside the hospital (09/27).

For directors, supervisors and heads of departments (n = 72),

- the training was given to healthcare workers, collection and incineration agents and some healthcare providers (76.39%);
- coordination activities were carried out by the hygiene service agents (68.06%); collection agents were supervised (43.06%) by the service supervisors and hygiene agents;
- user awareness by service providers (65.50%), although this awareness is still very low.

Management of liquid waste**For healthcare providers and services:**

- the wastewater from the various services is drained into septic tanks (65.90%), but also evacuated directly into the environment (3.50%);
- latrines and showers are available in the university hospitals (94.10%) and accessible to patients and attendants (62.40%) and actually used by patients and attendants (76.20%).

Regarding the collection and incineration agents, they stated that the:

- WW of the different services are drained into septic tanks (13/27), but also evacuated directly into nature (9/27);
- latrines and showers are available and accessible to patients in the UHC and attendants (23/27), these latrines are difficult to maintain (21/27) and therefore are not effectively used by patients and attendants.

For directors, supervisors, and heads of departments (n = 72), they stated that the wastewater from the various departments is connected to septic tanks and cesspools. There are no wastewater treatment plants (WWTPs), which they consider the best solution for managing hospital wastewater.

Upon observation, it is observed that wastewater is managed through septic tanks and cesspools. There are no WWTPs. The effluents from a number of departments are drained and connected to the same cesspool or septic tank. The wastewater from some departments (UHC-SO) is not routed to the septic tanks and cesspools and flows directly into the gutters, whose effluents end up in the city's collective wastewater network. The effluents of some departments are also connected directly to the cesspool without passing through the septic tank, which provides treatment before discharge. When the septic tanks are full, they are emptied and the effluent and sludge are evacuated off the Kara UHC site by vacuum trucks. Campus UHC effluents are evacuated into storm tanks on the

site and occasionally off-site by vacuum trucks. The effluents from the UHC-SO are evacuated into the collective wastewater network of the city of Lomé.

3.4. Waste Management Outcomes

The main results of waste management are as follows:

- GHW is often mixed with HCWI; this is observed and recognized by providers (25.90%), collection and incineration agents (27/27);
- existence of heaps of solid waste not disposed of in the UHC (**Figure 1**);
- the flow of wastewater at several points in the UHC (**Figure 2**);
- the incineration of waste constitutes a nuisance for the surrounding area, recognized by the service providers (21.80%), as well as the collection and incineration agents (17/27);
- the lack of satisfaction of internal and external clients with regard to waste management: providers (59.10%), collection and incineration agents (21/27), directors, heads and supervisors of services (32.73%), patients and attendants (36.36%). Physico-chemical and biological parameters were tested in the septic tanks of some of these three UHC. The values of BOD5 and COD, total coliforms, thermotolerant coliforms, yeasts and molds were relatively high and above the standards for CHU SO and Campus (**Table 7**).



Figure 1. Photos of waste taken during data collection at UHC in 2021.

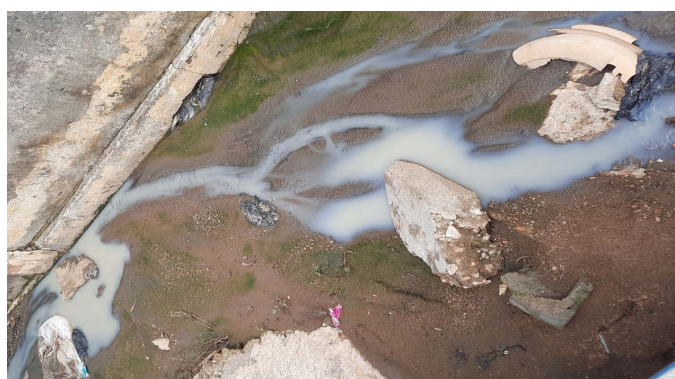


Figure 2. Photos of waste taken during data collection at UHC in 2021.

Table 7. Physico-chemical and biological parameters researched in wastewater at University Hospital (Minimum and Maximum).

Parameters/Germs	Methods of analysis	UHC Kara	UHC Campus	UHC SO	Norms
Physico-chemicals					
Temperature °C	Electrometry	29.8 - 30.1	28.8 - 29.1	29.4 - 30.2	<30
pH	Electrometry	7.25 - 8.1	7.12 - 7.48	6.63 - 7.28	6 - 9
Conductivity 20°C µ/cm	Conductimetry	472 - 1328	1350 - 2070	1275 - 2540	2000
SS mg/L	Filtration/Drying 105°C/Weighing	<10.0	<10.0	30 - 247.10	35
COD mg/L	Potassium dichromate	20 - 120	40 - 140	200 - 1600	<125
BOD ₅ mg/L	Respirometry	2.0 - 2.5	4.7 - 34.9	5.2 - 188	<25
Biologics		Number of germs in CFU/mL of sample			
Total coliforms 30°C		60 - 4200	680 - 15,000	35,000 - 500,000	-
Thermotolerant coliforms 44°C		50 - 2800	420 - 14,000	12,000 - 70,000	-
Yeasts and molds		7 - 43	8 - 38	150 - 1500	-

pH: Hydrogen potential; **SS:** Suspended solids; **COD:** Chemical Oxygen Demand; **BOD₅:** Biochemical Oxygen Demand in 5 days; **CFU:** Colony Forming Unit.

Table 8. UHC waste management score by stage.

Waste management steps	Scorage (%)		
	Kara	Campus	SO
Sorting	75	83	73
Collection	69	69	58
Storage	62	49	46
Transport	70	72	59
Treatment	62	60	56
Management	68	66	58

Score and ranking of UHC

Taking into consideration sorting, collection, storage, transport, waste treatment and their sub-items, and whether or not they are implemented in accordance with the standard, and by adding up the scores obtained, divided by the number of items or sub-items, the UHC obtained the scores shown in **Table 8**. The management step with the highest average score was sorting, with scores of 75%, 83%, and 73% for Kara UHC, Campus UHC, and SO UHC, respectively.

The management step with the lowest average score was storage (62% at Kara UHC, 49% at Campus UHC, and 46% at SO UHC). All the overall waste management scores obtained were below 80%. All of the UHC are therefore classified as having “poor management” (**Table 8**).

4. Discussion

The general objective of our study was to assess the management of solid and

liquid biomedical waste in the University Hospitals (UHC) in Togo in 2021. At the end of our study, we found that the management scores for Kara, Campus and SO UHCs were respectively 68%, 66% and 58%. The management is therefore “poor” overall. Waste sorting at source was not systematic according to providers (25.9%) and collection agents (27/27). None of the three university hospitals had a wastewater treatment plant. The resources provided for waste management were insufficient (67.6%) of the healthcare providers and services.

The sampling techniques and the diversity of the tools allowed us to collect data from different targets/sources, which made it possible to triangulate the data and reduce bias. To address recall bias, questions or items were worded in a way that would help the targets to recall the information sought.

However, the limitations of this study lie in the fact that it focuses only on university hospitals and does not take into account other types of health facilities, whose realities are not necessarily the same, and in the fact that it provides only a snapshot of the waste management situation at a given time.

Resources and organization

The availability of resources and the establishment of an appropriate organization remain the first elements of effective management. The results of our study showed that allotted financial resources for waste management, material resources such as garbage cans, carts, PPE, were relatively insufficient or in poor condition. Gizalew *et al.*, in a study, Ethiopia in 2021, found that 57% of color-coded containers were available in the respondents’ wards and the medical waste management guidelines and policy were known and implemented by only 29.6% of health workers [31]. Agbere *et al.*, Togo, 2021, found that only 18.3% of storage sites met international requirements. Incinerators were available in 72.0% and plastic pedal garbage cans were the most commonly used collection tools in 32.9% of the surveyed facilities [32]. Also, Saizonou *et al.*, Benin in 2013, had found a similar result where insufficient management of DBM was explained by a lack of management policy (22.6%) of the respondents [14]. In a study in Gaza in 2016, Caniato *et al.*, had reached the conclusion that, the management of healthcare waste required technical, financial and human resources, and this was a challenge for low- and middle-income countries [33]. This can also be explained by financial constraints at the level of hospital administrations with multiple and urgent needs such as payment of salaries of local budget staff, purchasing of equipment and others, or that hospital administrations pay very little attention to proper management of healthcare waste [3]. As well, many providers seem to give less importance to the texts and directives that contribute to waste management. The existence of functional hygiene committees within hospitals should facilitate the development of management plans, guidelines, definition of collection routes and implementation of waste management activities.

Sorting and managing solid waste

Careful sorting of waste at source into different categories minimizes the quantities of hazardous waste and remains the basis for effective management

from collection, storage, transport and disposal. In our study, source separation was not systematic according to the different respondents, and a mixture of GHW and HCWI was observed in the landfills. This lack of source separation resulted in “poor” waste management, explained by the non-use of waste management guidelines, insufficient training of service providers, insufficient training of collection agents, lack of user awareness sessions, insufficient coordination of waste management activities, insufficient supervision of service providers and collection agents, and insufficient monitoring and evaluation of waste management activities. Inadequate waste sorting has been found in several studies [16] [34] [35].

Kuchibanda *et al.*, in a study, Tanzania 2019, initially found that there was inadequate waste segregation and lack of knowledge of policies, laws and regulations and their enforcement resulted in poor waste management [3] but did not statistically link these factors to waste management. This difference is attributable to the type of study, which was purely descriptive. Training activities were organized for providers and collectors, but these were not sufficient to achieve the results. Parida *et al.*, in a 2019 study, concluded that repeated and comprehensive training was the only way to achieve effective management. Thus, training aspects of GDBM should be strengthened so that current and future regulations are diligently and consistently implemented [36]. Coordination remains an important aspect of GDBM. In a study in 2016, Caniato *et al.*, had identified a number of challenges including lack of clear definitions and regulations and poor coordination among key stakeholders in waste management [33].

Managing liquid waste

Liquid wastes such as WW and excreta are also generated in health facilities. Their proper management should be a concern for hospital administrations and all stakeholders. This will minimize the risks to the environment and the health of the population. These waste and excreta should be treated in appropriate facilities, and the effluent and sludge disposed of in accordance with discharge standards. Thus, WHO has developed guidelines to guide countries [37] [38]. In our study, the wastewater from the various departments was drained into septic tanks, but also evacuated directly into the environment. Latrines and showers were available in the university hospitals, but were not fully accessible to patients and their attendants. The physico-chemical parameters tested such as BOD₅, COD and biological parameters such as total and thermo-tolerant coliforms were relatively high. This means that the discharged wastewater contains organic or inorganic solids and microbial contaminants. A high BOD₅ indicates the presence of excessive amounts of organic carbon, so a high polluting capacity of these WW [39] [40]. Kasuku *et al.*, in a study in 2016, had found the existence of toxic substances in the effluents of the concerned hospital facilities and these could have a harmful impact on the environment. The water analysis of the river in which these effluents were discharged confirmed these findings [41]. Todedji *et al.*, in a study in 2020 in Benin, found a BOD and COD that respected the

standards [42]. This difference could be explained by facilities that provided at least secondary treatment. Wiafe *et al.*, in a study in 2016 in Ghana, found the inefficiency of wastewater treatment facilities based on the results of microbiological analysis of total coliform bacteria, faecal coliform bacteria and heterotrophic bacteria [43]. Typically, this is because these facilities are designed to provide primary treatment, which consists of temporarily holding the WW in a sump where settled and floating materials are retained and then the resulting effluent is subjected to secondary treatment. Primary treatment typically removes 30% - 40% of the BOD. Effective treatment should achieve secondary and tertiary treatment. Secondary treatment uses microbial degradation, either aerobic or anaerobic, to reduce the concentration of organic compounds. The combined use of primary and secondary treatment reduces BOD by approximately 80-90%. Tertiary treatment uses chemicals to remove inorganic compounds and pathogens. This is the final stage of treatment where the effluent after secondary treatment is first mixed with sodium hypochlorite, and then the effluent is passed through a filter where sand and activated carbon are used as filter media [39]. Overall, liquid waste management remains a concern in teaching hospitals.

5. Conclusion

Assessing solid and liquid hospital waste management in Togo's university hospitals has provided a clearer picture of this issue. Difficulties remain at several levels of the management chain, from sorting at source to waste disposal. Insufficient financial and human resources and unsuitable materials are one of the bottlenecks in this management. Moreover, the lack of organization, such as the absence of management plans and circuits, and the absence of hospital hygiene committees, does not encourage optimal waste management. Similarly, the lack of training for service providers, the lack of use of management guidelines, the lack of coordination of activities, the lack of supervision of service providers and collection agents, and the lack of monitoring and evaluation of waste management activities adversely affect good waste management. Sorting at source is not systematic, leading to a mixture of GHW and HCWI, thus increasing the volume of hazardous waste. Liquid waste management facilities do not meet standards, making treatment inefficient. Managing solid and liquid hospital waste in Togo's university hospitals is a major concern given the potentially high risks to human health and the environment.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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