GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(RESEARCH ARTICLE)

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Evaluation of solid biomedical waste management practices in six health facilities in southern Benin

Denise Assiba DAVOU [1, 2, *], Hervé Agbomakou GBEGNIDE [1, 2], Martin Pépin AÏNA [3] and Edgard-Marius OUENDO [1]

[1] *Regional Institute of Public Health (IRSP), Slave Route, BP 384 Ouidah, Benin.*
[2] *Ecohealth Regional Chair on Urban Air Pollution, BP 188, Cotonou, Benin.*
[3] *Laboratory of Water Sciences and Techniques, National Water Institute (INE), University of Abomey-Calavi 01BP 526 Cotonou, Benin.*

GSC Advanced Research and Reviews, 2022, 12(02), 144–163

Publication history: Received on 18 July 2022; revised on 19 August 2022; accepted on 21 August 2022

Article DOI: https://doi.org/10.30574/gscarr.2022.12.2.0223

Abstract

Introduction: Health care generates biomedical waste that present risks to humans and the environment if poorly managed. The objective of this study was to assess the management practices of solid biomedical waste in southern Benin.

Methods: This was a descriptive cross-sectional study conducted in six health facilities. The study included 12 administrative agents selected by reasoned choice and 431 health care agents selected by convenience. The data were collected by questionnaire, interview, and observation. They concerned variables related to the production, the practice of managing, knowledge of the impact of solid biomedical waste on the environment and health, training and protection of personnel. Data analysis was done with R 4.5.0 software. Quantitative variables were described by median and interquartile range. Proportions were compared with the chi-square test or that of Fisher at the threshold of 0.05.

Results: The health facilities did not have solid biomedical waste management database. Sorting was not systematic in 59.5 %. Final storage locations did not meet standards. Almost one in four health workers (24.4 %) were injured by biomedical waste. Overall, 45.8 % of the staff had been trained at least once on biomedical waste management. 61 % of the staff surveyed were vaccinated, hepatitis B (41.3 %), tetanus (32.9 %).

Conclusion: In view of the results, it is necessary to ensure the on ongoing awareness and training of medical staff in the sorting and packaging of biomedical waste and to set up an efficient and sustainable solid biomedical waste management system with effective monitoring mechanisms.

Keywords: Evaluation; Practices; Solid biomedical waste management; Health facilities; Benin

1. Introduction

During the provision of health care, health care facilities generate biomedical waste that is hazardous to humans and the environment [1]. According to the World Health Organization (WHO), biomedical waste refers to waste resulting from health care activities in hospitals, medical or research facilities, or produced during public health campaigns such as vaccination campaigns [2]. They represent about 0.2 % of the volume of domestic municipal waste [3]. It is estimated that about 85 % of health care waste is non-hazardous, and the remaining 15 % is hazardous and may be infectious,

* Corresponding author: Denise Assiba DAVOU
Institut Régional de Santé Publique (IRSP), Route des Esclaves, BP 384 Ouidah, Bénin.

toxic or radioactive [4]. The generation and disposal of medical waste is a serious problem, particularly in some underdeveloped countries [5]. It is the main cause of problems such as nosocomial infections or infection of staff as well as its potentially harmful effect on the health of staff and the population [6]. Despite the harmful potential of solid biomedical waste, in sub-Saharan Africa in 2019, only 60 % of hospitals and 38 % of other health facilities had basic waste management services. Seven out of ten public health facilities (71%) and half of private health facilities (55 %) were safely segregating their waste [7]. To ensure optimal management of biomedical waste, several measures have been proposed [8]. In Benin in particular, Decree n°2002-484 of 15 November 2002 on the management of biomedical waste in the Republic of Benin, which defines, among other things, the general framework for waste management and the evaluation of MBW management methods in health facilities, has been adopted [9]. In spite of these regulatory efforts, solid biomedical waste are not treated according to standards in Benin [10-12]. This is a major problem for both hospitals and the population and makes hospital hygiene a challenge to be overcome [13, 14].

The objective of this work was to evaluate the management practices of biomedical waste in six health facilities in southern Benin.

2. Material and methods

The study was conducted in southern Benin in health facilities with a functioning incinerator. It covered the three levels of the country's health pyramid. Given the means available, six health facilities were considered for the study, including two central, one intermediate and three peripherals. At the central level, the Centre Hospitalier et Universitaire de la Mère et de l'Enfant Lagune (CHU-MEL) and the Hôpital d'Instruction des Armées, Centre Hospitalier Universitaire (HIA-CHU) de Cotonou were selected at random. At the intermediate level, the only departmental center with a functional incinerator in the study area was selected. This was the Mono-Couffo Departmental Hospital (CHD-MC). At the peripheral level, a random selection was used to select three facilities: the Ouidah-Kpomassè-Tori Zone Hospital (HZ-OKT), the Cotonou 1-4 Health Center (CS), and the Zinvié Hospital La Croix (HLC).

This was a descriptive cross-sectional study that was conducted from October 2020 to June 2021. The study population in these health facilities consisted of administrative and health care staff. Administrative staff (administrative managers, hygiene department managers, care department heads and supervisors) were selected by reasoned choice and care staff involved in the production of solid biomedical waste (in charge of care, hygiene, and departmental maintenance) were selected by convenience. The study focused on the structures of the Ministry of Health involved in the regulation of biomedical waste management in Benin and the Ministry of the Living Environment and Sustainable Development, which provide the institutional and legal framework for the management of biomedical waste through legislative and regulatory texts. These include the Direction de la Protection, de l'Hygiène et de l'Assainissement de Base and the Direction de la Gestion des Pollutions, Nuisances et de la Police Environnementale.

The overall sample size was calculated using the Schwartz formula adapted to cross-sectional studies [15]: N= (Z)2*p*(1-p)/d2. In the absence of data on this specific target, we considered 50 % for p and N was 396. At each facility, the sample size was proportional to the number of medical and paramedical staff.

Data were collected by questionnaire, interviews and direct observation. They concerned variables related to solid biomedical waste production, management practice, knowledge of their impact on the environment and health, training and protection of personnel:

- The questionnaire was addressed to heads of departments, department supervisors and staff involved in the production and management of solid biomedical waste to assess the practices of agents in their management, the availability of resources useful for the management, the health and environmental risks induced by poor management of solid biomedical wastes;
- The interview guide was used with hygiene service managers and administrative managers to assess the mechanisms for managing of solid biomedical wastes. Two interviews were conducted in each of the six health facilities;
- The observation grid was used to compare and objectify the information collected by questionnaires and interviews within the services. Three services were observed in each of the six facilities
- and the digital camera to support the observations
- The collected data were entered and analyzed with EPI data and R 4.5.0 software. Quantitative variables were described by median and interquartile range. Proportions were compared with Fisher's chi-2 test with a significance level of 0.05.

3. Results

3.1. Participation rate by facility and by target

We received four hundred and thirty-one (431) questionnaires out of the four hundred and sixty-five (465) distributed to the health workers, for a participation rate of 92.7%.

The observations of the departments and the interviews of the managers of the facilities were carried out as planned (Table 1).

Table 1 Participation in the study in the six health facilities

Health facilities	Computed sample	Number of surveys submitted	Number of surveys received	Participation rate (%)	Number of services observed	Number of interviews
CHD-MC	47	48	46	95.8	3	2
CHU-MEL	153	176	155	88.1	3	2
CS Cotonou 1-4	16	21	21	100.0	3	2
HLC of Zinvié	45	58	54	93.1	3	2
HIA-CHU	103	111	105	94.6	3	2
HZ-OKT	32	51	50	98.0	3	2
Total	396	465	431	92.7	18	12

3.2. Number and profile of hospital employees

These health facilities employed 1,648 workers, 13 % of whom were at the CHD-MC, 40% at the CHU-MEL, 8 % at the CS Cotonou 1-4, 24 % at HIA-CHU, 6 % at the HLC of Zinvié and 9 % at HZ-OKT. Doctors represented 9.9 % of this staff, nurses 21.1 %, midwives 8.2 %, nursing assistants 22.5 %, maintenance workers 7.1 %, biologists 4.5 %, and other categories of agents 26.5 % (Table 2).

Table 2 Distribution of the number of employees by health facility

Health facilities	Doctors	Nurses	Midwives	Nurses' aids	Maintenance workers	Biologists	Other categories	Total
CHD-MC	17 (1.0%)	40 (2.4%)	12 (0.7%)	50 (3.04%)	16 (0.9%)	8 (0.4%)	66 (4.01%)	209 (12.7%)
CHU-MEL	49 (2.9%)	124 (7.5%)	74 (4.5%)	142 (8.6%)	49 (2.9%)	27 (1.6%)	190 (11.5%)	655 (39.8%)
CS Cotonou1-4	2 (0.1%)	34 (2.0%)	17 (1.03%)	28 (1.7%)	2 (0.1%)	4 (0.2%)	1 (0.06%)	88 (5.3%)
HIA-CHU	60 (3.6%)	100 (6.08%)	19 (1.1%)	100 (6.08%)	16 (0.9%)	17 (1.03%)	100 (6.08%)	412 (25.06%)
HLC-Zinvié	16 (0.9%)	26 (1.5%)	5 (0.3%)	22 (1.3%)	23 (1.4%)	10 (0.6%)	26 (1.5%)	128 (7.7%)
HZ-OKT	19 (1.1%)	23 (1.4%)	8 (0.4%)	28 (1.7%)	12 (0.7%)	8 (0.4%)	54 (3.2%)	152 (9.2%)
Total	163 (9.9%)	347 (21.1%)	135 (8.2%)	370 (22.5%)	118 (7.1%)	74 (4.5%)	437 (26.5%)	1648 (100%)

3.3. Respondents' characteristics

Of the respondents, 241 (55.9 %) were female, for a sex ratio of 0.79. The median age of the agents was 33 years with extremes of 20 and 63 years (interquartile range: 28-40 years) and 70.5 % were between 20 and 39 years. Nursing assistants (31.6 %) and registered nurses/specialized nurses (30.6 %) were more represented. The seniority of the officers in the position ranged from less than one (1) year to thirty-five (35) years with a median of 9 years (interquartile range: 4-13 years) and 59 % had less than 10 years in the profession (Table 3).

Table 3 Investigated agents characteristics in health facilities, (N=431)

	Size	**%**
Gender		
Male	190	44.1
Female	241	55.9
Age (year)		
20-39	304	70.5
≥40	127	29.5
Qualification		0.0
Caregiver	136	31.6
Nurse/Nurse Specialist	132	30.6
Maintenance worker	42	9.7
Midwife	36	8.4
General doctor	25	5.8
Laboratory technician	24	5.6
Specialist doctor	16	3.7
Hygiene technician	13	3.0
Radiology technician	7	1.6
Position		
Head of department	29	6.7
Supervisor	43	10.0
Care manager	166	38.5
Hygiene officer	7	1.6
Orderly	131	30.4
Maintenance agent	36	8.4
Others	19	4.4
Professional seniority (years)		
0-9	255	59.2
10-19	139	3.3
20-29	32	7.4
≥30	5	1.2

3.4. Types of waste generated by service

All different types of biomedical waste were generated across all departments. Health care waste was generated by almost all staff (99 %) compared to household waste (89 %). Among healthcare waste, the most common types produced were infectious waste (91.4 %) and sharps (88.1 %).

In the surgical or surgical specialty departments, infectious waste (93.7 %) and sharps waste (92.8 %) were produced more. The same observation was made in all other types of departments. On the other hand, waste similar to household waste was produced less in laboratories and blood banks (83.3%) than in other departments.

3.5. Systematic sorting and respect of color coding for waste packaging

Table 4 Systematic sorting and respect of color coding for packaging

Compliance with color coding for packaging						
	Total (N)	**Systematic sorting**	**Waste sharps/ pointy**	**Anatomical waste**	**Non-anatomical infectious waste**	**General wastes**
Health facilities						
CHD-MC	46	43 (93.5)	32 (69.6)	1 (2.2)	28 (60.9)	27 (58.7)
CHU-MEL	155	147 (95.5)	126 (81.3)	23 (14.8)	115 (74.2)	122 (78.7)
CS-Cotonou1-4	21	17 (81.0)	15 (71.4)	5 (23.8)	12 (57.1)	17 (81.0)
HlC-Zinvié	54	45 (83.3)	29 (53.7)	1 (1.9)	30 (55.6)	31 (57.4)
HIA-CHU	105	79 (75.2)	46 (43.8)	7 (6.7)	36 (34.3)	48 (45.7)
HZ-OKT	50	46 (92.0)	28 (56.0)	5 (10.0)	35 (70.0)	41 (82.0)
Total	431	377 (87.7)	276 (64.0)	42 (9.7)	256 (59.4)	286 (66.4)
p-value		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Services						
Surgery	111	101 (91.8)	88 (79.3)	8 (7.2)	73 (65.8)	78 (70.3)
Medical imaging	17	13 (76.5)	5 (29.4)	2 (11.8)	5 (29.4)	7 (41.2)
Laboratory/blood bank	48	48 (100.0)	20 (41.7)	6 (12.5)	26 (54.2)	35 (72.9)
Medicine	203	167 (82.3)	122 (60.1)	21 (10.3)	118 (58.1)	125 (61.6)
Emergency	44	41 (93,2)	33 (75.0)	4 (9.1)	30 (68.2)	33 (75.0)
Vaccination	8	7 (87.5)	8 (100.0)	1 (12.5)	4 (50.0)	8 (100.0)
Total	431	377 (87.7)	276 (64.0)	42 (9.7)	256 (59.4)	286 (66.4)
p-value		0.0041	<0.0001	0.9154	0.0602	0.0149
Category of agents						
Service Agent	42	25 (59.5)	19 (45.2)	8 (19.0)	13 (31.0)	13 (31.0)
Caregiver	136	127 (93.4)	90 (66.2)	17 (12.5)	85 (62.5)	92 (67.6)
IDE/nurse	132	121 (91.7)	96 (72.7)	9 (6.8)	86 (65.2)	94 (71.2)
General doctor	25	18 (72.0)	13 (52.0)	4 (16.0)	10 (40.0)	13 (52.0)
specialist doctor	16	14 (87.5)	9 (56.2)	0 (0.0)	8 (50.0)	10 (62.5)
Midwife	36	33 (94.3)	30 (83.3)	2 (5.6)	27 (75.0)	31 (86.1)

Compliance with color coding for packaging						
	Total (N)	**Systematic sorting**	**Waste sharps/ pointy**	**Anatomical waste**	**Non-anatomical infectious waste**	**General wastes**
Hygiene technician	13	10 (76.9)	9 (69.2)	0 (0.0)	10 (76.9)	12 (92.3)
labo technician	24	23 (95.8)	8 (33.3)	1 (4.2)	14 (58.3)	16 (71.4)
radio technician	7	3 (8.7)	2 (28.6)	1 (14.3)	3 (42.9)	5 (71.4)
Total	431	377 (87.7)	276 (64.0)	42 (9.7)	256 (59.4)	286 (66.4)
p-value		<0.0001	<0.0001	0.1276	0.0007	<0.0001

According to the surveys, the separation of infectious waste from general waste was systematic in 87.7 %. The percentage of separation was higher at the CHD-MC (93.5 %) and at the HZ-OKT (92.0 %). The lowest percentages were found at the Cotonou1-4 Health Centre (81.0 %) and at the HIA-CHU (75.0 %). Compared to the service, systematic sorting was more common in laboratories/blood banks (100.0 %), emergencies (93.2%) compared to medical imaging (76.5 %) or medicine (82.3 %). Observation data revealed that sorting was not systematically done in the services (Pediatrics CHD-MC), CHU-MEL (pediatrics and delivery room), or with mixtures (Intensive Care, Hospitalization of CHD-MC, HIA-CHU, CS Cotonou1-4, HLC of Zinvié). Laboratory technicians (95.8 %) or orderlies (93.4 %) responded more positively to systematic sorting than general practitioners (72 %). However, cleaning staff acknowledged that sorting is not systematic (59.5 %).

For the packaging of sharps waste, 64 % of the workers respected the use of safety boxes. A lower proportion of agents at HIA-CHU (43.8 %) respected the use of BS. Compared to the service, only 29.4 % of agents in the medical imaging service versus all agents in the vaccination services used safety boxes for sharps waste. The correct coding of anatomical waste was known by only 10 % of agents. There was a significant variation in this proportion by health facility ($p<0.0001$), but not by department ($p=0.9154$) or socio-professional category ($p=0.1276$).

In addition, the correct container for non-atomic infectious waste (yellow containers) was known by 59 % of the agents. This proportion was lower at the HIA-CHU (34.3 %) than at the CHU-MEL (74 %) on the one hand, and lower in the medical imaging (29.4 %) or vaccination (50 %) departments than in the emergency (68.2%) or surgery (65.8 %) departments.

The packaging of general waste in black containers was practiced by 66.4 % of the agents. At HZ OKT, 82 % of the agents complied with this coding compared to 45.7 % of the agents at HIA-CHU. There was a significant difference between hospitals and departments in compliance with correct general waste coding. It should be noted that none of the agents had a good practice of sorting and packaging according to colors considering all the different types of biomedical waste (Table 4).

Figure 1 SBMW sorting and packaging: non sorted waste and biomedical waste in dustbins and black containers

3.6. Compliance with sorting and packaging of other types of hazardous waste

Chemicals, pharmaceuticals, and radioactive waste must be separated from biomedical waste. Eight (08) agents out of 431 complied with this practice, i.e. 2 % of the sample. There was no significant difference in compliance with this practice according to health facility (p=0.1958) or department (p=0.8995) or socio-professional category (p=0.4162) (Table 5). The observation shows that this hazardous waste is not separated from biomedical waste.

Table *5* Respect of containers and colors for the conditioning of the other dangerous waste

Respect of container and color for the packaging					
	Total (N)	**Pharmaceutical waste**	**Chemical waste**	**Radioactive waste**	**Good* practice**
Health facilities					
CHD-MC	46	2 (4.3)	1 (2.2)	0 (0.0)	0 (0.0)
CHU-MEL	155	25 (16.1)	3 (1.9)	2 (1.3)	2 (1.3)
CS Cotonou1-4	21	6 (28.6)	3 (14.3)	0 (0.0)	0 (0.0)
HLC-Zinvié	54	4 (7.4)	1 (1.9)	1 (1.9)	1 (1.9)
HIA-CHU	105	9 (8.6)	8 (7.6)	7 (6.7)	5 (4.8)
HZ-OKT	50	7 (14.0)	2 (4.0)	2 (4.0)	0 (0.0)
Total	431	53 (12.3)	18 (4.2)	12 (2.8)	8 (1.9)
p-value		0.0269	0.0405	0.091	0.1958
Services					
Surgery	111	18 (16,2)	1 (0,9)	2 (1,8)	1 (0,9)
Medical imaging	17	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Laboratory/blood bank	48	0 (0.0)	4 (8.3)	0 (0.0)	0 (0.0)
Medicine	203	22 (10.8)	11 (5.4)	8 (3.9)	5 (2.5)
Emergency	44	11 (25.0)	2 (4.5)	2 (4.5)	2 (4.5)
Vaccination	8	2 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	431	53 (12.3)	18 (4.2)	12 (2.8)	8 (1.9)
p-value		0.0020	0.2254	0.5503	0.536
Category of agents					
Service Agent	42	6 (14.3)	1 (2.4)	2 (4.8)	1 (2.4)
Caregiver	136	29 (21.3)	3 (2.2)	1 (0.7)	1 (0.7)
IDE/nurse	132	12 (9.1)	7 (5.3)	7 (5.3)	5 (3.8)
General doctor	25	0 (0.0)	1 (4.0)	0 (0.0)	0 (0.0)
specialist doctor	16	1 (6.2)	0 (0.0)	0 (0.0)	0 (0.0)
Midwife	36	4 (11.1)	1 (2.8)	0 (0.0)	0 (0.80)
Hygiene technician	13	1 (7.7)	2 (15.4)	2 (15.4)	1 (7.7)
labo technician	24	0 (0.0)	3 (12.5)	0 (0.0)	0 (0.0)
radio technician	7	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	431	53 (12.3)	18 (4.2)	12 (2.8)	8 (1.9)
p-value		0.0089	0.1753	0.035	0.4162

*Defined by good practice for all three types of waste

3.7. Level of filling of safety boxes, warehousing, storage, means of transport, recycling of biomedical waste and presence of waste around services

3.7.1. Filling Safety Boxes

The safety boxes were 3/4 full according to 252 agents (58.5 %), completely filled according to 151 agents (35.0 %) and overloaded according to 28 agents (6.5 %). The proportion of staff who fulfilled the SBs to 3/4 was lower at the HIA-CHU (43 %) compared to the Zinvié HLC (75.9 %). According to the observation, most of the safety boxes are completely filled (HLC de Zinvié, CS Cotonou1-4, CHU-MEL) or overloaded (CHD-MC, HZ-OKT, HIA).

Figure 2 Observation on the filling of safety boxes: Overloaded safety box

3.7.2. Warehousing, storage, means of transport and recycling of waste

Table 6 Level of filling of safety boxes, storage, means of transport, recycling of biomedical waste and presence of wastes in the vicinity of the services

	Total (N)	Filling the BS to 3/4	Waste around the service	Transportation of waste by recommended means*	Supervision of AS and AE	Recycling or waste recovery
Health facilities						
CHD-MC	46	25 (54.3)	2 (4.3)	6 (13.0)	12 (75.0)	1 (6.2)
CHU-MEL	155	100 (64.5)	9 (5.8)	4 (2.6)	65 (100.0)	1 (1.5)
CS Cotonou1-4	21	15 (71.4)	0 (0.0)	3 (14.3)	6 (66.7)	0 (0.0)
HLC-Zinvié	54	41 (75.9)	11 (20.4)	18 (33.3)	26 (100.0)	0 (0.0)
HIA-CHU	105	45 (42.9)	18 (17.1)	20 (19.0)	37 (90.2)	14 (34.1)
HZ-OKT	50	26 (52.0)	7 (14.0)	4 (8.0)	18 (90.0)	4 (21.1)
Total	431	252 (58.5)	47 (10.9)	55 (12.8)	164 (92.7)	20 (11.4)
p-value		0.0004	0.0024	<0.0001	0.0002	<0.0001
Services						
Surgery	111	74 (66.7)	6 (5.4)	13 (11.7)	52 (94.5)	1 (1.8)
Medical imaging	17	6 (35.3)	4 (23.5)	5 (29.4)	4 (100.0)	0 (0.0)
Laboratory/blood bank	48	26 (54.2)	5 (10.4)	6 (12.5)	11 (91.7)	2 (16.7)
Medicine	203	119 (58.6)	26 (12.8)	23 (11.3)	81 (92.0)	15 (17.2)
Emergency	44	21 (47.7)	6 (13.6)	8 (18.2)	14 (87.5)	2 (12.5)
Vaccination	8	6 (75.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)
Total	431	252 (58.5)	47 (10.9)	55 (12.8)	164 (92.7)	20 (11.4)
p-value		0.0701	0.139	0.2168	0.9183	0.1058

* Good housekeeping practice defined as transporting wastes using pedal containers, cart or wheelbarrow. BS=Safety Box, AS=Assistant Caregiver, AE=Assistant Caregiver

At the level of the structures, a storage place was not fitted out. The permanent storage places were available in all the structures but did not meet the standards. The enclosure was fenced CS Cotonou1-4, at CHU-MEL, the enclosure was fenced with easy access to users. At HIA-CHU, Zinvié's HLC, unfenced but isolated spaces were reserved for DBMS storage. At HZ-OKT, the fenced area housed the incinerator and the DBMS storage area was accessible to users. At the CHD-MC, the space reserved was screened. Not all storage locations had a water point with soap or detergent. In all the structures, the final storage places are not identified by a pictogram. Bins are emptied by EAs in 56.1 % of cases and by caregivers in 43.9 % of cases. Transport of waste from services to storage sites is done by handling according to 366 agents (84.9 %), by trolley according to 58 agents (14 %), by wheelbarrow according to 62 agents (14.4 %), by 4 agents (0.9 %) and by other means in 17 agents (3.9 %). Transport equipment is not always covered (HIA-CHU Cotonou, CS Cotonou maternity hospital1-4). Disinfection of waste transport equipment is not always done, because the places are not suitable (CHD-MC). A good practice of the means of waste transport is noted only in 13% of the agents. Waste is removed from departments on a daily or daily basis according to 377 agents (87.5 %), twice a day according to 54 agents (12.5 %). Observation shows that waste in some departments is eliminated after more than 48 hours or more depending on the quantity of waste (CS Cotonou1-4) but not in other structures (Table 6).

In some departments, there was waste on the ground such as cotton, gloves, syringes and soiled tubes. According to 11 % of the agents there was waste around the services, this more at the HLC of Zinvié (20.4%) and at HIA-CHU (17.1 %).

3.8. Wastes treatment

Solid biomedical waste is treated on site in all hospitals. General waste, however, is treated off-site. Off-site waste treatment is provided by the municipality through state structures (SGDS) or by private structures (Grand Nokoué by two hospitals, NGO Association de salubrité de Lokossa, CIS-Afrique). It should be noted that the MOEDs are still not well separated from the DBMS (CHD-MC, CS Cotonou1-4, HIA-CHU). Inadequate treatment has been observed according to the type of waste (CS Cotonou1-4, CHD-MC). All waste from health care activities is incinerated in all hospitals. The means used for incineration do not allow for complete destruction of the waste (CS-Cotonou1-2, HIA-CHU) and the remainder is buried (CS Cotonou1-4, HZ-OKT) or disposed of by the city waste services (HIA-CHU, CHD-MC, HLC de Zinvié). There were traces of solid biomedical waste that was partially incinerated at the treatment site (CS Cotonou1-4, HIA-CHU, and CHD-MC).

3.9. Training of personnel on solid biomedical waste management

Overall, 45.8% of officers were trained at least once on biomedical waste management. There was a significant difference in the proportion of staff trained between hospitals ($p<0.0001$). Only 9% of the personnel were trained at the Cotonou CS1-4 compared to 64 % at the CHU-MEL. Compared to the service ($p<0.0001$), staff in the laboratory (59.6 %) or surgery (57.7 %) departments are more trained than those in medical imaging or vaccination (25 %). Maintenance workers (19%) and general practitioners (8%) were less trained than hygiene technicians (77 %) or nurses (55.3 %). It should be noted that an annual training budget for agents on the management of solid biomedical waste is only available in the HZ-OKTs and at CHU-MEL (Table 7). It should be noted that the training strategy at the national level takes into account only maintenance agents and nursing assistants.

Table 7 Personnel training on biomedical waste management

	Total (N)	**Training of personnel on GDBM**		**p-value**
		Yes	No	
Health facilities				< 0.0001
CHD-MC	45	27 (60.0)	18 (40.0)	
CHU-MEL	154	98 (63.6)	56 (63.6)	
CS Cotonou1-4	21	2 (9.2)	19 (9.5)	
HLC-Zinvié	54	16 (29.6)	38 (29.6)	
HIA-CHU	105	33 (31.4)	72 (31.4)	
HZ-OKT	49	20 (40.8)	29 (40.8)	
Service				< 0.0001
Surgery	111	64 (57.7)	47 (42.3)	

Medical imaging	17	4 (25.0)	12 (75.0)	
Laboratory/blood bank	48	28 (59.6)	19 (40.4)	
Medicine	203	79 (38.9)	124 (61.1)	
Emergency	44	19 (44.2)	24 (55.8)	
Vaccination	8	2 (25.0)	6 (75.0)	
Category of agents				< 0.0001
Service Agent	42	8 (19.0)	34 (81.0)	
Caregiver	136	70 (52.2)	64 (47.8)	
IDE/nurse	132	73 (55.3)	59 (44.7)	
General doctor	25	2 (8.0)	23 (92.0)	
specialist doctor	16	5 (31.2)	11 (68.8)	
Midwife	36	15 (41.7)	21 (58.3)	
Hygiene technician	13	10 (76.9)	3 (23.1)	
labo technician	24	11 (45.8)	13 (54.2)	
radio technician	7	2 (33.3)	4 (66.7)	

GDBM: Biomedical waste management

3.10. Immunization status of agents surveyed in the six health facilities

Of the 431 staff surveyed, 261 mentioned being vaccinated, or 61 %. The vaccinations performed were against hepatitis (178 subjects, 41.3 %), tetanus (142 subjects, 32.9 %), and diphtheria (30 subjects, 7.0). The proportion of staff vaccinated varied significantly by health facility (p=0.015), socio-professional category (p<0.0001), but not by type of service (p=0.179). We note that 90 % of the personnel surveyed were vaccinated at the Cotonou1-4 Health Center, compared to 64% at the HZ-OKT, and 86% of the midwives were vaccinated, compared to 38% of the maintenance workers and 39% of the orderlies (Table 8).

Table 8I Immunization status of agents surveyed in the six health facilities

	Total (N)	**Vaccination n (%)**
Health facilities		
CHD-MC	46	28 (60.9)
CHU-MEL	155	84 (54.2)
CS Cotonou1-4	21	19 (90.5)
HLC-Zinvié	54	28 (51.9)
HIA-CHU	105	70 (66.7)
HZ-OKT	50	32 (64.0)
Total	431	261 (60.6)
p-value		0.015
Department		
Service Agent	111	59 (53.2)
Caregiver	17	9 (52.9)
IDE/nurse	48	34 (70.8)

	Total (N)	Vaccination n (%)
General doctor	203	125 (61.6)
specialist doctor	44	27 (61.4)
Midwife	8	7 (87.5)
Total	431	261 (60.6)
p-value		0.179
Category of agents		
Service Agent	42	16 (38.1)
Caregiver	136	53 (39.0)
IDE/nurse	132	99 (7.0)
General doctor	25	18 (72.0)
specialist doctor	16	13 (81.2)
Midwife	36	31 (86.1)
Hygiene technician	13	9 (69.2)
labo technician	24	17 (70.8)
radio technician	7	5 (71.4)
Total	431	261 (60.6)
p-value		<0.0001

3.11. Resource availability for biomedical waste management in hospitals

The containers were available according to 47.2 % of the agents in the departments and accessible according to 90% of them. Safety boxes was available and accessible to 95 % of participants. The availability of containers or BS was lower at HZ OKT (36 %) and Hôpital la Croix de Zinvié (89 %) respectively. Shortages of containers or bags were mentioned by 44 % of agents. The different reasons for the shortage of containers or bags were insufficient budget (23.70 %) and logistics (28.4 %). In more than half of the cases, the agents were not aware of the reasons for the shortage of these materials (51.5 %). The equipment available for handling personnel was gloves (98.8 %), pants (30.9 %), aprons (21.6 %), boots (25.5 %) and masks (11.5 %).

There was a difference in the availability, accessibility, and scarcity of important resources to better manage DBMs across hospitals and departments (Table 9).

For biomedical waste management, hospitals employed a total of fifty-four (54) staff, including 13 (24.1 %) management staff and 41 (75.9%) support staff. At CHU-MEL, there were 4 management staff versus 15 support staff; at HIA-CHU, there were 4 management staff versus 16 support staff; at CS Cotonou1-4, there was one management staff member and 5 support staff; at CHD-MC, there were 2 management staff versus 3 support staff; and at HLC Zinvié, there was only one staff member, who was backed up by all the support staff in the facility.

Table 9 Availability and accessibility of essential materials for solid biomedical waste management in hospitals

	Total (N)	Availability of regulatory containers	Accessibility of the containers	Shortage of containers or bags	Availability of security boxes	Accessibility of security boxes	Availability of PPE
Health facilities							
CHD-MC	46	20 (43.5)	44 (95.7)	9 (19.6)	44 (95.7)	44 (95.7)	46 (100.0)
CHU-MEL	154	63 (40.9)	144 (92.9)	82 (53.2)	148 (95.5)	142 (97.3)	144 (94.1)
CS Cotonou1-4	21	13 (61.9)	18 (85.7)	12 (57.1)	18 (90.0)	17 (80.9)	19 (95.0)
HLC-Zinvié	54	36 (66.7)	51 (94.4)	25 (46.3)	48 (88.9)	45 (93.8)	54 (100.0)
HIA-CHU	105	53 (50.5)	90 (85.7)	37 (35.2)	98 (96.1)	87 (88.8)	98 (93.3)
HZ-OKT	50	18 (36.0)	38 (79.7)	25 (52.1)	45 (93.8)	41 (97.6)	46 (95.8)
Total	430	203 (47.2)	385 (89.7)	190 (44.0)	401 (94.4)	376 (95.2	407 (94.4)
p-value		0.0077	0.0255	0.0004	0.4335	0.0155	0.0428
Services							
Surgery	111	55 (50.0)	98 (89.1)	50 (45.5)	106 (96.4)	102 (98.1)	111 (100.0)
Medical imaging	17	12 (70.6)	15 (93.8)	9 (52.9)	7 (46.7)	7 (100.0)	14 (87.5)
Laboratory/blood bank	48	24 (50.0)	45 (93.8)	14 (29.2)	48 (100.0)	48 (100.0)	48 (100.0)
Medicine	203	89 (43.8)	181 (89.2)	100 (49.8)	191 (94.6)	172 (91.5)	182 (94.8)
Emergency	44	19 (43.2)	39 (88.6)	17 (38.6)	41 (97.6)	40 (97.6)	44 (100.0)
Vaccination	8	4 (50.0)	7 (87.5)	0 (0.0)	8 (100.0)	7 (100.0)	8 (100.0)
Total	431	203 (47.2)	385 (89.7)	190 (44.0)	401 (94.4)	376 (95.2)	407 (94.4)
p-value		0.3627	0.9304	0.0134	< 0.0001	0.0484	0.0089

3.12. Health and environmental risks associated with solid biomedical waste management in hospitals

Table 10 Health and environmental risks related to solid biomedical waste in hospitals

	Total (N)	Injury/ cut	Environmental risks	Health risks
Health facilities				
CHD-MC	46	9 (19.6)	43 (93.5)	44 (95.7)
CHU-MEL	155	44 (28.4)	142 (91.6)	146 (94.2)
CS Cotonou1-4	21	3 (14.3)	18 (85.7)	21 (100.0)
HLC-Zinvié	54	4 (7.4)	31 (57.4)	49 (90.7)
HIA-CHU	105	35 (33.3)	92 (87.6)	93 (88.6)
HZ-OKT	50	10 (20.0)	38 (76.0)	39 (78.0)
Total	431	105 (24.4)	364 (84.5)	392 (91.0)
p-value		0.0052	<0.0001	0.0062
Services				
Surgery	111	30 (27.0)	101 (91.0)	104 (93.7)
Medical imaging	17	1 (5.9)	12 (70.6)	13 (76.5)

Laboratory/blood bank	48	4 (8.3)	46(95.8)	47 (97.9)
Medicine	203	53 (26.1)	164 (80.8)	182 (89.7)
Emergency	44	15 (34.1)	33 (75.0)	38 (86.4)
Vaccination	8	2 (25.0)	8 (100.0)	8 (100.0))
Total	431	105 (24.4)	364 (84.5)	392 (91.0)
p-value		0.0246	0.0038	0.0619
Category of agents				
Service Agent	42	8 (19.0)	29 (69.0)	35 (83.3)
Caregiver	136	41 (30.1)	111 (81.6)	122 (89.7)
IDE/nurse	132	31 (23.5)	115 (87.1)	122 (92.4)
General doctor	25	8 (32.0)	23 (92.0)	24 (96.0)
specialist doctor	16	3 (18.0)	14 (87.5)	14 (87.5)
Midwife	36	10 (27.8)	32 (88.9)	34 (94.4)
Hygiene technician	13	3 (23.1)	12 (92.3)	12 (92.3)
labo technician	24	0 (0.0)	23 (95.8)	23 (95.8)
radio technician	7	1 (14.3)	5 (71.4)	6 (85.7)
Total	431	105 (24.4)	364 (84.5)	392 (91.0)
p-value		0.1268	0.0639	0.6402

Nearly one out of every four agents suffered an injury or cut from solid biomedical waste. These accidents were more frequently reported at the HIA-CHU (33.3 %) and the CHU-MEL (28.4 %). They were less frequent at the HLC in Zinvié (p=0.0052). Emergency room staff (34.1 %) and orderlies (30.1 %) were more affected.

Health or environmental risks related to poor management of solid biomedical waste were mentioned by 91% and 84.5% of workers respectively. The health risks most frequently mentioned by workers were the risk of injury and infection (88.5 %). The environmental risks mentioned included soil and groundwater contamination (17.7%), air pollution (39.8 %), and environmental pollution (45.1 %). Cases of accidents related to the management of solid biomedical waste are fully managed in all hospitals except Cotonou HC1-4 and Zinvié HLC (Table 10).

3.13. Knowledge of health and environmental risks

According to 73 % of agents, the outdoor air is polluted and 61.3 % are informed of the health effects of outdoor air pollution. A higher proportion of agents at the HIA-CHU (67.6 %), in the vaccination services (87.5 %) or hygiene technician (92.3 %) had mentioned more the effects on the health of outdoor air pollution.

In addition, 84 % of the agents recognized that incineration is a risk factor for the environment and the health of the surrounding populations. The agents of the HIA-CHU (76 %), or the HZ-OKT (82 %), of the surgical services (82 %) were not aware of the impacts of the incineration of waste. To limit the health and environmental risks of poor management of hazardous waste, it is necessary to ensure the implementation of a system for compliance with good practices (32.0 %), awareness of the risks associated with healthcare waste and practices (9.5 %) and the choice of safe and environmentally friendly solutions (20.2 %) (Table 11).

It should be noted that the majority of officers (92 %) are sensitive to environmental issues. For better management of hazardous materials, agents wanted action on bottlenecks such as lack of knowledge of health and environmental hazards (1.2 %), insufficient training in waste management (19.0 %), limited availability of collection equipment (16.1 %), lack of guidelines and supervision (1.6 %), shortage of trained and motivated staff to collect waste effectively (1.9 %), limited support infrastructure (16.7 %) and low awareness of the importance of sorting at the service level (1.4 %).

Table 11 Outdoor air pollution, health effect of outdoor air pollution, impact of incineration

	Total (N)	Outdoor air pollution	Health effects of air pollution	Waste incineration as a risk factor	Sensitivity to the environment
Health facilities					
CHD-MC	46	38 (82.6)	26 (56.5)	44 (95.7)	46 (100.0)
CHU-MEL	155	107 (69.0)	94 (60.6)	134 (86.5)	139 (89.7)
CS Cotonou1-4	21	14 (66.7)	9 (42.9)	20 (95.2)	21 (100.0)
HLC-Zinvié	54	39 (72.2)	33 (61.1)	44 (81.5)	46 (85.2)
HIA-CHU	105	81 (77.1)	71 (67.6)	80 (76.2)	100 (95.2)
HZ-OKT	50	37 (74.0)	31 (62.0)	41 (82.0)	45 (90.0)
Total	431	316 (73.3)	264 (61.3)	363 (84.2)	397 (92.1)
p-value		0.4420	0.3853	0.0273	0.0311
Departments					
Surgery	111	81 (73.0)	68 (61.3)	91 (82.0)	98 (88.3)
Medical imaging	17	15 (88.2)	12 (70.6)	15 (88.2)	17 (100.0)
Laboratory/blood bank	48	42 (87.5)	35 (72.9)	46 (95.8)	46 (95.8)
Medicine	203	139 (68.5)	111 (54.7)	166 (81.8)	187 (92.1)
Emergency	44	33 (75.0)	31 (70.5)	38 (86.4)	41 (93.2)
Vaccination	8	6 (75.0)	7 (87.5)	7 (87.5)	8 (100.0)
Total	431	316 (73.3)	264 (61.3)	363 (84.2)	397 (92.1)
p-value		0.0946	0.0521	0.2498	0.3737
Category of agents					
Service Agent	42	29 (69.0)	20 (47.6)	35 (83.3)	34 (81.0)
Caregiver	136	96 (70.6)	76 (55.9)	115 (84.6)	128 (94.1)
IDE/nurse	132	95 (72.0)	76 (57.6)	104 (78.8)	121 (91.7)
General doctor	25	19 (76.0)	20 (80.0)	22 (88.0)	23 (92.0)
specialist doctor	16	10 (62.5)	13 (81.2)	12 (75.0)	14 (87.5)
Midwife	36	28 (77.8)	27 (75.0)	34 (94.4)	35 (97.2)
Hygiene technician	13	9 (69.2)	12 (92.3)	12 (92.3)	12 (92.3)
labo technician	24	23 (95.8)	14 (58.3)	23 (95.8)	23 (95.8)
radio technician	7	7 (100.0)	6 (85.7)	6 (85.7)	7 (100.0)
Total	431	316 (73.3)	264 (61.3)	363 (84.2)	397 (92.1)
p-value		0.1840	0.0047	0.2526	0.2129

3.14. Legal framework for the management of solid biomedical waste in hospitals

All hospitals had a hospital waste management policy, based on Decree No. 2002-484 of November 15, 2002 on the rational management of hazardous waste in the Republic of Benin. The structures did not have a database on the management of biomedical waste. The HZ-OKT and the CHU-MEL had no difficulty in implementing this decree. The difficulties encountered by the structures mainly resulted from the provision of adequate equipment while avoiding

shortages. According to 50 % of the agents, the services had solid biomedical waste management procedures and for 40.8% there were local regulations on the management of health and environmental risks (Table 12).

Table12 Legal framework for the management of solid biomedical waste in health facilities

	Total (N)	**Existence of procedures for managing DBMs**	**Local regulations on environmental health risk management**
Health facilities			
CHD-MC	46	31 (67.4)	28 (60.9)
CHU-MEL	155	66 (42.6)	72 (46.5)
CS Cotonou1-4	21	6 (28.6)	1 (4.8)
HLC de Zinvié	54	25 (46.3)	15 (27.8)
HIA-CHU	105	54 (51.4)	41 (39.8)
HZ-OKT	50	32 (64.0)	19 (38.0)
Total	431	214 (49.7)	176 (40.8)
p-value		0.0042	0.0001
Departments			
Surgery	111	57 (51.4)	48 (43.2)
Medical imaging	17	10 (58.8)	6 (35.3)
Laboratory/blood bank	48	33 (68.8)	24 (50.0)
Medicine	203	86 (42.4)	81 (39.9)
Emergency	44	20 (45.5)	14 (31.8)
Vaccination	8	8 (100.0)	3 (37.5)
Total	431	214 (49.7)	176 (40.8)
p-value		0.0010	0.5871

DBMs: solid biomedical waste

4. Discussion

Health care waste was produced by almost all the agents surveyed (99 %) compared to non-infectious medical waste (89 %). The most common types of health care waste produced were infectious waste (91.4 %) and sharps (88.1 %). The same observation was made in the hospitals of the Sidi Bel Abbés commune in 2020, where infectious hospital waste. Similarly, at the Buruli Ulcer Screening and Treatment Center in Allada and at the Madjrè Leprosy Management Center in Benin in 2019, hazardous waste, particularly Waste from Care Activities with Infectious Risks, is the most produced [12]. The results of the study conducted in the public health facilities of El Hajeb in Morocco in 2020, also show that non-hazardous waste is the most produced (72.69 %) and only 0.56% of the waste is infectious [17]. Large health care facilities produce not only hazardous waste but also general waste such as stationery and food waste.

Systematic waste sorting was done by 7 out of 8 workers (87.7 %) however with mixtures of sharps, potentially infectious waste and domestic waste observed in some places (the departments of 03 hospitals out of the 06). This proportion of agents who mentioned doing systematic waste sorting in our study, is higher than those reported in Brazzaville hospital in Congo in 2012, or in Daloa regional hospital center in Côte d'Ivoire in 2021 where there are respectively 55.12 % and 71.1 % of agents who ensured waste sorting [18,19] The situation is more critical in most health facilities in the capital region of Ghana in 2014 where 83% of health facilities do not sort their waste [20]. In a meta-analysis of medical and healthcare waste management practices in 2021 in 78 countries including 23 in Africa, 18 in Europe, 19 in Asia, 10 in the Middle East, 2 in North America and 6 in Latin America, on average only 38.9% of medical waste is sorted [21]. In another study conducted in Benin in 2021 in the commune of Agbagnizoun, the bulk of biomedical waste is general waste (38%), followed by non-atomic infectious waste (24%), and sharp materials (5%)

[11]. In the university hospitals of Cotonou in Benin in 2021, waste sorting was not performed in 51.9% of cases [10]. In contrast to our finding, in the majority of public health facilities in the province of El Hajeb (Morocco) in 2020, waste separation is performed at source in the different departments, especially for sharps waste [17]. Effective source separation of medical waste is essential to any effective waste management strategy in any health facility.

Compliance with waste garbage can coding by waste type ranged from 2.8% for hazardous waste to 64 % for sharp waste and 66.4 % for general waste. This finding is similar to that made by other authors. A study conducted at the level of five hospitals in Dakar, Senegal, in 2012, showed that sorting of biomedical waste was inadequate in 53.5% of the services and the use of the color-coding system is effective in only 31.4 % of the services [22]. In addition, medical waste sorting and management practices in five hospitals in Ghana, also show that although contaminated sharps were segregated in brown safety boxes, compliance with color coding of other infectious waste containers was inconsistent in the health facilities [23]. In health facilities in northern Cameroon, or in the suburbs of Dakar in Senegal, the sorting of solid biomedical waste was also inadequate and the use of the color-coding system is non-existent in health facilities [24,25]. This lack of respect for coding is justified by the non-existence in some facilities of different types of garbage cans. A three-container sorting system (sharps, potentially infectious waste, and household waste) is an effective first step that is easy to implement and can significantly reduce the most important risks.

In our study, a storage area was not present in all facilities and those observed did not have a water point with soap or detergent. They were often located close to the wards. The same observation was made at the Teaching Hospital of Cocody in Côte d'Ivoire, where the authors reported that the safety boxes were stored in the infirmary (57.29%) and the storage garbage cans in various places in the department, including the patients' room and department corridors [26]. Similarly, in medical and biological laboratories in Togo, while in 67.0% of cases, the place for waste storage is available, only 18.3 % of these places meet international requirements [27]. According to Chakpa C., this poor practice of waste storage does little to promote sanitation in the health care environment and facilitates the proliferation of germs, with a consequent increase in nosocomial diseases [28]. The storage area should be easy to clean, have good lighting and ventilation, and be designed to keep out rodents, insects and birds. In addition, any biomedical waste storage area should be identified with the infectious waste pictogram and should not be located upstream from a water source.

The safety boxes are 3/4 full according to 58.5 % of the agents, but with overloads or overflowing when observed in the hospitals of CHD-MC, HIA-CHU Cotonou or CS Cotonou1-4. According to Ndiaye and al. the filling of the safety boxes did not comply with standards. The safety boxes were fully filled instead of being filled to 3/4 of their volume and the garbage cans did not have a lid [25]. Similarly, in the management of biomedical waste in health facilities in Cameroon, inadequate packaging with safety boxes filled to overflowing is noted [24]. This practice facilitates the proliferation of biomedical waste in and around the departments.

In the study, 85% of the workers reported that waste was transported from the wards to the storage areas by handling, and only 13 % of the workers used secure means of transporting the waste. The same observation was made by Tchakpa C. in all the health facilities in the municipality of Agbangnizoun in Benin, where 80% of the collection containers do not comply with the rules for transport within the health facilities. Transport is done with wheelbarrows and carts by health care workers and guards without any safety provisions [28]. In a slightly higher proportion than ours, the authors had found that manual transport of waste represents 90 % of the means of transport and the safest means such as carts, wheelbarrows and machines are less used [16]. Among health workers in two laboratories in Bangui in the Central African Republic, the transport of solid biomedical waste is totally manual [29]. However, in contrast to our study, N'Zi and al. in Côte d'Ivoire noted that the biomedical waste collected was collected by the cleaning staff and transported on carts (81.82 %) to the hospital waste storage site [26]. Optimization of the means of transport is crucial in the management of biomedical waste, because during transport many risks can occur on the route [30]. Secure means (wheelbarrows, wheeled containers, carts) should be used for transport and different for each category of waste. Internal transport of waste should be done during low activity periods. The route should be planned to avoid exposure to staff, patients and the public. Passage through clean areas (sterilization), sensitive areas (operating room, intensive care) and public areas should be minimized. Manual transport of biomedical waste puts workers at high risk for needle-stick injuries.

We found that one agent out of two had access to waste garbage cans, 44% of the agents mentioned shortages of waste garbage cans or bags, and the main equipment available to handling personnel was gloves (98.8%). According to Todédji et al. in 2021, in Cotonou hospitals, personal protective equipment (PPE) for maintenance workers was insufficient and the quantity of PPE available to the departments did not depend on the number of employees, with delays in supplying the departments sometimes resulting in stock-outs [10]. In the district hospital of Gaweye in Niamey in 2018, the note that the quality of availability and accessibility of inputs essential to the proper management of biomedical waste was

25 % with PPE of maintenance workers old and barely replaced [31]. Moreover, at the University Hospital of Cocody in Côte d'Ivoire in 2017 the material often available, consisted of safety boxes (59.22 %), black bags (95.15 %) and waterproof garbage cans (90.3 %), but generally lacking closures in 70.9 % [6]. The proportion noted in our study is also comparable to the 45.5 % availability of PPE consisting of protective rubber gloves, masks, aprons and boots found in health facilities in Cameroon in 2020 [24]. In all services, single-use PPE such as masks (gloves, caps) and multipurpose PPE (gown, boots, and apron) must be permanently available to avoid conditional management of biomedical waste.

In the study, solid biomedical waste in all hospitals is treated by incineration in situ. Off-site general waste treatment is provided by the municipality through state and NGO structures. According to Tchakpa C, more than 50% of municipalities in Benin ensure the management of their general waste in partnership with NGOs, private associations and the road network. Waste disposal is ensured by all the health structures themselves according to the technical, financial and human resources available [28]. The treatment of biomedical waste produced by health facilities undergoes incineration as a method of treatment, of which only one hospital has an incinerator in situ, for the other health facilities, they have signed an agreement with a private company specializing in incineration DASRI and biomedical waste [16]. Unlike the results of our study, at the Regional Hospital of Ngaoundéré, Adamaoua, Cameron in 2016, the waste was eliminated by incineration in a waste pit in an archaic way, by burial and for the most part, the anatomical parts are given to the sick families. [32]. Similarly, according to Barima and al, in Côte d'Ivoire, in the absence of a functional incinerator, sharp/sharp waste, pharmaceutical waste, non-sharp/non-sharp waste and household waste are burned in the open air. As for the anatomical waste, it is buried in the pits [19]. According to Chisholm JM and al, incineration is often the preferred disposal method due to the rapid reduction of up to 90% of waste, as well as the production of heat for boilers or for power generation. This method can create dangerous risks in itself, such as harmful emissions and residues [33]. Our study focused only on health facilities with incinerators, this may justify this practice for which however the management of residues remains a challenge.

In the present study, 46 % of agents were trained in the management of biomedical waste. This proportion is comparable to that of 43.2 % of private hospital staff and 44.2 % of public hospital staff trained in medical waste management at Bahir Dar city hospital in Ethiopia in 2020 [34]. On the other hand, it is low compared to those reported in Cotonou hospitals in 2021, where more than half of the staff had received training in biomedical waste management, i.e. 60.6% and the CHU-MEL and 80% at the CHUZ-SL. [10]. A higher share of 91% of the staff has undergone continuous training on the management of biomedical waste according to Mwisa and al. in 2020 [35]. However, proportions lower than ours are observed. Sawalem and al. in 2019 in Libya, found that 15% of staff involved in waste management were trained and had insufficient knowledge of potential hazards [36]. Similarly, a proportion of 9% of staff trained in the management of BMW was found at the Biyem-Assi district hospital in Yaoundé [37]. Staff training is essential to the implementation of an appropriate management system for hospital waste. All staff involved in waste management should be trained to understand the benefits of the healthcare waste management system and the responsibilities that will be involved. In the absence of continuous training or a diploma, periodic retraining is necessary for the benefit of all health workers.

The proportion of vaccinated personnel varied significantly according to the health facility ($p=0.015$), the socio-professional category ($p<0.0001$), but not according to the type of service ($p=0.179$). Of the 431 personnel surveyed, 261 mentioned being vaccinated (61 %). 41.3 % and 32.9 % of respondents were respectively vaccinated against viral hepatitis B and tetanus, high rates compared to the respective rates of 10.25 and 21.79 % reported by Mokoko and al at the Brazzaville University Hospital in 2017[38].

The health risks associated with poor management of solid biomedical waste were mentioned by 91 % of agents. This proportion is high compared to 40 or 63 % of staff in Bangui and Senegal [25,30]. Moreover, according to Agbere and al in Togo, in medical and biological laboratories the most frequently reported health problems were respiratory disorders (32.9 %), followed by gastrointestinal disorders (17.1 %) [27]. The self-administered nature of the questionnaire in the study with the list of health risks could have guided the choices of the participants.

Nearly one in four officers (24.4 %) suffered an injury or cut from HMDs. This proportion is lower than that of 40% of medical staff and 32% of collection staff who were injured while handling biomedical waste and reported in the health sectors of Sidi Bel Abbés in 2020 [16]. According to Kebede and al in Ethiopia in 2016, 34.5 % nurses reported having had a needlestick injury in the previous 12 months higher than ours [39]. On the other hand, the proportion observed is high at the frequency of needle stick injuries of 18.8 % at the Baharloo hospital in Iran in 2013 [40]. Even if the agents are victims of accidents, in the hospitals in the Congo, it is reported that 71 % of the respondents mentioned the existence of a high risk of accident during the handling of biomedical waste [41].

According to 50% of the agents, the services had procedures for managing HMD and the triangulation by the investigators during the interviews and observations shows the posters on the sorting of waste only. In the reference health structures in northern Cameroon, hospital waste management plans were present in very few health facilities (only 16.70 %) as well as protocols (25 %), among which only one health facility had displayed its protocols in the services and 66.67 % of health facilities did not have a reference document [42].

This study focused on a large number of agents involved in waste handling with the collection of data on the various actors involved in the organization of a hospital waste management system. The declarative data of the agents that could be subject to prevarication bias were coupled with non-participant observations which made it possible to reduce any information bias. Although geographically limited, this study provides an overview of solid biomedical waste management practices across the health pyramid in Benin and is an excellent advocacy tool.

5. Conclusion

The results of this work show that the management of solid biomedical waste in health facilities remains a challenge. The risks for professionals and patients persist due to a poor management system for solid biomedical waste. In the six hospitals surveyed, all different types of biomedical waste are produced. Healthcare waste was generated by almost all agents (99 %) compared to general waste (89 %). The practice of systematic sorting according to the coding type must be improved. A compliant waste storage site was not present in the structures and the final storage sites available did not comply with the standards in force. The security boxes are filled beyond 3/4 in nearly half of the agents with overflows in certain departments. The transport of waste from the services to the storage sites is done by handling by the majority of agents. The study revealed a lack of logistical means, a failure in staff training and a difficulty in waste management. Thus, it is necessary to establish a sorting system with appropriate labeling in all health establishments, to ensure the on ongoing awareness and training of medical personnel and waste managers in the sorting and packaging of waste. In view of these practices that do not comply with the recommendations, in the six health structures, it is urgent to set up an efficient and sustainable waste management system with efficient monitoring mechanisms. It also appears necessary to assess the risks related to solid biomedical waste management practices for patients and their companying persons.

Compliance with ethical standards

Acknowledgments

The research team thanks all the participants to the current study and especially the manager of health facilities.

Disclosure of conflict of interest

The authors declare no conflict of interest.

Funding

The current work has received the funding of the Chaire pol CRDI 107347 projects.

Statement of ethical approval

This study obtained the approval Comité Local d'Ethique pour la Recherche Biomédicale de l'Université de Parakou (CLERB-UP) (local ethics committee for biomedical research) in Benin, under the number N°0321/ CLERB-UP/P/SP/R/SA the 09 October 2020. The study has also been approved by the Ministry of Health through the letter N° 1342 /MS/DC/SGM/DRFMT/SA of the 10th March 2020. The participation to this study was volunteer after the explanation and the informed consent. Anonymity and confidentiality of investigated persons were respected.

Statement of informed consent

Informed Consent was obtained from all the study participants.

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