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Research article

State of the art of the management of medical and biological laboratory solid wastes in Togo

Sadikou Agbere *, Mamatchi Melila, Ameyo Dorkenoo, Mabozou Kpemissi **, Kamilou Ouro-Sama, Gnon Tanouayi, Dominique Hodabalo Solitoke, Kissao Gnandi

University of Lomé, Togo

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ABSTRACT

The biomedical analysis laboratory is a structure intended to carry out biological, immuno-serological, biochemical, hematological or other examinations of substances of human origin to provide information useful for the diagnosis, management, prevention or treatment of diseases. These laboratories produce solid and liquid biomedical waste (BMW) that constitutes a serious health problem for humans and their environment. Temain goal of this study is to assess the management of solid BMW produced by biomedical laboratories in Togo. It is a descriptive, exploratory and transverse study that took place from March 5 to July 5, 2018. Through a systematic random sampling 82 public and private biomedical analysis, laboratories were selected and submitted to a questionnaire. Direct observation and an interview were made with the managers of these laboratories to assess the state of BMW management. The assessment of BMW management of the prospected centers showed that among the 67.1% of public centers and 32.9% of private centers present in the study sample, only 26.3% present all laboratory units and together in 87.8% of cases. Males predominate in these facilities (85.3%) with an average age of 37.07 ± 7.34 years and work experience of 10.24 ± 5.81 years. While in 67.0% of the cases, the location of waste storage is available, only 18.3% of these locations meet international requirements. Incinerators were available in 72.0%. Plastic pedal/balance garbage cans were the most commonly used tools for collection in 32.9% of the facilities. Black bags are used 82.9% for collection. Waste generation is significant with 13.4% of the laboratories producing more than 8 kg/d. Gloves were available and taps in sufficient number in the laboratories. The most common health problems reported were respiratory disorders (32.9%) followed by gastrointestinal disorders (17.1%). BMW is in most cases (18.3%) disposed of in public dumps, while 72% of producers have received training on BMW management.

The problem of BMW management remains a concern in health facilities in Togo. Safe disposal of BMW is therefore necessary.

1. Introduction

Biomedical analysis laboratories are a structure intended to carry out biological, immuno-serological, biochemical, hematological or other examinations of substances of human origin to provide information useful for the diagnosis, management, prevention or treatment of diseases. These laboratories produce continuously biomedical waste (BMW) [1]. They refer to any waste generated during diagnosis (microbiology, virology and biochemistry waste) [2]. These wastes are produced by all hospitals, regardless of their size [3]. Waste from biomedical laboratories has a higher potential for infection due to infections and injuries caused by accidental needle sticks [4, 5]. There is a risk of infection to staff, patients, visitors and the general public [6, 7, 8]. Approximately 20 blood-borne diseases can be transmitted if waste is not properly managed [9]. Along with the growth of healthcare industry and the improvement of healthcare services, generation of medical waste has rapidly increased over the past few decades partly because of the wide acceptance of single-use disposable medical devices [9, 10] and during this novel coronavirus pandemic time [6, 11]. Many types of medical and hazardous waste including infected masks, gloves, and other protective equipment, along with a higher volume of non-infected items of the same nature are generated during an outbreak [6, 11]. Although medical waste

* Corresponding author.
** Corresponding author.
E-mail addresses: sadikagbere77@gmail.com (S. Agbere), mabozou@gmail.com (M. Kpemissi).

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represents a small portion of all solid waste streams in a municipality, the management of the waste is of great concern due to its potential environmental hazards and public health risks [4, 5, 12]. It contains potentially infectious and hazardous materials (e.g., human immunodeficiency virus (HIV), hepatitis viruses B and C, coronavirus (COVID-19), cytotoxic drugs, halogenated and nonhalogenated solvent and heavy metals) [1, 4, 11, 13]. Improper treatment and disposal of such waste can result in serious public health consequences arising from injury and infection and environmental contamination [4, 5, 6]. Some of the problems arising from improper management of BMW include accidental exposures to infectious materials, a growing concern over potential damage to humans by sharp instruments [9], diseases transmitted to humans by infectious agents, and contamination of the environment by the infectious and hazardous chemicals [2, 7, 14]. Therefore, it is essential that adequate protection measures are to be provided against occupational health hazards [3]. The management of biomedical waste in general and that of the medical biology laboratory in particular poses a public health problem [2, 7]. In developing countries, medical waste has not received the attention of sufficient. In many countries, hazardous and medical waste is still handled and disposed of with household waste, creating a significant health risk for municipal workers, the public and the environment [15]. In other developing countries, waste disposal options are often limited, and small-scale incinerators have been used as an interim solution. Like many developing countries, Togo needs to work to improve hospital waste management and achieve good results. Indeed, to address this problem, Togo has established several strategic plans covering the following periods: 2010–2014, 2014–2017 and 2016–2020 [16]. However, these strategic plans were focused on solid waste and are still not sufficient. In Togo, the law n° 2009–007 on the Public Health Code of the Togolese Republic in these 30 fundamental principles stipulates in its article 23 that the dumping and burial of toxic industrial, biomedical or hospital waste is prohibited [17]. This law stipulate that industrial toxic waste, BMW and other special waste must be disposed of imperatively, in accordance with the provisions of national and international texts applicable in Togo [16]. Despite these provisions, BMW management in Togo are still inadequate. The development of national policies to improve waste management in Togo is still a priority. The objective of this work, which is part of this context, is to take stock of the state of medical laboratory waste management in Togo through a survey of the different management modalities from production to the site of destruction of this waste.

2. Materials and methods

2.1. Study framework

The study was carried out in the medical biology analysis laboratories of public and private hospitals in Togo. Togo is a western African country lying between Burkina Faso in the North, Benin in the East, Ghana in the West and the Atlantic Ocean in the South. The country is divided into five administrative regions namely Savannah Region, Kara Region, Central Region, Plateaux Region, and Maritime Region. This study was conducted in all regions. The map below shows the localities surveyed in the administrative regions Figure 1.

2.2. Methods

2.2.1. Calculation of the sample size

The recent census of medical analysis laboratories in Togo has put the number of medical analysis laboratories at 355 [18]. Of this number, the sample size was calculated by the formula used by Naing, et al. [19]:

$n = t^2p(1\text{-}p)/y^2$.

With: $t = 1.96$ for a 95% confidence level; $y = 0.1$; $p = 0.5$. We have $n = 96.04$. For a total finite population $N = 355$, we have: $n' = n/(1 + ((n\text{-}1)/N)) = 75$. To compensate for refusals, resignations, and data record errors, 'n' was weighted with $t = 1/10$; $nt = 75 \times 1/10 = 7.5$, therefore, sample size $n'' = 75 + 7 = 82$. Probability sampling was thus conducted using a simple random sample of 82 of the 355 laboratories.

This is a descriptive, exploratory and cross-sectional study that took place from March 5 to July 5, 2018 in 82 official and private medical biology laboratories in all administrative regions of Togo. The project has been approved by the Commission for Bioethics and Research Ethics of Togo (agreement n^0 34/December 21, 2017) and by the Ministry of Health and Social welfare (project authorization n^0 065/2018/MSPS/CAB/SG/DGAS/DPML/CBRS).

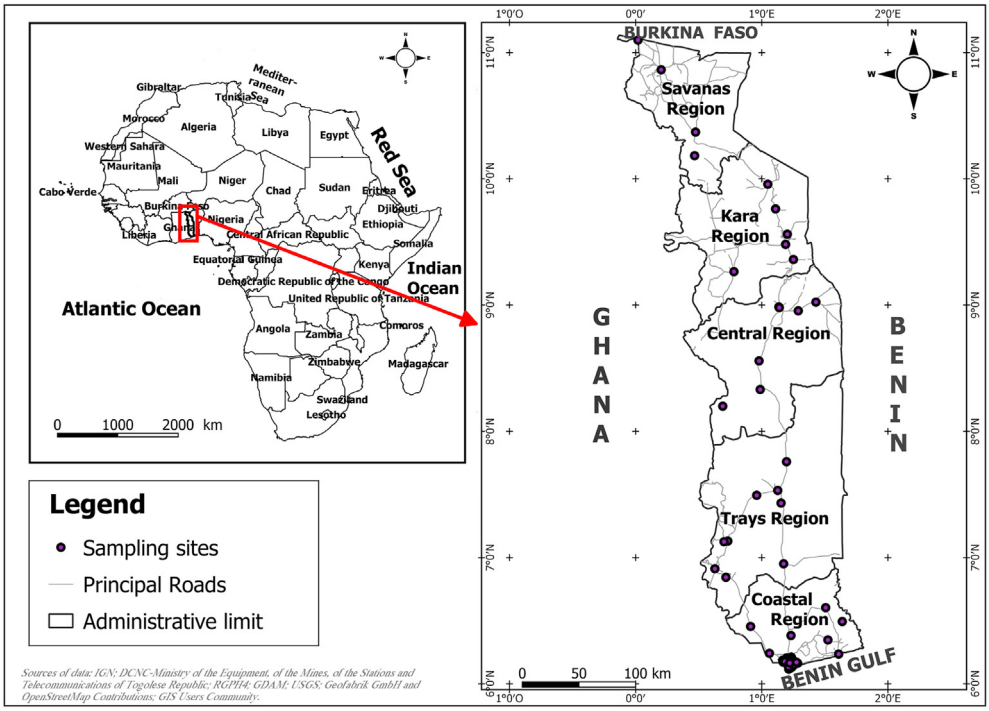

Figure 1. Map showing the localities prospected.

The survey concerned the producers of medical biology laboratory waste (biological works engineers and/or senior technicians or laboratory technicians) using an anonymous questionnaire followed by direct observation of waste management. It took place in small health centers, medium centers and large centers. For the choice of variables and questionnaires, those of the International Committee of the Red Cross was used, adapted to the reality of Togo [20].

Survey parameters were carefully selected to give meaningful information. The parameters selected were:

- ❖ type and category of the hospital (Identification of the health structure),
- ❖ person surveyed: age, professional duration, position and level of study,
- ❖ equipment used,
- ❖ daily quantity of solid waste generated from laboratories,
- ❖ packaging, storage, transportation, treatment and disposal,
- ❖ safety and consequences (infectious risks, chemical toxicity) during management,
- ❖ training on BMW management and vaccination status.

2.3. Statistical analysis of the data

GraphPad Prism 8 software (San Diego, CA, USA) was used as tools for analyzing the survey data. The significance threshold was set at 5% ($P < 0.05$).

3. Results

3.1. Identification of the health facility and of the respondent

The hospital centers in which the laboratory units are located represent 46.3%, 34.2% and 19.5% respectively for small, medium and large hospitals. The public health centers surveyed were more represented with 67.1% versus 32.9% for private centers.

All laboratory units namely bacteriology, biochemistry, hematology, immuno-serology and parasitology were present in 26.3% of the health centers while health centers with the other laboratory units except bacteriology represented 73.7%. Similarly, units such as biochemistry, hematology, immuno-serology and parasitology were present together in 87.8% of centers compared to 12.2% of centers where they are separate. Among the respondents, males predominated with 85.3% compared to females (14.7%). Figure 2 [A]. illustrates the percentages of the different age groups with an average age of 37.07 ± 7.34 years. Figure 2 [B] illustrates the variation in the length of work experience among respondents. The average length of work experience was 10.24 ± 5.81 years, while 40.2% of respondents had between 6 and 10 years of work experience. 89.1% of respondents had a university degree and only 10.9% had a high school education Figure 2 [C].

3.2. The equipment used, the waste management policy, the daily quantity, the sorting, storage, transportation and disposal of waste

The place where the waste is stored is a very important place for proper management. 67.0% of the hospitals surveyed have a place to store waste, while 33.0% do not. Only 18.3% of these storage sites meet international requirements (closed, covered, cleaned regularly, protected from animals, ventilated and lit). Non-conventional deposits representing 81.7% are found in garages, toilets or in the open air. In 72.0% of cases, the centers have at least one incinerator (Montfort, MP 100 or other) compared to 28.0% who do not.

3.2.1. Equipment

Figure 2 [E] shows the proportions of the different garbage cans used for waste collection. There are three types of garbage cans: simple, pedal and scale garbage cans. They can be characterized by their basic material: plastic, iron or stainless steel. Plastic pedal/balance garbage cans are the most used (32.9%) for waste collection in the laboratories surveyed.

3.2.2. Sorting

Sorting is done according to the type of waste (Household Waste Assimilable to Domestic Waste (HWADW) or Health Care Waste at Risk of Infection (HCWRI). Among waste generators that carry out sorting is a category of qualified persons as shown in Figure 2 [D]. The use of garbage cans for HWADW accounts for 90.7%, while the use of garbage cans for HCWRI is cited at 88.9%. This shows that waste producers try to sort their waste.

Biologists are involved in the production of BMW for only 20.7%, while biological workers engineers (BWE) predominate in this responsibility. The same percentage (20.7%) was observed for the

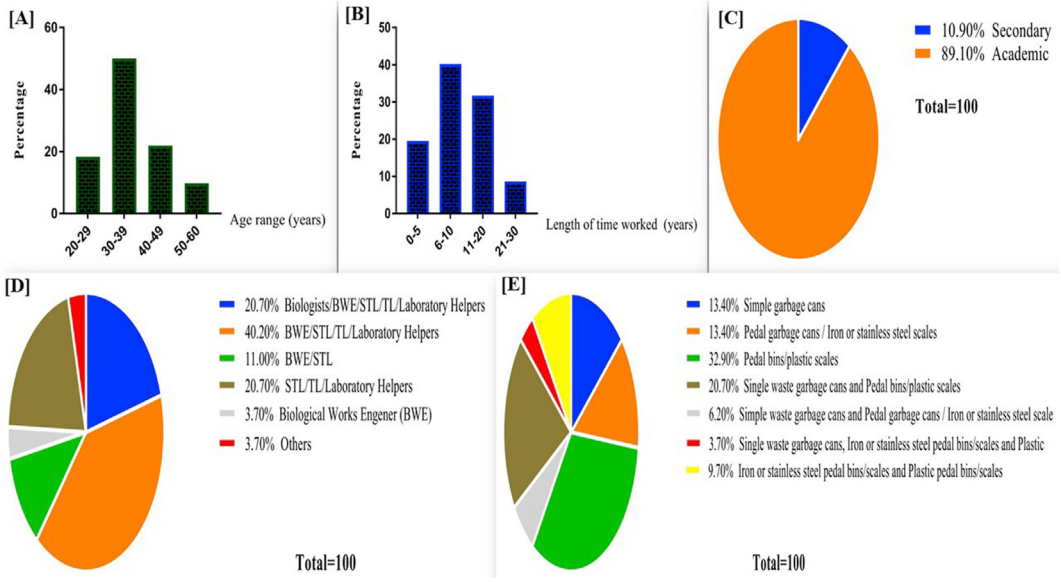

Figure 2. [A] Age proportions of respondents in laboratories, [B] Distribution of respondents' length of work experience, [C] Distribution of respondents' level of education, [D] Proportions of categories of people involved in the production of biomedical waste in laboratories, [E] Proportions of different types of equipment used for the collection of biomedical waste in laboratories.

responsibility of Senior Laboratory Technicians (SLT) assisted by Laboratory Technicians (Figure 2 [D]). The principles of quality assurance require that a waste management policy or plan be posted or established. This waste generation policy or poster covers the sorting, collection, storage and transportation of BMW to the laboratory. Only 35.4% have a waste policy or poster, while 64.6% of the laboratories do not have a poster. A total of 67.1% of the laboratories are unaware of the existence of the national legislation in force for the management of BMW in Togo. A very small percentage (20.7%) have traceability documents for BMW management and only 22.0% of laboratories have a management plan.

The budget allocated to waste management is showed on Figure 3 [A].

The identification of waste by the color of the bag or symbol represents only 13.4%. On the other hand, Figure 3 [B] illustrating the proportions of the types of bags used for waste collection indicates that the majority (82.9%) use black bags to collect their waste.

3.2.3. Storage and transport

It should be noted that 81.5% of the laboratories surveyed have a waste removal schedule, and during waste removal 45.4% exhibit odour release with run-off emission (9.3%). HWADW garbage cans are used to dispose of expired reagents in 31.7% of cases while 68.3% are used for the disposal of HCWRI.

In waste management, storage time is regulated and depends on the quantity produced. Figure 3 [C] shows the residence time of waste in storage sites. Of course, the residence time here is not a function of the quantity but rather of the availability of the waste collectors. The majority (75.6%) of waste removal is done in less than 24 h, especially in official structures, by the waste collectors.

During waste removal, gloves are the only protective material (93.3%). This means of protection is followed by the use of the hypochlorinated solution (96.3%) to disinfect the bench.

The amount of waste produced by the laboratories per day is not negligible (Figure 3 [D]). In fact, 13.4% of the laboratories produce more than 8 kg and the average production is 4.17 ± 0.29 kg.

3.3. Health, safety and consequences (infectious, chemical and toxic risks) in the management of biomedical laboratory waste

3.3.1. Hygiene

Hygiene boils down to hand washing and respect for a certain number of rules. Indeed, to wash your hands, you need the sink combined with a faucet (automatic according to the hygiene rules in quality assurance). Laboratories that have the only manual contact faucet are the most represented (42.86%). Also, 2.38% of the laboratories do not even have taps (Figure 4 [B]).

The percentage of the number of automatic taps in the laboratories was only 11.0%. While automatic soap dispensers in the laboratories represent 9.8% with a total absence of automatic towel dispensers.

3.3.2. Security

Personal safety in the laboratory involves the wearing of personal protective equipment (PPE). Indeed, this equipment consists in wearing the long gown preferably and gloves. It can evolve towards the wearing of a cap, apron, mask or bib, boots, hat and glasses. To evaluate the wearing of gloves, we estimated the quantity of gloves per month used by each laboratory (Figure 4 [A]) with an average of 4.99 ± 5.01 gloves per month of which 29.3% use more than 7 boxes per month. These are mainly public centers.

The Blood Exposure Accident (BEA), which is managed by the national algorithm, requires a strategy when a needle prick or projection and spillage of a biological liquid to carry out a certain number of tests (retroviral serology, etc.), viral hepatitis B surface antigen (HBsAg), syphilis...) on the victim and the incriminated blood (Figure 4 [C]) with 51.81% BSA tests positive for Human Immunodeficiency Virus (HIV), HBsAg and syphilis. Uncorking tubes is cited as the activity that exposes more to risk than others (32.93%) Figure 4 [D].

Personal Protective Equipment (PPE) provides safety for technicians while preventing exposure. However, this personal protective equipment is often incomplete and consists only of gown and gloves or gown, gloves and mask or bib. (Figure 5 [A]).

3.4. Method of waste disposal, training, risks and vaccination status of the producers of its waste

3.4.1. Risks incurred

Waste management exposes producers to a multitude of risks. These include respiratory (cough, cold and throat pain), gastrointestinal (nausea, vomiting and diarrhea), dermatological (skin irritation), eye and musculoskeletal disorders. Table 1 summarizes the disorders listed.

3.4.2. Method of waste disposal

Three different modes are cited, namely incineration, burning and burial (Figure 5 [B]). However, the dumping of biomedical waste in

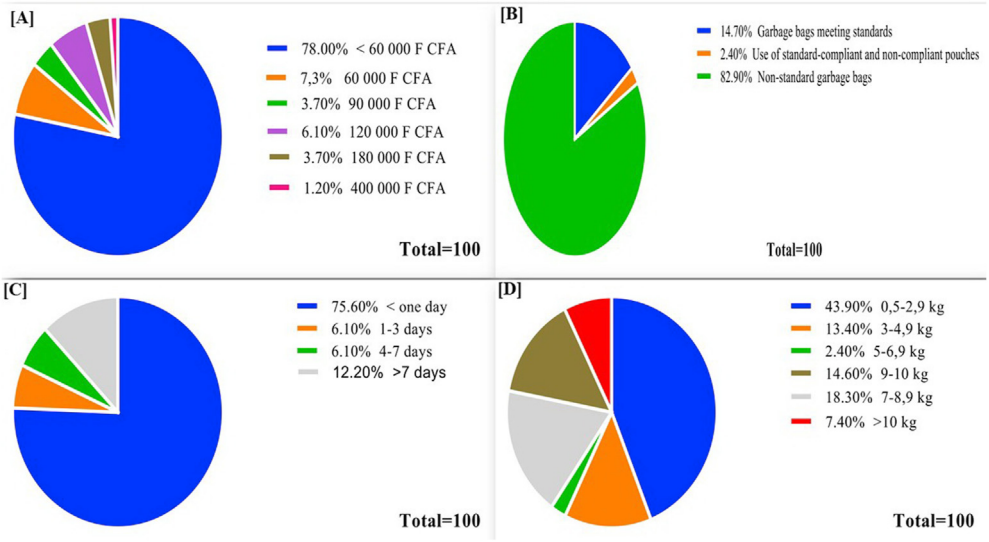

Figure 3. [A] Proportions of annual budgets allocated to biomedical waste management in health centers, [B] Proportions of the types of garbage bags meeting the standards (PVC-free, solid and adapted size), [C] Variation in the residence time of laboratory waste in storage facilities, [D] Variation in the daily mass of laboratory Biomedical Waste (LBMW).

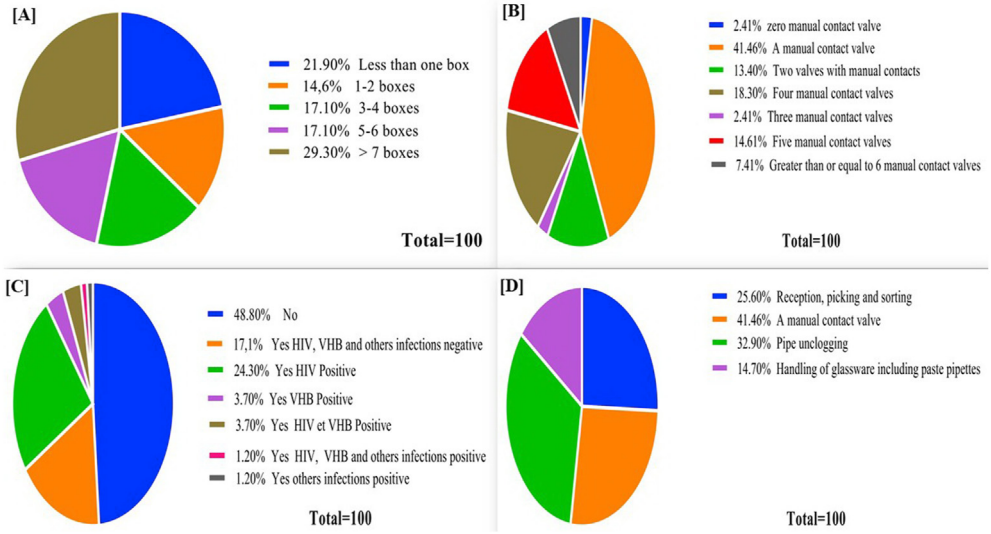

Figure 4. [A] Variation in the number of gloves used per month in each laboratory, [B] Variation in the number of manual valves available in the laboratories, [C] Proportions of Blood Exposure Accidents in the Past 12 Months in Laboratories, [D] Proportions of handling series where one is more exposed in laboratories.

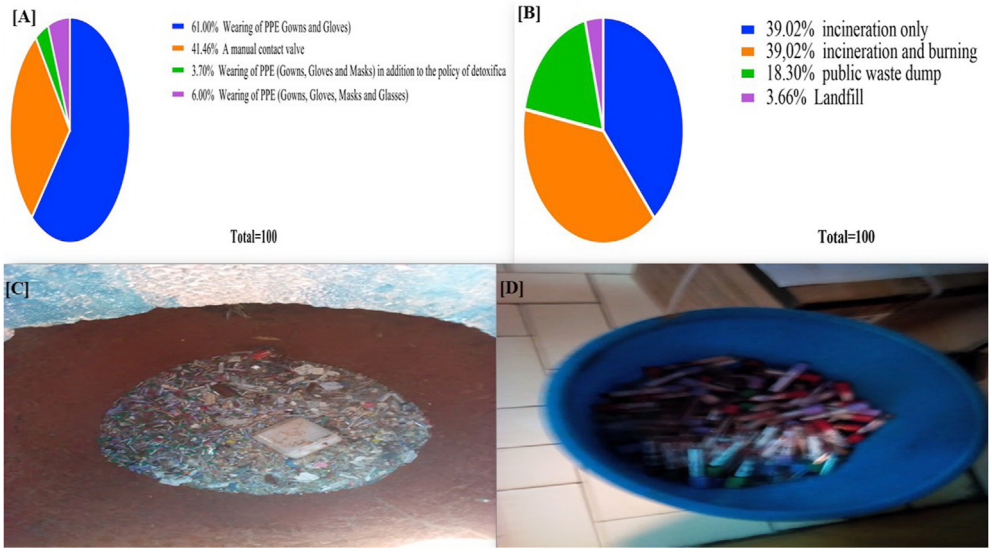

Figure 5. [A] Proportions of existence and type of personal protective equipment (PPE) to fight against biological and chemical agents, [B] Proportions of the different means used for the destruction of laboratory wastes, [C] Remains of the multitudes of laboratory waste buried in a hole, [D] Remains of the multitudes of tubes collected in a laboratory waste garbage can.

public landfills is not negligible (18.3%). Example of laboratory waste buried in a hole (Figure 5 [C]). Example of the remains of multitudes of tubes collected in a laboratory waste bin at a public waste disposal site (Figure 5 [D]).

3.4.3. *Training*

The producers of Biomedical Waste in the laboratory were trained in the principles of Biomedical Waste management by the laboratory network (72.7%).

Table 1. Frequency and existence of post-handling and post-collection disorders in biomedical laboratory waste.

Disorders	Yes	%	No	%
Respiratory	27	32,9%*	55	67,1 %
Gastrointestinal	14	17,1%	68	82,9 %
Dermatological	05	5,6%	77	94,4%
Eyepieces	02	2,4%	80	97,6%
Musculoskeletal	17	20,7%*	65	79,3%

* The most indicated disorder is respiratory disorders (32.9%), followed by musculoskeletal disorders (20.7).

3.4.4. Immunization status

Producers received no vaccine in 32.9% of cases. In contrast, 32.9% of producers were vaccinated against tetanus alone. A proportion of 29.26% received the tetanus/hepatitis A/hepatitis B vaccine and finally 2.43% were vaccinated against both tetanus/hepatitis A and tetanus/hepatitis B.

4. Discussion

The crisis brought upon by the COVID-19 pandemic has altered global waste generation dynamics and therefore has necessitated special attention [6]. Therefore, the safe handling and final disposal of this waste is a vital element of an effective emergency response [7, 21, 22]. Appropriate identification, collection, separation, storage, transportation, treatment, and disposal, as well as important associated aspects including disinfection, personnel protection, and training, become part of effective management of biomedical and health-care waste [6, 7, 12].

The identification of health structures that was the subject of the study resulted in 43.3% of small centers (social medical centers, some district hospitals and some church health centers equipped with laboratories) producing waste. It should be noted that 71.1% of the centers are public health centers versus 32.9% private centers where the existence of variability and large medical biology laboratory equipment leads to the production of very heterogeneous waste. Birpinar et al [23] obtained 15.10% of the public health centers against 71.35% of the private centers. This increase in the proportion of private centers on the one hand and the decrease of public ones on the other hand could be justified by the differentiation of health structures in developed and developing countries. Proper management of BMW requires the appropriate storage, collection, treatment and disposal techniques in order to minimize the health and environmental risks associated with medical wastes [6, 12]. Improper disposal of medical waste may pose a significant risk to human health and the environment. Some of the problems arising from poor management of medical waste may include damage to humans by sharp instruments, diseases transmitted to humans by infectious agents, and contamination of the environment by toxic and hazardous chemicals. Thus, the management of medical waste is a subject of major concern for any regulatory agency. The laboratory units (biochemistry, hematology, immuno-serology and parasitology) of these health centers are together (87.8%) and the bacteriology unit existed in only 26.3% of the laboratories surveyed. The state of the storage facilities plays an important role in waste management. It has been cited that 81.7% of the storage sites do not meet international requirements (closed, covered, cleaned regularly, protected from animals, ventilated and lit, etc.) for biomedical waste. This percentage is between those obtained by [24] in China (06.0%). The low percentage observed by the Chinese study of [24] could be explained by its quality of developed countries. The majority of centers, especially public hospitals, are equipped with an incinerator, and the most commonly used equipment for waste collection is the pedal bin/plastic scale. Sorting waste during collection is a very important phase of management. It is practiced at 90.7% for HWADW and 88.9% for HCWRI. This could be explained by the cascades of training sessions for this purpose organized by west African network of analytical laboratories (WANAL) after 2015 in Togo. Works engineers are much more represented in the production of biomedical waste as laboratory managers (54.9%) and medical biologists (20.7%) are poorly represented in these laboratories. The policy or posters on the stages of production in the laboratory only exist for 35.4% of laboratories. In 67.1% of cases, the producers of laboratory waste are not aware of national legislation on BMW management. In the medical waste generation at different health care facilities in the Hospital, 17% can be generated by laboratories [25]. The average daily amount in this study is 4.17 ± 0.29 kg. This increase in the quantity of waste in our study could be explained by the evolution of medical technology with the appearance of a multitude of devices producing surprising quantities of waste. On the other hand [26], in China obtained almost four times 19.07 kg/day the daily production of this study, this could be explained by the technical level or the population between China and Togo. During the collet, the identification of waste by its colors or symbols makes this management relevant. However, it was cited that 86.7% do not comply with this identification. In addition, the bags used for collection do not meet the standards (82.9% of black bags). It is moreover their use that disrupts the entire sorting process during collection and thus encourages the public dumping of biomedical laboratory waste in an anarchic manner. Some of them may still dispose of their waste along with municipal solid waste in the common curbside bins designated for Municipal waste [27]. Wearing incomplete personal protective equipment (PPE) (gown and gloves) is the main PPE cited. The results obtained by Joshua et al [28] in Nigeria (66.0%) are similar to those obtained in this study (61.0%). In addition, the percentage of complete PPE wear observed in this study (6.0%) is weak due to lack of eyeglass boots and caps. The collection gives off nauseating odors (45.4%), this would be the cause of respiratory disorders (32.9%) mainly rhinitis and itching of the throat and gastrointestinal disorders (17.1%) mainly diarrhea. Finally, the collection involves intense muscular activity, which is the cause of musculoskeletal disorders (20.7%), especially back pain and hip pain. The disposal of BMW emits in nature a multitude of highly volatile oxygenated compounds and toxic compounds which pose a serious problem to the environment [29, 30]. For this reason, their elimination through incinerators is desirable. The health centers surveyed have an incinerator in 72.0% of cases and these hospitals incinerate BMW in 39.0% of cases and 39.0% both incinerate and burn it. Given the long duration of degradation of plastics and glass that most laboratory waste contains, disposing of laboratory waste in public landfills as observed in 18.3% and/or burying it (3.7%) is essentially a major problem. Thus, the results of the present work indicate a need for sensitization to this effect. Blood Exposure Accidents (BEAs) are so ubiquitous as safety measures are constantly being reinforced. This study indicates 51.2% of BSE in the last 12 months. This decrease is also explained by the recent biosafety training courses organized by the WANAL. In fact, 72.7% received training on waste management and biosafety. This result is similar to that of Joshua et al [28] in Nigeria (73.0%). The percentage of hepatitis B vaccine (31.69%) in this study is low. The low percentage of tetanus could be justified by the young working age, as awareness of the risk depends on work experience.

5. Conclusion

The generation of medical waste in Togo has been increasing in quantity and variety, due to the wide acceptance of single-use disposable items such as gloves, plastic syringes, medical packages, bedding, tubing. The management of medical waste has been of major concern due to potentially high risks to human health and the environment. In recent years, increased public concerns over the improper disposal of medical waste have led to a movement to regulate the waste more systematically and stringently by the World Health Organization.

The main findings and recommendations of the study were:

- Waste minimization and recycling are still not well-promoted, which results in significant amounts of medical waste.
- The quantity of solid medical waste from the surveyed hospitals was 4.17 ± 0.29 kg/day, with an average generation rate of 2.2 ± 0.12 kg/laboratory/day.
- Some of the storage facilities in the surveyed laboratories failed to meet the requirements. There is a need for upgrading the storage facilities in the hospitals.
- The most frequently used treatment for solid medical waste was incineration; but this facility did not meet the national pollution control regulations. Improper incineration practices have been adversely reflected on the public health of the surrounding communities. There is a need for upgrading medical waste incinerators to meet the requirements.

- The study indicated a need for training programs for different levels of hospital staff from laboratories administrators to waste handlers and maintenance and incinerator operations staff. Therefore, toxic substances such as dioxin emissions at medical waste incinerators should be closely monitored to reduce potential risks to humans and the surrounding environment. Other potential treatment technologies, such as pyrolysis and microwave disinfection, should be examined as alternatives to incineration in order to better manage medical waste in Togo.

Declarations

Author contribution statement

Sadikou Agbere and Kissao Gnandi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Mamatchi Melila, Gnon Tanouayi, Dominique Hodabalo Solitoke, Kamilou Ouro-Sama and Mabozou Kpemissi: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Ameyo Dorkenoo: Conceived and designed the experiments; Analyzed and interpreted the data.

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Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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