

Original Research

The Intra-Institutional Waste Management in Montevideo Healthcare Centers

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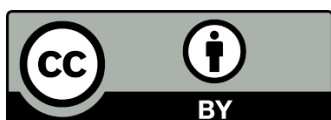
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Abstract

Healthcare Waste (HCW) management is a pressing challenge in Latin America, where insufficient regulatory enforcement, poor segregation practices, and the lack of accurate generation data hinder sustainable waste management. This study presents a methodological proposal for the internal management of HCWs in Healthcare Centers (HCCs) in Uruguay, based on Decree 586/009 and developed through a situational diagnosis conducted at the Hospital de Clínicas "Dr. Manuel Quintela." The diagnosis involved the qualitative and quantitative characterization of HCW and implementing a weighing and classification campaign. Although the original campaign was interrupted due to a COVID outbreak, a second weighing campaign was successfully carried out at a tertiary-level private healthcare facility in Montevideo. The results from both facilities revealed generation rates significantly higher than the ratios suggested by the World Health Organization (WHO), particularly in the case of contaminated healthcare waste (HCW), which accounted for 0.5 to 0.7 kg/kg of total HCW—three to four times higher than the 15% WHO recommendation. These findings underline the urgent need to improve waste segregation practices, update national regulations, and



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institutionalize systematic HCW weighing campaigns to generate reliable, context-specific data for sustainable waste management in Uruguay's healthcare sector.

Keywords

Healthcare waste; waste management; waste segregation; generation rates

1. Introduction

The primary focus of Healthcare Centers (HCCs) is patient care; therefore, their policies have traditionally been oriented towards the health and well-being of patients, often overlooking environmental concerns [1]. However, environmental protection must be incorporated among the objectives of HCC to prevent the emergence of vicious cycles of disease stemming from the improper management of HCW, which can affect not only the personnel responsible for this task but also patients, caregivers, and the general population [2].

In developing countries, there is a general trend for growth in the total quantity of HCWs [3]. In Latin America and the Caribbean, the management of HCW remains at an incipient stage, where various health determinants and educational factors negatively affect the population's health [4]. Healthcare personnel, who are in constant contact with waste, are exposed to occupational and environmental risks, potentially leading to different types of illnesses, including infectious diseases [5]. Moreover, Latin American countries still face a notable lack of environmental statistical data, and their situations are heterogeneous, both in terms of the capacity to produce statistics and the quality of the resulting information [6]. To gradually overcome this situation and move forward as a region toward the production and harmonization of environmental statistics, efforts have been made to strengthen institutions and develop national technical capacities [7]. This has been reflected in the growing interest in waste management, including the management of HCW. Such interest has facilitated institutional support for studies aimed at determining the rate of solid waste generation in HCCs and conducting situational diagnostics of waste management [8].

According to Rezzano et al. [9], by 2011, all countries borrowing from the Inter-American Development Bank had environmental legislation addressing waste management in general. However, only fifteen had specific regulations for HCWs, four had official technical standards, another four had some form of legal instrument referring to HCW management, and three lacked any legal framework related to the issue. Regarding current specific regulations linked to HCW management, the situation in Latin America and the Caribbean is characterized by heterogeneity and insufficiency. In some countries with particular regulations, enforcement is limited due to overly rigid frameworks or vague principles that fail to clearly define the responsibilities of the involved institutions, identify different waste categories, or establish handling requirements and monitoring mechanisms [10].

In 2019, Uruguay enacted [11] the first national regulation governing Integrated Waste Management. As part of its implementation process, the National Waste Management Plan was presented in November 2021. This plan identifies integrated waste management as a key issue for national sustainable development due to its environmental, social, and economic implications. It also proposes that, for waste management to be appropriately addressed, it must consider the

origin and composition of the waste. In Uruguay, the issue of healthcare waste (HCW) began to be studied in 1999 with the enactment of [12], which was repealed ten years later by Decree 586/009. This decree outlines the guidelines for the study and management of healthcare waste (HCW) in the country. According to [13], the following categories for HCWs are common (CHW) and contaminated. Contaminated healthcare waste (CHCW) should be further classified as infectious, sharp or cutting, or special waste. Common healthcare waste should be classified as either recyclable or non-recyclable.

In recent years, the generation of HCWs has increased significantly due to population growth, the rising number of healthcare facilities, and the increased use of disposable medical supplies. In this regard, [14] states that a university hospital in a high-income country can produce up to 10 kg of HCW per bed per day (including both contaminated and common healthcare waste); while an International Committee of the Red Cross (ICRC) hospital with 100 beds will generate an average of 1.5 to 3 kg of HCW per patient per day. Many developed countries implement strict guidelines regarding the segregation, storage, and transport of HCW; however, developing countries often lack the resources to manage the waste they generate [15].

High-income countries generate an average of up to 0.5 kg of contaminated healthcare waste per hospital bed per day, while low-income countries generate an average of 0.2 kg. However, in low- and middle-income countries, poor practices often lead to the mixing of contaminated and common healthcare waste (HCW), increasing the actual amount of contaminated waste and, consequently, raising management costs [16]. When reporting healthcare waste generation rates, it is important to specify whether common healthcare waste is included, as the World Health Organization (WHO) states that approximately 85% of the total waste generated by healthcare activities is non-hazardous and comparable to domestic waste. In comparison, the remaining 15% is considered hazardous and may be infectious, chemical, or radioactive [16].

Regarding healthcare waste generation rates in Latin America, [17] indicates that the average generation range is between 1.00 and 4.50 kg/bed/day, with a tendency for this rate to increase over time. This trend mirrors the progression observed in HCW generation in developed countries, although the current rates in those countries are significantly higher than those in developing nations. The leading causes of this progressive increase include the growing complexity of medical care and the rising use of disposable materials [18].

According to Rezzano et al. [19], there are few systematic studies specifically focused on determining HCW generation rates in Uruguay. As a result, the rates used have often been based on bibliographic data, for which clear information about data collection methods is usually lacking. It is worth noting that the most recent and relevant experimental studies on HCW generation in Uruguay have been conducted by the Environmental Engineering Department of the Faculty of Engineering at the University of the Republic (Udelar), at the Maternity Building of the Hospital Pereira Rossell [20] and Hospital Maciel [18]. Nevertheless, in general, data from studies conducted in other Latin American countries continue to be used as a reference.

Based on the information presented above, it can be concluded that HCW management in Latin America and the Caribbean, including Uruguay, faces significant challenges. The lack of financial and technological resources, deficiencies in waste segregation at the source, and the high costs associated with treatment and final disposal underscore the urgent need to focus efforts on conducting specific studies. These studies should analyze the current situation of HCW management,

determine and evaluate local generation rates, and produce updated, systematic research on the subject.

2. Methods

The reference regulation of these studies was [13]. The intra-institutional management system of healthcare waste (HCW) of a third-level hospital for caring for adults with acute pathologies was analyzed to design a methodological proposal for intra-institutional management of Healthcare Waste in Healthcare Centers in Uruguay.

Article 23 of Decree 586/009 establishes that each Healthcare Center (HCC) must have a Healthcare Waste Management Plan approved by the Ministry of Public Health. The preparation of the Healthcare Waste Management Plan is structured based on two general components: the internal management component and the external management component. The Healthcare Waste Management Plan should begin with the execution of the situational diagnosis of the HCC, to identify the aspects that do not comply with the regulations, and then to define proper corrective measures [21]. Once Healthcare Waste leaves HCC, from the moment it is collected by the companies providing this service, it is assumed that the internal or intra-institutional management of this waste, i.e., all the activities carried out with waste within HCC, have been adequately carried out.

This section is based on the methodology proposed in [22, 23]. The work begins with the diagnosis of the intra-institutional management situation of HCWs in the Hospital de Clínicas [17, 24]. The treatment facilities to which the Healthcare Waste will be sent depend on its management in HCC. Thus, this methodological proposal aims to define the points to be considered to generate an Intra-institutional Management System for Healthcare Waste, complying with the guidelines established in Decree 586/009 [23]. To carry out the analysis of the intra-institutional management system of Healthcare Waste generated in a HCC, [23] defines the following work stages:

1. Carrying out the diagnosis of the initial situation of intra-institutional management in the Healthcare Centers.

2. Design of the Comprehensive Healthcare Waste Management Plan.

The Hospital de Clínicas “Dr. Manuel Quintela” is the hospital of the Universidad de la Republica of Uruguay. It is a public, autonomous subsector hospital, co-governed by teaching and non-teaching officials, graduates, and students. Teaching, care, outreach, and research are carried out here for several of the programs of Universidad de la República. In total, the Hospital de Clínicas is organized into 63 departments and is staffed by 3.915 staff members, of which 1.037 are teaching staff, 2.825 are technical, administrative and general services staff, and 53 are interns. Additionally, an average of 8,500 students pass through the Hospital annually. The latest data on the number of beds at the Hospital is 342 in 2019, including intensive, intermediate, and moderate care beds for adults and 8 specialized beds for newborn care. Also, for 2019, there is data on the percentage of bed occupancy of 85%, an average stay of 12 days, 8.416 total discharges and a 4.35% Global Mortality percentage [25].

2.1 Diagnosis of the Initial Situation of Intra-Institutional Management in the Healthcare Centers (HCC)

The initial diagnosis of the initial situation is considered the "key" activity in the analysis of HCC's intra-institutional waste management system, as it allows for the identification of strengths and weaknesses within the intra-institutional waste management system, which will enable the identification of opportunities for improvement. Furthermore, it represents a significant contribution at the national level, since finding information with the necessary level of detail through background information in the form of documents or testimonies from HCC officials remain a constraint on progress. This diagnosis consists of carrying out the qualitative and quantitative characterization of the waste generated in each of the areas of the Healthcare Centers (HCC), under the provisions of Decree 586/009. Three work stages are proposed [16, 23]; what is to be done in each of the phases of the diagnosis is described in more detail below.

2.1.1 Identification of Background and Existing Documentation

Referring to managing Healthcare Waste generated in the Healthcare Centers (HCC).

2.1.2 Identification of Services Located on Each of the Floors of the HCC

To carry out this stage, it is important to have floor plans or construction plans for each of the floors of the hospital, which should be provided by the HCC architecture area.

2.1.3 Survey of Generation, Transportation, and Storage

In this stage, the location and dimensions of the waste containers, collection practices, internal transport circuits, characteristics and location of the temporary and final storage areas in the different sectors of the hospital should be surveyed in detail. Once the sources of waste generation have been identified, the quantities and types of waste generated will be estimated and immediately recorded on forms designed for this purpose (Figure 1). In addition, the typology, volume and location of waste containers at the generation sites, the intermediate storage reservoirs and the flow of contaminated and common healthcare waste (HCW), for each of the HCC sectors in the construction plans previously provided by the HCC architecture area should be referenced.



Figure 1 Guide for Protocol for surveying management of HCW.

- Type of Healthcare waste generated by the service

The different types of waste generated in all healthcare and administrative areas of the HCC should be identified. It must also be determined whether the provisions of Article 6 of Decree 586/009 are complied with, i.e., if all generators of Healthcare Waste classify it at the generation point according to what is established in Article 7 of the Decree.

- Characteristics of bags and containers

The characteristics of the containers and bags used in each HCC area should be recorded to package the HCW at the time of their generation, considering the category to which they belong.

- **Bags**

For each of the bags used to collect HCW when generated, the following issues should be controlled:

1. Color of the bag, considering the type of HCW it contains.
2. Size of the bag, considering both the type and quantity of healthcare waste (HCW) it contains, as well as the

3. Size of the container in which the bag is placed.
4. Material of the bag and its micron rating, considering the type of waste it contains.
5. Number of bags placed in each container. If more than one bag is collected per container, the color of all of them should be recorded.
6. Method of closing the bags placed in the containers, considering the type of HCW it contains.

In addition, it should be determined who the Healthcare Centers (HCC) officials are responsible for providing the bags used in each of the areas and whether the bags have any type of labeling that allows identifying the area the HCW contained in them come from, after they leave the area where they were generated.

- **Containers**

For each of the containers used in the administrative and care areas of Healthcare Centers (HCC), the characteristics regarding shape, dimensions and material from which they are made should be recorded, considering the category of the healthcare waste (HCW) their content corresponds, according to Article 7 of Decree 586/009.

It must also be determined whether the containers have a lid or not, how the lid is opened if they have one and whether they have wheels.

- **Internal collection**

The following points, related to the collection of HCW from the primary collection container to the corresponding intermediate storage, should be identified:

- **Personnel responsible for the task**

For each HCC area, the officials who oversee collecting the waste bags at these sites will be identified. It is important to clearly define whether the collection task is carried out by officials from a contracted company or by HCC officials, and in either case whether they are dedicated exclusively to carrying out tasks related to Healthcare Waste collection and transportation and cleaning the intermediate deposits and final storage, or whether they also participate in other cleaning tasks.

- **Collection frequency**

In each HCC area, the number of times during the day that the bags containing the HCW are collected should be determined, depending on the characteristics and operation of each region.

- **Closing the bags before transport**

It should be determined whether the bags containing sharps collected from the HCC areas are closed with a knot or tape. Considering the color of each bag, it should be assessed:

1. Whether the bags containing common HCW are closed with a knot,
2. Whether the bags containing infectious HCW are closed with tape, and
3. Whether the containers with contaminated HCW and sharps are covered, whether the lid is secured with adhesive tape, whether they are packaged in a red bag labeled "SHARP WASTE" and whether the bag is sealed.

- **Traceability**

It should be determined:

1. If all the bags collected are labeled,
2. If a specific labeling code is implemented that indicates the date, service and shift of generation,
3. Who is the person responsible for labeling the bags?

4. If the bags are labeled with a marker and if it is indelible, or if an adhesive label is attached to them,
5. If the bags are labeled before being placed or removed from the container.

- **Primary collection from the point of generation**

For each HCC sector, it should be determined to which intermediate storage the bags containing the collected HCW are to be transferred.

When there is intermediate storage in the current sector, it should be determined whether the bags are transferred there manually or by using carts, and whether they are carried separately, or whether the small bags are put inside a larger bag of the same color. It must also be established whether the contents of the containers are emptied into a larger bag when the collected waste bags are relatively empty, and if so, whether the original bags remain in the containers without changing or relabeling them.

If there is no intermediate storage, it should be defined whether the collected bags are placed somewhere in the sector for an official to collect them later or whether they are transferred directly to the final storage depot.

- **Intermediate storage places**

The precise location of the intermediate storage on each of the Healthcare Center's (HCC) floors should be identified. Once the existing intermediate depots have been identified, in each of them, the following points should be recorded:

- Check whether the site has a tiled floor, a tiled wall (or another smooth, washable finish), and the height up to which it is tiled.
- Determine whether the place where the depot is located is accessible to HCC patients and the public.
- Define the size and capacity of the containers placed in the waste storage, considering the type of waste they contain.
- Determine whether compaction is observed in the waste placed in the storage containers or if any element is observed in the place that could probably be used for waste compaction.
- Establish whether signposting is indicating the type of waste that should be put in each of the containers.
- Identify whether the waste bags are closed and how they were closed, that is, whether the bags containing common waste are tied and those containing contaminated waste are sealed.

- **Internal transport**

The following aspects regarding the transport of waste from the intermediate deposits to the final storage deposit of the HCC should be identified:

- The officials who carry out the transfer from the intermediate deposits located on the different floors of the HCC to the final storage site.
- If the abovementioned officials use or do not use the personal protective equipment for carrying out this task (glasses, mask, gloves, and apron).
- Characteristics and volume of the carts used for transporting waste.
- Infrastructure used within HCC for the transfer of waste; specifically, whether it is carried out by stairs, whether there are exclusive freight elevators for carrying out this task, or whether the elevators used to transport patients, other people, food, etc., are also used for waste transportation.

- Collection circuits identified in the HCC.
- Final storage deposit

All Healthcare Waste generated at Healthcare Centers (HCC), once collected from the intermediate depots or from the area where it was generated, should be transferred to the final storage at HCC. There, the different types of waste are stored until they are removed by the companies contracted for this purpose. In the diagnostic phase, it is intended to determine some characteristics of this site, for example:

- If the site is divided into isolated sectors to store the different types of healthcare waste (HCW) (contaminated, common, recyclable, etc.).
- If each of the sectors defined in the storage has lighting, tiled floors and walls, and perimeter ditches for collecting wash water.
- If the storage is securely closed (with a padlock or security lock).
- Waste generation by sector

To diagnose healthcare waste management, a weighing campaign should be implemented to determine the generation rates of common and contaminated waste in each of the primary Healthcare Centers' services. This activity will consist of the systematic weighing of garbage and its registration during the diagnosis period and should be implemented by the company's officials responsible for the cleaning.

Although this procedure is carried out to evaluate waste generation rates by sector during the diagnosis, it is highly recommended that the system of weighing waste and recording data be carried out permanently; it should be incorporated as a routine task assigned to the collectors.

This is an activity whose performance has been revealed in some HCCs of the country during the development of some of the DIA-IMFIA projects. However, data are sometimes not even processed, despite corroborating that the monthly payment to the companies responsible for the removal and transport of HCW should be done according to the monthly weight removed of waste. However, waste generation data can help detect opportunities for improvement in management, as well as being used to obtain data on the monthly weight of HCW generated in the HCC and the respective generation rates.

- **Methodology for Weighing Campaigns for Healthcare Waste**

Since the aim is to quantify the waste generated throughout the HCC, the personnel responsible for collection in each work shift should be requested to transport the waste directly to the weighing site, without mixing it with waste collected on another floor of the HCC. The same procedure should be done with standard and contaminated waste streams. Weighing should be implemented at all final storage sites of the HCC; a suitable scale should be available on each of them.

When the staff enters the final waste storage site, the carts containing the waste bags should be weighed, the corresponding records should be made, and then the carts with waste should be placed in the storage area for later removal by the transport company. The general procedure consists of weighing each of the carts that were removed from each storage site on each floor of the HCC and estimating the volume occupied by the waste bags. The person responsible for weighing must record the data obtained for each weighed cart on the corresponding registration form.

Procedure for Weighing Campaigns for Healthcare Waste. The procedure explained below was designed in 2021 to execute the Weighing and Characterization Campaigns of Sanitary Waste. This procedure is based on work experience within the framework of projects carried out by the DIA-IMFIA team [18, 20].

The personal protective equipment that should be used to conduct the weighing consists of waterproof overalls, acrylonitrile gloves with a closed cuff, goggles, face masks and foot protection.

1. On the first day of the survey, the carts and containers are characterized by determining their dimensions and empty weight (Figure 2 and Figure 3).

Carts		
Weight (kg)	40	
Volume (L)	800	
Horizontal section area (m ²)	0,78	

Figure 2 Dimensions of carts used in HCC of Montevideo.

Containers		
Weight (kg)	5	
Volume (L)	120	
Horizontal section area (m ²)	0,15	

Figure 3 Dimensions of containers used in HCC of Montevideo.

2. For each of the carts that arrive at the final storage site, the characteristics of the bags and waste disposed of are observed and recorded.

3. For each of the carts with bags of contaminated waste that arrive at the final storage sites, 5 bags will be randomly chosen (before they are placed in containers) to weigh them, perform a visual inspection, and determine if the classification in the generation service was carried out correctly. If black bags or common waste are found in red bags, the findings should be recorded photographically, and the information on the bag label should be identified.

The general procedure consists of:

- Identify the origin of the bag (if it is labeled) and then weigh it on a proper scale.
- Before opening the bag, register the characteristics of the closure, whether fluids are leaking, whether the bags are perforated or compacted, or any other characteristic that deserves to be recorded.
- Then, open the bag, taking care not to damage it, and carry out a visual inspection of its contents.
- Finally, seal the bag (if it is CONTAMINATED healthcare waste (CHCW)) or close it appropriately to be disposed of according to the established procedures.

4. During the weighing campaign, the procedure begins with the weighing of each waste cart. For this purpose, registration forms will be available.

5. The weight of waste is determined using a high-capacity portable scale. Each cart should be weighed on a platform (Figure 4), which ensures that the carts are centered on the scale and, consequently, that the indicated weight is correct.



Figure 4 Platform designed by DIA IMFIA, to be used in HCW weighing and characterization.

6. Once each cart containing bags of common waste and bags of contaminated waste have been weighed, the volume of garbage inside each container is estimated based on the height to which it has been filled, which is also noted.

7. At the end of the weighing of the carts containing bags of contaminated waste from the corresponding intermediate deposits per floor, the total number of containers used to dispose of the waste collected on each floor should be counted.

8. The procedure described above should be implemented as the collection personnel transport the carts with bags of Contaminated Waste and then the carts with bags of Common Waste from each intermediate depot to the corresponding final storage site.

9. The weighing process is planned for twelve days, to have data on the weighing of healthcare waste at the two final storage sites and during two different times of the day. The sampling methodology proposed by [19] establishes that, to have representative data, daily weighing by type of HCW should be implemented for at least seven consecutive days.

3. Results and Discussion

Using the proposed methodology, a situational diagnosis of the in-house healthcare waste management was carried out at the Hospital de Clínicas "Dr. Manuel Quintela". Based on this diagnosis, management protocols and training manuals were developed, which were used as reference materials in training sessions held at the Hospital de Clínicas.

To conduct the initial situational diagnosis of HCW management at the Hospital de Clínicas, the waste generated in different areas of the hospital was characterized both qualitatively and quantitatively. Initially, a detailed survey was conducted to determine the location of waste containers, their capacity, the type of containers and bags used in each healthcare area, collection methods and practices, internal transport circuits, and the characteristics and location of temporary and final storage sites across the institution.

This initial diagnosis of healthcare waste (HCW) management at the Hospital de Clínicas was conducted between 2018 and 2021, with the participation of students from the second semester of 2018 and the first semester of 2019 in the undergraduate course "Environmental Engineering Extension Workshop Module".

As part of the HCW management diagnosis, a weighing campaign was proposed to determine the generation rates of both general and contaminated waste on each floor of the hospital. This activity consisted of systematically weighing waste during defined periods, in collaboration with the staff responsible for waste collection [26]. Since the goal was to quantify waste generated throughout the hospital, collectors on the corresponding shifts were instructed to transport waste directly to the weighing site without mixing it with waste from other floors. This procedure is applied to both general and contaminated waste streams. Weighing took place at the hospital's two final storage sites, both equipped with appropriate weighing scales. When collectors arrived at the final waste storage site, the carts containing waste bags were weighed, records were kept, and the carts were then moved to the storage area for later pickup by the waste disposal company. The general procedure involved weighing each cart removed from each hospital floor and estimating the volume occupied by the waste bags. The weighing personnel recorded the data for each weighed cart in the corresponding data sheet.

Two weighing periods were defined for the campaign: Tuesday, September 7 to Monday, September 13, and Monday, September 13 to Monday, September 20. The plan involved weighing waste over twelve days to obtain data from both final storage sites and during two different moments of the day, as waste at the Hospital de Clínicas is removed twice daily, once in the morning (around 10 a.m.) and once in the afternoon (around 3 p.m.). Priority was given to the Hospital's West Wing storage site, where most patient care services are located. The campaign was designed to obtain, as far as possible, one data point for each collection shift in the West Wing on every day of the week; to perform weighing during both shifts in the West Wing at least once on a weekday and once on a weekend; to obtain data from both collection shifts at least once in the East Wing; and to collect both data points on the same day at least once (Sunday activities in the East Wing were not prioritized due to minimal or exceptional operations).

The waste weighing campaign began on Tuesday, September 7. However, on Friday, September 10, an outbreak of SARS-CoV-2 was reported on the 7th floor of the hospital, leading to the suspension of the campaign. In response, a revised weighing schedule was proposed in October and approved by the Hospital's Environmental Hygiene Department. Nonetheless, the campaign could not resume due to insufficient staff available for waste collection, according to hospital personnel. As a result, work focused on processing the data collected during the days when weighing and waste characterization were conducted. Additionally, the decision was made to perform a new weighing campaign at a different healthcare facility, which would enable updated national waste generation data and enable comparisons with previous campaigns, including the initial one at the Hospital de Clínicas.

After completing the necessary arrangements, the weighing of general and contaminated healthcare waste was scheduled between January 4 and January 10, 2022, following the previously established procedures. The new campaign occurred at a tertiary-level healthcare facility in Montevideo that receives patients nationwide. The facility has 211 beds and an average daily occupancy rate of 85% [27]. A private company is responsible for the collection, transportation, and final disposal of both general and contaminated healthcare waste generated at the facility.

3.1 Results - Healthcare Waste Quantification and Characterization Campaign at the Hospital de Clínicas

Seventy-five percent of the characterized bags contained Common Healthcare Waste (CHW), such as paper, cardboard boxes, plastic containers, food packaging, organic waste, and black bags with common healthcare waste, among others. One possible reason for this could be that the bags containing Contaminated Healthcare Waste (CHCW) come from hospital sectors where, due to their activities or patient care for infectious-contagious diseases, all waste should be disposed of in red bags. However, as mentioned earlier, this is a common practice throughout all the hospital's floors, and to confirm it, the information regarding the service generator and shift should be checked on each label. It was also found that 75% of the CHCW bags characterized did not contain this information.

Regarding determining the generation rates for contaminated and common healthcare waste, the plan was to obtain this information from data collected during thirteen days of daily weighing of all healthcare waste generated at the Hospital de Clínicas. This was in line with the sampling methodology proposed by [26], which establishes that to obtain representative data, daily weighing should be conducted on healthcare waste over seven consecutive days. However, it is a well-known fact that due to the complexity of conducting weighing campaigns in healthcare facilities, regional and international approaches have opted for other methods to estimate the quantities of healthcare waste generated. Examples include: applying questionnaires to collect data that could be related to the amount of waste generated (e.g., the number of red and black bags used daily) [28]; reviewing contracts with companies responsible for waste collection and transportation, which provides information about the total quantity removed from healthcare facilities by type of waste; and even weighing healthcare waste on a single day of generation [29]. Healthcare waste management planning at national, regional, or local levels should consider the [30] core principles for safe and sustainable healthcare waste management. Planning should cover the six objectives listed below: develop the legal and regulatory framework for healthcare waste management; rationalize waste management practices within healthcare facilities; develop specific financial investments and operational resources dedicated to waste management; put in place training and capacity development programs; establish a monitoring plan; reduce pollution associated with waste management.

Therefore, the data obtained from the daily weighing of healthcare waste over three consecutive days at the Hospital de Clínicas is presented below. This data should not be discarded and represents a valuable contribution at the national level regarding the production of local generation data:

- The average generation rate for Common Healthcare Waste during the monitored period was 1.8 kg/bed/day, with a minimum of 1.3 kg/bed/day and a maximum of 2.6 kg/bed/day.

- The average generation rate for Contaminated Healthcare Waste during the monitored period was 2.1 kg/bed/day, with a minimum of 1.8 kg/bed/day and a maximum of 2.8 kg/bed/day.
- The average total healthcare waste generation rate during the monitored period was 3.9 kg/bed/day, with a minimum of 3.2 kg/bed/day and a maximum of 5.4 kg/bed/day. It is remarkable that [10] reports that the average healthcare waste generation rates in Latin America range from 1.00 to 4.50 kg/bed/day. Therefore, the average generation rate for total healthcare waste at the Hospital de Clínicas during the monitored period falls within the range suggested by the most current reference literature for Latin America.
- Another interesting result is that the data on the generation rate of Common Healthcare Waste and Total Healthcare Waste from the weighing campaign show lower values than those provided by [31]. However, the values for the generation rates of Contaminated Healthcare Waste are similar (Table 1).

Table 1 Summary of Data Obtained - Hospital de Clínicas - Generation Rate.

	Weight data (kg)			Generation rate (kg/bed/day)		
	Contaminated HCW	Common HCW	Total HCW	Contaminated HCW	Common HCW	Total HCW
Average	723	625	1348	2.1	1.8	3.9
Maximum	930	900	1830	2.7	2.6	5.4

From Table 2, it can be concluded that, during the monitored period, for every kg of total healthcare waste, 0.5 kg of Contaminated Healthcare Waste was generated on average, with the highest ratio being 0.6. This ratio is significantly higher than the 0.15 ratio suggested by [16].

Table 2 Summary of Data Obtained - Hospital de Clínicas - Weight Ratios.

	Weight data (kg)			Weight Ratios	
	Contaminated HCW	Common HCW	Total HCW	Cont. HCW (kg)/ Comm. HCW (kg)	Cont. HCW (kg)/ Total HCW (kg)
Minimum	600	445	1045	1.3	0.6
Average	723	625	1348	1.2	0.5
Maximum	930	900	1830	1.0	0.5

Table 1 and Table 2 below summarize the data obtained from the weighing of Contaminated and Common Healthcare Waste generated at the Hospital de Clínicas between Tuesday, September 7, and Thursday, September 9, 2021. The generation rates of healthcare waste in kg/bed/day were calculated based on the available 342 beds for medical care at the Hospital de Clínicas.

3.2 Results - Healthcare Waste Weighing and Characterization Campaign at a Private Healthcare Center in Montevideo

Due to the impossibility of completing the weighing and characterization campaign of healthcare waste at the Hospital de Clínicas, it was decided to conduct the healthcare waste weighing at another healthcare facility. After the corresponding arrangements, it was determined that the

weighing of both Common and Contaminated healthcare waste would be conducted from January 4 to 10, 2022, at a tertiary-level healthcare facility located in the city of Montevideo.

Following the procedure developed and previously implemented during the weighing campaign at the Hospital de Clínicas, and based on the sampling methodology established by [26], which proposes daily weighing by waste type over seven consecutive days, the daily weighing of the waste generated in this facility was conducted, and the following information was obtained:

- The average generation rate of Common healthcare waste for the period surveyed was 0.8 kg/bed/day, with a minimum rate of 0.5 kg/bed/day and a maximum of 1.0 kg/bed/day. The median value was also calculated and was equal to the average generation rate, i.e., 0.8 kg/bed/day.
- The average generation rate of Contaminated healthcare waste was 1.7 kg/bed/day, with a minimum of 0.8 kg/bed/day and a maximum of 2.4 kg/bed/day. In this case, the median value obtained was 2.0 kg/bed/day.
- The average generation rate of Total healthcare waste was 2.5 kg/bed/day, with a minimum of 1.5 kg/bed/day, a maximum of 3.0 kg/bed/day, and a median value of 2.7 kg/bed/day. According to [10], the average healthcare waste generation range for Latin America is between 1.00 and 4.50 kg/bed/day. Therefore, the mean generation rate for the total healthcare waste (HCW) during the surveyed period falls within the reference range suggested in the literature.
- From Table 3, it can be concluded that, on average, for every kilogram of total healthcare waste, 0.7 kg of Contaminated healthcare waste was generated. This value matches the one obtained for the median calculation, with a minimum ratio of 0.5 and a maximum of 0.8. This ratio is significantly higher than the one proposed by [16].

Table 3 Summary of Data Obtained - Healthcare Facility Montevideo - Generation Rate.

	Weight data (kg)			Generation rate (kg/bed/day)		
	Contaminated HCW	Common HCW	Total HCW	Contaminated HCW	Common HCW	Total HCW
Minimum	175	106	281	0.8	0.5	1.3
Average	366	164	530	1.7	0.8	2.5
Median	414	167	581	2.0	0.8	2.8
Maximum	508	209	717	2.4	1.0	3.4

- Another significant result arises from comparing the values obtained from the weighing campaign with those presented in the healthcare waste Management Plan of the facility, prepared by the [20]. As shown in Table 4, the information related to the generation rates of Common healthcare waste and Total healthcare waste obtained from the weighing campaign corresponds to lower values than those provided by [27]. However, the figure for the generation rate of Contaminated healthcare waste is the same.

Table 4 Summary of Data Obtained - Healthcare Facility Montevideo - Weight Ratios.

	Weight data (kg)			Weight Ratios	
	Contaminated HCW	Common HCW	Total HCW	Cont. HCW (kg)/ Comm. HCW (kg)	Cont. HCW (kg)/ Total HCW (kg)
Minimum	175	106	281	1.7	0.6
Average	366	164	530	2.2	0.7
Median	414	167	581	2.5	0.7
Maximum	508	209	717	2.4	0.7

3.3 Final Considerations

The presentation of this methodological proposal provides Healthcare Centers in Uruguay with the possibility of working systematically in the intra-institutional management of Healthcare Waste.

The fulfillment of each of the activities proposed in this methodological proposal allows both the service personnel and the assistance personnel of the Healthcare Centers to be sure that the management of the waste is being carried out correctly. The elaboration of this methodological proposal also allows for improving the execution of those activities included in the management of Healthcare Waste, in which important deficiencies were identified, establishing in detail the steps to follow to guarantee that incorrect practices are eliminated. It also establishes procedures that are entirely new for the staff, since they refer to aspects not incorporated in the management of Healthcare Waste in the Healthcare Centers in Uruguay. However, it is essential to highlight that several good practices identified during the development of the diagnosis stage of the current situation in the management of healthcare waste within the framework of the projects carried out by the DIA - IMFIA work team of the Udelar in some HCC of Montevideo, were considered and incorporated into the methodological proposal.

Each of the stages of the design of the methodological proposal, presented in this paper, was developed taking as the primary reference and boundary condition Uruguayan Decree No. 586/009.

The classification of HCW is the first activity to be carried out once healthcare waste is generated. It is the most basic activity and, simultaneously, the most decisive for correctly carrying out the other activities included in each of the stages of HCW management in a Healthcare Center [1, 32]. Regarding the regulatory standards for the management of hospital waste, the Master Plan for Solid Waste in Montevideo and the Metropolitan Area [33], the projects carried out by the research team of DIA-IMFIA and the Master's and Doctorate Theses of the author were also considered.

It is unavoidable to establish the need for new regulations that refer specifically to the intra-institutional management of waste in the HCC of Uruguay and to promote the updating of the current rules, taking into account the results of the situation diagnoses carried out in some HCC of the city of Montevideo and certain specific situations identified, such as: the non-inclusion of management aspects of some waste such as uncontaminated sharps waste (thin glass) that could we'll be managed as recyclable waste and obtain some use from them; and the case of recyclable waste, which although they are mentioned in Decree 586/009, clear guidelines for them management are still lacking.

4. Conclusions

Based on the implementation of the work methodology proposed by the authors to conduct the diagnosis of the situation of intra-institutional management of HCW in the HCC of Uruguay, including aspects related to the design and implementation of weighing and characterization campaigns of HCW, some issues have been detected that are analyzed below:

1. During the activities to characterize the bags with contaminated HCW in the different HCC, it was found that the incorrect classification of HCW at the generation points is a recurring practice. Thus, the need to design and carry out training and capacity building for the assistance and service personnel in the HCC of Uruguay is confirmed. To this end, the authors have worked on the development of HCW management protocols (Intra-institutional management protocol for HCW - Chemical Substances; Intra-institutional management protocol for Anatomical-pathological HC); Intra-institutional management protocol for Cytostatic HCW; Intra-institutional management protocol for Common Non-Recyclable HCW; Intra-institutional management protocol for Contaminated HCW; Intra-institutional management protocol for Common Recyclable HCW; Intra-institutional management protocol for Pharmaceutical HCW; Intra-institutional management protocol for Radioactive HCW and training guides (Training Guide for Medical Staff (Figure 5) and Training Guide for General Service Staff (Figure 6)). For the preparation of these documents, the management protocols presented in the author's Master's Thesis, the Udelar Waste Management Protocols whose preparation was led by the author, the State Health Services Administration (ASSE) Comprehensive Health Waste Management Manual and the Pharmaceutical Waste Management Procedure at the Hospital de Clínicas were considered [22, 23, 34-36].

TRAINING GUIDE POR HCC MEDICAL STAFF	
01	GENERAL ASPECTS This Guide aims to outline the main aspects that should be taken into account when training the healthcare staff at the HCC on best practices related to this topic for the improved performance of their daily work. Situations arising from poor practices are not considered, as the intention is to eliminate them, nor are action guidelines for contingency cases included
HCW MANAGEMENT • Generation • Handling and segregation of waste at source • Collection • Transfer and Transport • Treatment and Final Disposal	02
03	CURRENT NATIONAL REGULATORY FRAMEWORK • Type of Waste • Risks Associated with Contaminated HCW • Classification of HCW
GENERATION AND SEGREGATION • Objectives of segregation • Colors, Bags and Containers • Symbols • Packaging and Identifications	04

Figure 5 Index of training guide for HCC Medical staff.

TRAINING GUIDE POR HCC GENERAL SERVICE STAFF	
01	GENERAL ASPECTS This Guide aims to outline the main aspects that should be taken into account when training the general service staff at the HCC and best practices related to this topic for the improved performance of their daily work
HCW MANAGEMENT • Generation • Handling and segregation of waste at source • Collection • Transfer and Transport • Treatment and Final Disposal	
02	
03	CURRENT NATIONAL REGULATORY FRAMEWORK • Type of Waste • Risks Associated with Contaminated HCW • Classification of HCW
GENERATION AND SEGREGATION • Objectives of segregation • Colors, Bags and Containers • Symbols • Distribution of Waste bags • Labeling: Waste generation sector/date and shift of bag placement • Bag Placement and Collection • Internal Transport • Intermediate Storage • Final Storage • Handling of Recyclable Common Waste	
04	

Figure 6 Index of training guide for HCC General Services staff.

2. These protocols and training guides have already been used as study and reference material in training sessions carried out by the primary author at the Hospital de Clínicas “Manuel Quintela” and at the Faculty of Veterinary Medicine, both university services of the Udelar Health Area.

3. Based on the diagnosis of the intra-institutional management situation carried out in different HCC in Uruguay, it can be stated that the surveyed practices linked to intra-institutional management prevent proposing national rates of HCW generation beyond having established certain relationships of interest.

4. The data analysis obtained during the HCW weighing campaign at Hospital de Clínicas shows that contaminated HCWs accounted for 53% of the total HCW generation in the facility during the evaluation period. Therefore, the remaining 47% corresponds to the generation of common healthcare waste (HCW). The average generation rates for the period were 1.8 kg/bed/day for common healthcare waste (HCW) and 2.1 kg/bed/day for contaminated healthcare waste (HCW). It is concluded that, on average, 0.5 kg of contaminated HCW was generated for every kilogram of total HCW during the evaluated period, a ratio more than three times higher than that proposed by [16].

5. From the analysis of the data resulting from the weighing campaign by type of HCW at the Healthcare Facility in Montevideo, it is concluded that the average generation rates for the period were 0.8 kg/bed/day for common HCW and 1.7 kg/bed/day for contaminated HCW. It was also concluded that, on average, 0.7 kg of contaminated HCW was generated for every kilogram of total

HCW during the period, a ratio that, as in Hospital de Clínicas, is significantly higher than that proposed by [16].

6. It is important to propose a national-level discussion on whether the provisions established in the current national regulation-Decree 586/009-lead to compliance in Uruguay's healthcare facilities with what is suggested by [16], which recommends that 15% of total HCW generation should correspond to contaminated HCW, and the remaining 85% to common HCW. That is, whether full compliance with this regulation guarantees achieving this percentage of contaminated HCW generation, or if these values reflect the reality of countries from other regions. To advance this discussion and considering that the classification and labeling practices for HCW bags in Uruguay's healthcare facilities are not being correctly implemented, it is necessary not only to reinforce training and capacity building of healthcare and service personnel but also to conduct annual HCW weighing and characterization campaigns. These would make it possible to gather data on contaminated and common HCW generation in the facilities, and in turn verify whether these data align with proper institutional waste management practices. This is the only way to assess whether achieving the WHO-recommended contaminated/common HCW generation ratios is realistically possible in Uruguay.

7. Based on the application of the methodological proposal presented in this work (Figure 7) and what was proposed by [37], the authors conclude that it is vital to promote a discussion at the national level regarding whether the provisions established in the current national regulations, i.e. Decree 586/009, lead to compliance in Uruguay's Healthcare Centers with what is suggested by [9], regarding that 15% of the generation of total healthcare waste might correspond to contaminated HCW and the remaining 85% to common HCW. That is, whether full compliance with this regulation guarantees achieving this percentage of generation of contaminated healthcare waste (HCW) or whether these percentages obey the realities of countries in other regions. To move forward on this approach, and taking into account that the current practices of classification of HCW and labeling of bags in the Healthcare Centers of Uruguay should be improved, defining it is possible to comply in Uruguay with the percentages of generation of contaminated HCW and common HCW suggested by [16], only could be known after intensifying training and formation of the assistance and service personnel of the relevant HCC, carrying out annual weighing and characterization campaigns of HCW to obtain weighing data of contaminated healthcare waste and common healthcare waste generated in the HCC and in turn, verifying that these data effectively correspond to correct intra-institutional management practices.

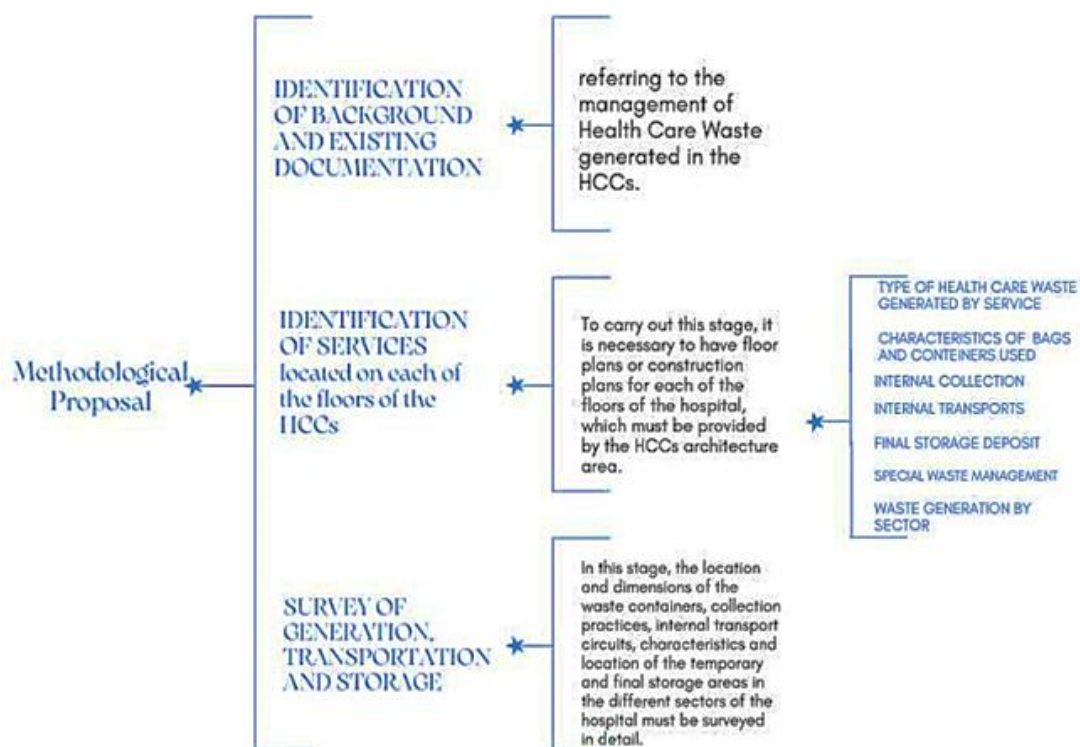


Figure 7 Methodology for the analysis of intra-institutional waste management systems in.

Abbreviation/Acronym List

DIA-IMFIA	Department of Environmental Engineering IMFIA - School of Engineering of Udelar
HCC	Healthcare Centers
HCW	Healthcare Waste
Udelar	Universidad de la República Oriental del Uruguay
WHO	World Health Organization
CHW	Common Healthcare Waste
CHCW	Contaminated Healthcare Waste

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Author Contributions

Authors contributed equally to this work.

Competing Interests

The authors have declared that no competing interests exist.

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