

HOSPITAL WASTE: CAN WE REDUCE THE ENVIRONMENTAL IMPACT OF A LARGE UNIVERSITY HOSPITAL?

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ABSTRACT

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Introduction: As technology advances, society must reflect on the destination of materials which are no longer needed. Hospital waste requires special attention due to the associated risk of disease transmission and biological accidents. Also, it tends to increase proportionally to the economic development and is associated with increased use of disposable material. The purpose of this study is to analyze the management of hospital waste at the Hospital de Clínicas de Porto Alegre (HCPA) and to evaluate the effectiveness and feasibility of the measures adopted by the institution to mitigate the impact of its waste on the environment.

Methods: Observational study with field research. Hospital waste management is divided into generation, disposal, storage and final destination.

Results: Between 2010 and 2015, the HCPA produced 21.4 tons of biological and sharps waste, 23,000 liters of chemical waste and 113,9 tons of solid waste per month. The main improvements include the implementation of a inspection of the hospital's waste bins every 2 months, a reduction from 29.42% to 2.79% in the rate of inappropriate disposal of hazardous waste, a 313% increase in investments in staff training, the expansion and adaptation of external areas for temporary storage of hospital waste and the collection of more than 1 ton of waste generated by the local community (sharps, X-ray films, kitchen oil, batteries), as well as the establishment of contracts which will guarantee the appropriate treatment of all types of health care waste.

Conclusions: These results demonstrate that mitigating the impact of hospital waste on the environment is possible and should encourage the adoption of similar measures at other institutions.

Keywords: Health care quality management; environmental management; hospital administration; medical waste

Hospitals have been responsible for a growing environmental impact due to the production of health care waste, which has increased concomitantly with the economic development. This is associated with increased health care complexity and use of disposable material¹.

A study has reported a mean waste generation of 3.26 kg/day per hospital bed, of which 17.2% is discarded as infectious waste². In Brazil, the mean is between 1.2 and 3.8 kg/day per bed³. The estimated monthly production is 20 tons of biological waste for a 700-bed hospital, which would require an investment of approximately R\$ 20,000 in adequate treatment per month⁴. In Portugal, regarding only food leftovers, a mean waste of almost 1 kg/day per bed has been found, equivalent to the emission of 1.8 kg of air pollutants⁵. In addition to the excessive waste generation, inadequate waste destination should also be noted, especially in Brazil: in 2005, it was estimated that less than 20% of solid waste was treated in the South region⁶. This practice increases the risk of disease transmission⁷ and contributes to the high rates of biological accidents at hospitals⁸.

The present study aims to review the feasibility and effects of strategies to minimize the environmental impact of health care waste implemented in a high-complexity university hospital. Thus, we seek to analyze critically the impact of large hospitals on the environment and to propose mechanisms of damage reduction that contribute to health care quality management.

METHODS

This is an observational study with field research performed at the Hospital de Clínicas de Porto Alegre (HCPA). It involved a visual inspection of the physical structure of the HCPA Environmental and Waste Management Committee, the internal and external waste storage areas, and the arrangement of waste bins at the hospital facility, associated with a review of the literature on environmental actions aiming internal and external publics. Also, a time-trend analysis of the different types of waste produced at the hospital between 2010 and 2015 was performed, as well as a review of the indicators of adequate hazardous waste disposal based on data from bimonthly inspections of the hospital's waste bins and a description of final waste destination.

RESULTS

The HCPA, opened in 1971, is one of the main health care centers in southern Brazil. In 2006⁹, the Institute of Applied Economic Research (IPEA) estimated that the hospital welcomes an average of 16,000 people daily, including staff, patients and visitors. In 2016, there were 34,400 admissions and 612,200 medical visits at this 842-bed facility. Given the high number of patients treated and the visibility resulting from this, the hospital as a public entity with great social responsibility performs actions of health knowledge dissemination, promotion of citizenship and environmental preservation¹⁰.

In terms of environmental actions, especially regarding waste management, the HCPA has shown improvements over the years: in the 1970s, there were no green areas and waste was burned in furnaces; in the 1980s, native trees started being planted and an incinerator was purchased; in the 1990s, the process of separation according to types of waste was initiated, adequate waste bins were placed in all hospital areas, and guidance was disseminated through posters and the Internet. In the 2000s, in line with an increasing world awareness of the human impact on the environment, more changes were introduced: the implementation of selective waste collection, the replacement of energy matrix and light bulbs, and the commitment to sustainable

bids, which led to the hospital being accredited by the Brazilian National Accreditation Organization and by the Joint Commission International.

Another important step was the creation of a committee dedicated to environmental and waste management, in accordance with the resolution no. 283/2001 of the Brazilian National Environment Council (CONAMA), which required that hospitals formed an Environmental Management Committee with at least one member with academic training in the field, formulated a Health Care Waste Management Plan and implemented a training program for employees performing waste-related activities. In 2010, there was an investment of approximately R\$ 700,000.00 in infrastructure and human resources in the area of environmental management. That year, a professional graduated in environmental management was hired; the construction of a new external waste storage area was approved; and there was an increase in the number of temporary storage rooms. Also, a truck was purchased to transport waste in dumpsters, which made internal collection safer. Currently, the coordinating team of the Environmental and Waste Management Committee consists of an environmental engineer and two interns, who work together with the heads of all departments to perform the proposed actions¹¹.

Generation

Between 2010 and 2015, the HCPA produced, per month, an average of 21.4 tons of biological and sharps waste (groups A and E in waste classification)¹², 23,000 liters of chemical waste (group B) and 113.9 tons of recyclable and non-recyclable solid waste (group D). The rate of daily waste generation per hospital bed is shown in Table 1. In the period, the generation of all types of waste tended to rise, consistent with the increased complexity of care. It increased by 17.32% in group D and 8.63% in groups A and E. Group B showed a substantial increase of 314.04%, from

Table 1: Mean waste generation by type of waste per bed per day between 2010 and 2015 at the HCPA.

	Mean
Groups A and E (biological and sharps waste, kg)	0.874 (0.064)*
Group B (liquid chemical waste, L)	0.793 (0.298)*
Group B (solid chemical waste, L)	0.045 (0.033)*
Group B (total, L)	0.838 (0.326)*
Group D (non-recyclable waste, kg)	3.151 (0.126)*
Group D (recyclable waste, kg)	1.340 (0.070)*
Group D (total, kg)	4.491 (0.170)*

*The values in parentheses refer to standard deviation.

less than 7,000 liters in 2010 to 28,000 liters in 2015. This elevation was more significant until 2013 due to changes in waste classification criteria, associated with the expansion of the oncology department and the emergence of new pharmacological options in chemotherapy¹³. Currently, the hospital uses a total of more than 41,000 products¹¹. Even when groups A and B are taken together, waste generation increases by 83.1%.

Approximately 30% of group D was sent to recycling, which shows commitment to selective waste collection. The ratio between the amount of waste from hazardous waste groups (groups A, B and E) and the total amount of waste (all the previous groups plus group D) was 27.41%, which is far above the 15% suggested by the World Health Organization (WHO) as hospital waste that should be plausibly treated as infectious¹⁴. This shows that a high amount of common waste has been mistakenly discarded as infectious waste at the hospital. It should be noted that, in order to calculate this ratio, 1 m³ of chemical waste was converted into 1 ton of total waste. In addition, Brazilian legislation, specifically the Resolution of the Collegiate Board of Directors (RDC) of the National Health Surveillance Agency (ANVISA) no. 216/2004¹⁵, is, in some aspects, incompatible with international classifications, limiting the validity of direct comparisons. Nonetheless, considering an average monthly generation of 44,435 kg of infectious waste, an adjustment to the proposed standards could redirect more than 24 tons to common waste, resulting in significant reduction in treatment costs and consequent financial sustainability. However, adjusting is difficult due to the great circulation of students with less professional experience and the unawareness of the correct forms of disposal by the health care team. In 2011, a qualitative study found that the HCPA's nursing teams tended to discard common waste in the white waste bins, which should be used for health care waste¹⁶.

The mean consumption of fluorescent light bulbs was approximately 941 units/month, and of A4 paper sheets was 303 sheets per active employee/month¹⁷. Food leftovers from both the cafeteria and the wards amounted to approximately 10 tons/month. However, since the estimated daily production of meals is approximately 9,000, only 37 grams per meal are discarded. Thus, it is possible to infer that a patient receiving a solid diet with five daily meals (breakfast, lunch, afternoon snack, dinner and supper) wastes an average of 185 grams/day, far less than the 953 grams/day found in a large Portuguese study⁵. This indicator, although inferred indirectly, shows that conscious food consumption is encouraged at the hospital, probably due to an

effective management of the Nutrition and Dietetics Department, which uses a computerized diet prescription system. Furthermore, harmful substances, such as mercury, askarel, glutaraldehyde and chlorine-based disinfectants, were correctly removed from the hospital facility, and awareness campaigns were launched.

Disposal

Waste containers are placed at the back of the wards in each hospital wing. Containers and transporters are properly identified according to the color coding established by the CONAMA¹⁸. Solid waste packaging bags are made of material resistant to rupture and leakage, and emptying or reusing them is not permitted. In the wards, the aim is to standardize all waste bins using models with lid and pedal in order to prevent accidents.

Narcotic drugs are discarded in rigid bottles with a light orange label and a sealing screw cap, containing a polymer solution that changes the consistency of this material and transforms it into a liquid gel that cannot be used later, as recommended by the Ordinance no. 344/1998. Chemotherapy agents, which are discarded as solid chemical waste, are first packed in sealed plastic bags, preventing leakage and contamination of the environment. Appropriate apparatus is arranged in all waste disposal areas, as shown in Figure 1. Boxes for sharps waste disposal are in accordance with the RDC/ANVISA no. 306/2004, which provides about technical regulation for health care waste management.

Currently, Brazilian legislation determines that the waste producer is responsible for correct disposal¹⁹. Since 2013, the HCPA performs visual inspections of all waste containers every 2 months and discloses data on the rate of appropriate disposal



Figure 1: Arrangement recommended for waste disposal areas at the hospital wards.

of hazardous waste. Inspected departments receive reports with their disposal rates, and heads of departments are encouraged to discuss the matter with employees. The implementation of this measure has had an immediate impact: reduction in the rate of inappropriate disposal from almost 30% to less than 3% in only 3 years, as described in Figure 2.

The hospital offers several face-to-face courses for newly hired employees. Also, since 2012²⁰, all employees are required to take a training course -- which includes correct waste disposal -- using a virtual platform that reproduces different workplaces. The purpose is to promote continuing education and to provide guidance on the improved measures included in the Health Care Waste Management Plan. Quantitatively, investments in staff training increased by more than 313% between 2010 and 2015, from R\$ 214,578.00 to R\$ 690,347.00²¹. In addition, campaigns related to the Regulatory Standard no. 32 of the Brazilian Ministry of Labor dated of November 16, 2005, and environmental awareness activities seem to have had a positive impact on these indicators²¹.

Inspections have also allowed the identification of critical hospital areas requiring immediate measures, such as face-to-face courses, and of important misconceptions. A report has shown that the higher number of occurrences of inappropriate disposal involved the sharps waste box, especially the following: disposal in nearby areas, loose objects on the workbench and failure to replace boxes when they are full.

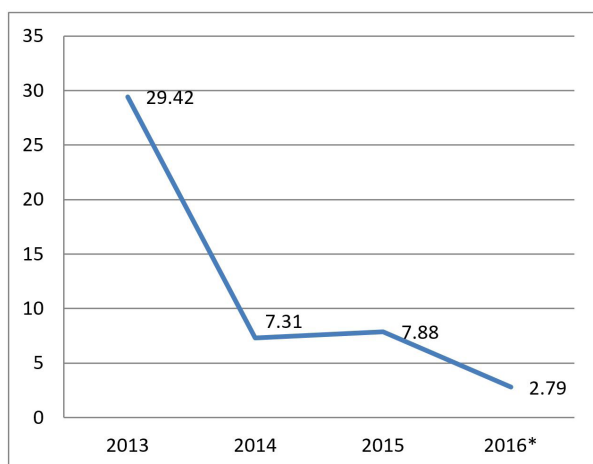


Figure 2: Evolution of the percentage of inappropriate hazardous waste disposal found in inspections performed between 2013 and 2016. *Data were obtained in HCPA's Annual Accountability Reports except for 2016, which was provided by the hospital administration. The 2016 report has not been disclosed yet.

Internal and External Storage

Each hospital ward has its own exclusive area for internal waste storage, which is managed by the sanitation team. There are also 32 rooms for temporary external storage and exclusive areas for storage of regular and hazardous liquid waste. The storage area is divided into risk groups and access is restricted to employees and companies responsible for waste transport and final destination, which reduces environmental, occupational and sanitary risks. Trucks, dumpsters and compactors are also used. In 2012²⁰, there was a large investment of approximately R\$ 1,000,000 involving construction work, equipment and vehicles.

Specific vehicles are used to transport waste from internal to external storage areas. General management and transportation of waste are expected to be made effective through an integrated effort of several departments, particularly the Nutrition and Dietetics Department, the Logistics and Safety Department, the Clothing Processing Department and the Governance and Sanitation Department.

Final Destination

The HCPA sends recyclable waste to waste pickers associations since the 1990s. With the RDC/ANVISA no. 306/2004, the hospital changed the process of separation according to the risk associated with each type of waste.

The recyclable subgroup, part of group D in waste classification, is referred to two associations, in accordance with the Decree no. 5.940/2006²². Fragmented printer paper and high-density polyethylene plastic containers used for detergents and sanitizers are sent to the Association of Workers of the Screening Unit of the São Pedro Psychiatric Hospital, combining environmental awareness with the possibility of rehabilitation and occupational therapy to psychiatric patients. All hospital wards and outpatient clinics are equipped with waste bins for disposal of "paper for fragmentation" placed at the exit of the prescription rooms in order to facilitate visualization and access. As a result of these efforts, a ton of waste is sent to the association per month, and waste treatment is converted into income to hospital users and residents of Vila São Pedro^{23,24}. All the remaining types of recyclable waste, such as plastic bags, Styrofoam, cardboard and copper wires, are referred to waste screening units. Approximately 40 tons of waste are sent to recycling per month, which accounts for 30% of total solid waste produced in the hospital. Batteries and light bulbs are recycled after decontamination.

Food leftovers from both the cafeteria and from patients and their family members are discarded as common waste and are collected by the City Hall



Figure 3: Recycling drop-off location in front of the hospital's Emergency Department.

services to be used in the Program of Organic Waste Reuse in Pig Breeding, which was created in 1992 and provides food to approximately 1,800 pigs²⁵. Biological and sharps waste, in turn, is submitted to autoclaving, a process that uses steam and water at high temperatures to destroy potential pathogens from the contaminated material, reducing environmental risks. Diesel or lubricant oil is sent to treatment by external contractors.

Community Education

The HCPA's environmental actions also seek to promote environmental awareness among the population. Thus, a recycling drop-off location was created for disposal of community-generated waste, with waste bins with standardized colors, drawings and texts appropriate for community education, as shown in figure 3. Total amount of waste collected at this location and divided by type of waste is shown in Figure 4. In addition, a collection site for expired medications was implemented at the primary health center that serves local residents through the national public health program Family Health Strategy.

DISCUSSION

The present study evaluated the feasibility and effectiveness of socio-environmental measures adopted at the HCPA. The percentage of inappropriate hazardous waste disposal showed a more than 10-fold reduction between 2013 and 2016. This figure reveals the short-term effectiveness of performing inspections of waste containers and confirms the importance of environmental awareness actions. It is possible

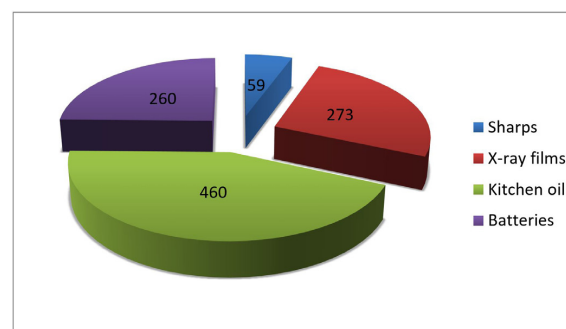


Figure 4: Total amount of waste discarded by the local community at the recycling drop-off location in 2016 (kg).

to assume that this improved indicator is related to increased investments in staff online training. Conversely, the percentage of hazardous hospital waste -- an average of 27.44% from 2010 to 2015 -- is still alarming, suggesting the need of educational measures with an impact on the hospital's financial sustainability.

The amount of all types of waste produced at the hospital increased in the study period, a common global phenomenon related to epidemiological and care issues, such as inverted population pyramid and improved care quality. For instance, studies have shown a mean health care waste generation of only 2.5 to 4 kg/bed/day in Taiwan compared to 7 to 10 kg/bed/day in the United States, suggesting that this indicator is associated with economic and technological development^{26,27}. Therefore, although a significant reduction in health care waste generation

is unlikely in our country, the present study provides a new look at the possibilities of waste management aiming to reduce environmental impact and ensure compliance with social tasks. Due to selective waste collection, approximately 30% of solid waste was referred to recycling, favoring projects designed to improve the income of poor people and provide occupational therapy to psychiatric patients. Moreover, food leftovers are separated and used in pig breeding, and the risk of hazardous waste is reduced through an adequate treatment and the appropriate arrangement of internal and external temporary storage areas.

This study has some limitations. Not only does the HCPA receive high-complexity patients but is also a university hospital, which results in the circulation of more than 16,000 people. These distinguishing factors have a significant impact on waste generation and on

the adoption of socio-environmental measures, and prevent comparisons with other Brazilian hospitals. In addition, the HCPA adopts a public-private model of financial management with multiple funding sources, which has an effect on its revenue and investment capacity.

This study reported the main strategies used in an important Brazilian hospital to reduce the environmental impact of health care waste and analyzed their effectiveness quantitatively and qualitatively. National studies on these indicators are scarce, and the successful results of waste management at HCPA show that minimizing the environmental impact of hospitals is possible. These findings suggest that the HCPA may serve as a model of waste management and that other hospitals should be encouraged to adopt environmental and care quality measures.

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