

# REVISTA AIDIS

de Ingeniería y Ciencias Ambientales:  
Investigación, desarrollo y práctica.

## ANALYSIS OF HEALTHCARE WASTE GENERATED BY DRUGSTORES IN BELO HORIZONTE, BRAZIL

Ana Teresa Rodrigues de Sousa <sup>1,4</sup>

Camila Costa Maia <sup>2</sup>

Maria Esther de Castro e Silva <sup>2</sup>

Kryscia Palhares Napoli Affonso <sup>2</sup>

Luiz Carlos Moutinho Pataca <sup>1</sup>

Max Filipe Silva Gonçalves <sup>3</sup>

Gisele Vimeiro Vidal <sup>4</sup>

\* Marcos Paulo Gomes Mol <sup>1\*</sup>

Recibido el 27 de febrero de 2023. Aceptado el 9 de enero de 2024

### Abstract

Healthcare wastes (HCW) are generated in establishments involved in human and animal healthcare activities, including pharmacies and drugstores. These activities also generate HCW, although they have been little studied in the scientific context. The present study aims to quantify and characterize the HCW generated by drugstores in Belo Horizonte, Brazil. Information contained in the Healthcare Waste Management Plans (HCWMP) was used and statistical analyzes were conducted in order to obtain the average generation by waste groups and by regions of the city. From the available data, an average global daily generation of 1218 kg/day (8140 L/day) of HCW was obtained in Belo Horizonte city, with an estimated generation per establishment of  $8.98 \pm 1.50$  kg/day ( $60 \pm 10$  L/day), ranging from 0.03 kg/day (0.21 L/day) to 39.64 kg/day (265 L/day). The study revealed that the majority of the waste is non-hazardous, accounting for 97% of the total generated (1185 kg/day; 7900 L/day), while hazardous waste constituted only 3%. Most of the hazardous waste was chemical in nature.

**Keywords:** waste management, healthcare waste, pharmacy waste, healthcare waste management plan.

<sup>1</sup> Diretoria de Pesquisa e Desenvolvimento, Fundação Ezequiel Dias. Belo Horizonte, Brasil.

<sup>2</sup> Superintendência de Limpeza Urbana (SLU), Prefeitura Municipal de Belo Horizonte, MG, Brasil.

<sup>3</sup> Mackenzie Presbyterian University, Engineering School, São Paulo, SP, Brazil.

<sup>4</sup> Centro Federal de Educação Tecnológica de Minas Gerais. Belo Horizonte, MG, Brasil.

\* *Autor correspondal:* Diretoria de Pesquisa e Desenvolvimento. Fundação Ezequiel Dias – FUNED. Rua Conde Pereira Carneiro, 80. Bairro Gameleira. Cidade Belo Horizonte. Estado Minas Gerais. Código Postal (CEP) 30510-010. Brasil. Email: [marcos.mol@funed.mg.gov.br](mailto:marcos.mol@funed.mg.gov.br)

## Resumo

Os resíduos de serviços de saúde (RSS) são gerados em estabelecimentos com atividades voltadas à saúde humana e animal, dentre esses estabelecimentos estão as farmácias e drogarias. Essas atividades também geram RSS, embora pouco estudadas no meio científico. O presente estudo tem como objetivo quantificar e caracterizar os RSS gerados por drogarias de Belo Horizonte, Brasil. Foram utilizadas informações contidas nos Planos de Gerenciamento de Resíduos de Serviços de Saúde (PGRSS) e realizadas análises estatísticas para obtenção da geração média por grupos de resíduos e por regiões da cidade. A partir dos dados disponíveis, obteve-se uma geração média global diária de 1218 kg/dia (8140 L/dia) de RSS na cidade de Belo Horizonte, com geração estimada por estabelecimento de  $8.98 \pm 1.50$  kg/dia ( $60 \pm 10$  L/dia), variando de 0.03 kg/dia (0.21 L/dia) a 38.64 kg/dia (265 L/dia). O estudo mostrou que a maior parte dos resíduos não perigosos (1185 kg/dia; 7900 L/dia), representando 97% do total gerado, e os resíduos perigosos representaram apenas 3% do total gerado, sendo a maior parte química.

**Palavras chave:** gestão de resíduos, resíduos de serviços de saúde, resíduo farmacêutico, plano de gerenciamento de resíduos de serviços de saúde.

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## Introduction

Waste generated in establishments engaged in human (WHO, 2014; Brasil, 2018) and animal healthcare (Brasil, 2018) is classified as healthcare waste (HCW) according to WHO (2014) Brasil (2018). HCW are defined and classified according to the risk they pose to human and environmental health. WHO (2014) defined hazardous HCW as biological, chemical, radioactive or sharp wastes. According to Brasil (2018) legislation, HCW are classified as: group A consisting of biological, infectious or possibly infectious wastes; group B consisting of chemical wastes; group C containing the radioactive wastes; group D consisting of waste comparable to household waste and; E group corresponding to sharp wastes. Non-hazardous waste (group D) is represented by those that do not pose additional risks to public health, while hazardous wastes are represented by the other groups (A, B, C, and E).

The proportion of hazardous HCW typically varies between 10% and 25% of the total wastes generated by a healthcare facility, as suggested by WHO (2014). Therefore, solid waste management measures aimed at separating hazardous waste from non-hazardous waste are essential in the routine of waste-generating establishments (Barbosa and Mol, 2018). However, factors such as the lack of knowledge about the associated risks, inadequate training of professionals involved in management, and the absence of good practices actions compromise the HCW management. This leads to a greater generation of unnecessary hazardous waste (Mosquera *et al.*, 2014, Chikanma *et al.*, 2021; Boricha *et al.*, 2021; Sabbahi *et al.*, 2020).

The proper HCW management is established in the Healthcare Waste Management Plans (HCWMP), a document that covers all stages of waste management, including generation, segregation, classification, packaging, storing, transporting, treatment and disposition.

The increase of hazardous waste generation in an establishment can elevate the probability of occupational risks, incur greater financial expense, and contribute to environmental impacts. This is often associated with inadequate waste disposal to selective collection, resulting in a low recovery of materials through recycling (Vieira et al., 2011; Zolnikov *et al.*, 2018). It is noted that training workers usually contribute to the decrease waste problems during the generation process, and consequently reducing hazardous waste generation (Mosquera *et al.*, 2014).

Among the establishments that generate HCW, drugstores are a less discussed typology in the scientific context, despite providing healthcare services such as adequate dosage, habits readjustment and general guidelines for treatment, among other healthcare activities (CFF, 2001). Therefore, due to the activity described in these establishments, waste generation with biological and chemical risk is expected, as well as sharps and waste comparable to domestic (WHO, 2014, ANVISA, 2006).

The aim of this work is to quantify and describe the HCW generated by drugstores in the city of Belo Horizonte, Brazil, based on the Healthcare Waste Management Plans formally submitted to the Urban Cleaning Superintendence of Belo Horizonte.

### **Metodology**

Belo Horizonte is the capital of Minas Gerais state, located in the southeastern region of Brazil, with an estimated population of 2.521 million inhabitants in 2020 (IBGE, 2022). The city is divided into nine regions, called: Center-South, Barreiro, East, West, Northwest, Northeast, North, Pampulha and Venda Nova. These regions have different characteristics depending on population density and per capita income (Belo Horizonte, 2022). Thus, data analysis took into account the region to which the establishment belongs.

The present study utilized the database of the Urban Cleaning Superintendence of Belo Horizonte (SLU), from information contained in the HCWMP of all active healthcare establishments. The dataset includes details on establishments generating HCW, such as the description of their activities, location, classification of each waste generated and quantities (Belo Horizonte, 2016). This information aligns with the current national legislation, specifically the RDC ANVISA 222/2018 (Brasil, 2010; Brasil, 2018).

The selected plans were those from drugstores that had “implemented”, “approved” or “approved with conditions” status. A total of 134 HCWMP from drugstores were evaluated. Of these, only five had data about subgroup A1 waste (a type of biological waste, group A, according to RDC ANVISA 222/2018), and due to this low representation, were discarded. The other classification groups contained the following amounts of data: subgroup A4 (biological with reduced risks): 97 records; group A total (all biological wastes): 99 records; group B total

(chemicals wastes): 133 records; total common waste, group D (similar to domestic waste): 134 records; total recyclable waste, group D: 56 records; group E total (sharps or similar waste): 101 records. There were 134 data points for both hazardous and non-hazardous waste. Aiming for the standardization of data, the units were converted from L/day to kg/day following the approach used by Neves *et al.* (2022). The density values adopted were 100 kg/m<sup>3</sup> for groups A and B; 150 kg/m<sup>3</sup> for group D; and 200 kg/m<sup>3</sup> for group E (Neves *et al.*, 2022).

Statistical analyzes were performed using the R software version 4.2.1 (R Core Team, 2022). The averages of total waste generation in the municipality and per regions were obtained, along with the averages of HCW per classified group. Quartiles (first, median, third) and data variability estimators (absolute deviation from the median - MAD and standard deviation - SD) were also determined. Statistics by region were performed using bootstrap with 1000 replicates, using the contributed R package “boot” (Canty and Ripley, 2021). To compare the generation rates of hazardous HCW between the regions of the city, Kruskal-Wallis tests with post hoc analysis using Nemenyi were conducted (non parametric data - p-value <0.05 in Shapiro Wilk test).

### Results and discussion

The generation of HCW in Belo Horizonte totaled 4.8 thousand tons in 2015. This amount represents 0.3% of the total municipal solid waste (MSW) generated in 2015 in the city (Belo Horizonte, 2016). According to Abrelpe (2020), the expected proportion of HCW related with USW in Brazil is 0.32%, similar to data found in the Belo Horizonte city. The generation of pharmaceutical waste in Belo Horizonte, as indicated by this study, amounts to approximately 441.65 tons per year, constituting 9.2% of the total 4.8 thousand tons generated in 2015.

The HCW from drugstores in Belo Horizonte has an average generation of 1217 kg/day (8140 L/day). Of this total, 1185 kg/day (7900 L/day) were non-hazardous waste, representing 97% of the total, and 30 kg/day (240 L/day) were waste classified as hazardous, corresponding to 3% of the total HCW generated. The percentage of non-hazardous waste is below the reference range listed by WHO (2014) and ANVISA (2006), which indicates a range of 75 to 90%. This deviation is likely attributed to the nature of drugstore activities, which involve few direct interventions in patients. All 134 HCWMP evaluated in this study predicted the generation of hazardous and non-hazardous waste, as seen in Tables 1 and 2, and Fig. 1 and 2.

It was also observed that hazardous waste falls below the range described by the references. This lower percentage of hazardous waste is likely attributed to the limited healthcare interventions provided by drugstores to patients. His justification aligns with the observed pattern of lower hazardous waste generation when compared to more complex establishments like hospitals, which typically exhibit higher values of hazardous waste generation (Mol *et al.*, 2022).

**Table 1.** Descriptive statistics of the generation of waste in drugstores according to the HCW type, in the city of Belo Horizonte. Values in kg/day

| Waste group         | N   | Mean  | SD   | Median | MAD  | Min  | Max   | IQR   |
|---------------------|-----|-------|------|--------|------|------|-------|-------|
| Subgroup A4         | 97  | 0.07  | 0.07 | 0.10   | 0.01 | 0.00 | 0,50  | 0.08  |
| Total group A       | 99  | 0.07  | 0.07 | 0.10   | 0.06 | 0.00 | 0.50  | 0.08  |
| Total grupo B       | 133 | 0.11  | 0.28 | 0.02   | 0.03 | 0.00 | 2.17  | 0.03  |
| Total group D       | 134 | 4.56  | 4.80 | 4.50   | 5.10 | 0.03 | 36.00 | 6.17  |
| Total D recyclable  | 56  | 10.25 | 6.15 | 15.00  | 0.00 | 0.08 | 15.00 | 11.00 |
| Total group E       | 101 | 0.06  | 0.07 | 0.05   | 0.04 | 0.00 | 0.52  | 0.06  |
| Hazardous waste     | 134 | 0.23  | 0.39 | 0.19   | 0.19 | 0.00 | 3.09  | 0.19  |
| Non Hazardous waste | 134 | 8.78  | 9.00 | 4.55   | 6.45 | 0.00 | 36.00 | 19.58 |
| Total HCW waste     | 134 | 9.02  | 9.13 | 4.89   | 6.73 | 0.03 | 39.61 | 19.73 |

*Legend: Subgroup A4 (biological with reduced risk); Group A (all biological wastes); Group B (chemicals wastes); Group D (similar to domestic waste); Group E (sharps or similar waste); N: number of values; SD: standard deviation; MAD: absolute deviation from the median; Min: minimum value; Max: maximum value; IQR: interquartile range.*

**Table 2.** Description of wastes generated by drugstores according to the HCWP

| Type of healthcare waste | Description   |
|--------------------------|---|
| Biological waste         | Waste generated from healthcare activities includes items like procedure gloves and cotton that may be potentially contaminated with the patient's blood or body fluids. Additionally, waste arising from vaccination activities, involving both live and attenuated or inactivated microorganisms, encompasses items such as vials containing expired vaccines or vials with unused contents.  |
| Chemical waste           | Pharmaceutical products; waste of sanitizing agents, disinfectants; laboratory reagents, including containers contaminated by them; effluents from automated equipment used in clinical analysis; other products considered dangerous: toxic, corrosive, flammable and reactive.  |
| Ordinary waste           | Wastes similar to household waste, including: sanitary paper and diapers, sanitary pads, disposable clothing, disposable caps and masks, patient food waste, material used in antisepsis and hemostasis of venoclysis, gloves for procedures that did not come into contact with blood or body fluids; leftovers from food and food preparation; restroom food; waste from administrative areas; sweeping waste, flowers, pruning and gardens; recyclable waste without associated biological, chemical and radiological contamination. |
| Sharps waste             | Sharp or scarifying materials, such as: razor blades, needles, scalpels, glass ampoules, lancets; micropipette tips; slides and coverslips; spatulas; and all broken glassware.   |

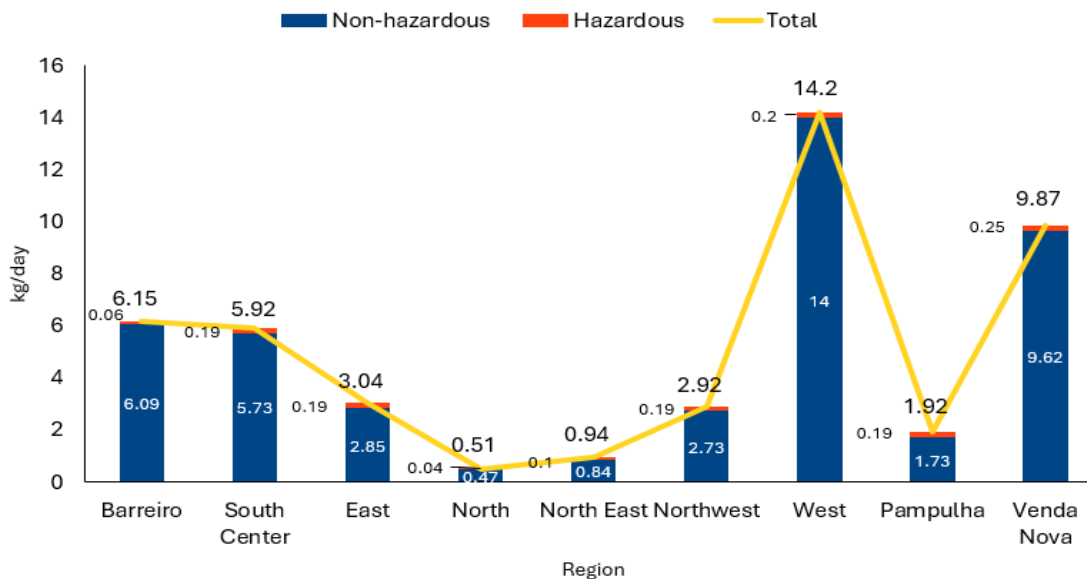


Figure 1. Hazardous, non-hazardous and total HCW generated among Belo Horizonte, per region. Values in kg/day

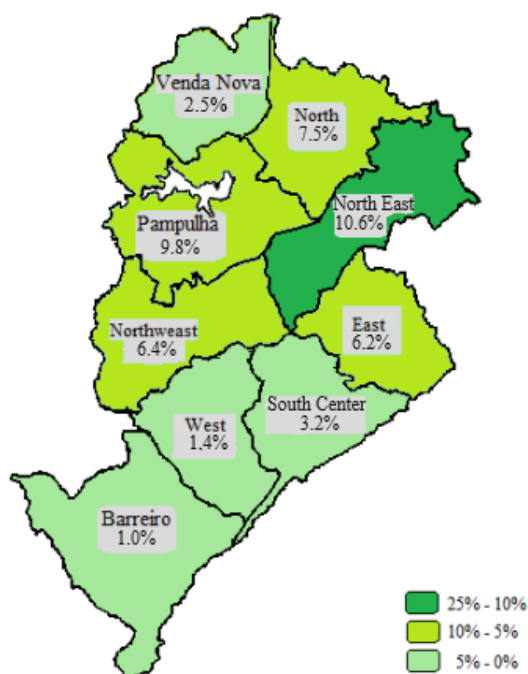


Figure 2. Hazardous waste percentage related to the HCW total generated among the regions of Belo Horizonte, Brazil.



The data revealed an average total generation of biological waste (group A) in Belo Horizonte of 7.2 kg/day (72 L/day). On average, each establishment in the city contributed 0.07 [0.06 - 0.09] kg/day (0.73 [0.60 - 0.87] L/day) of this type of waste. This category is documented in 99 HCWMP studied, constituting 30% of hazardous HCW generated in drugstores in Belo Horizonte and 0.49% of the total HCW. This percentage is lower than the figures suggested by WHO (2014) and ANVISA (2006), which recommended a 10% threshold for biological waste in relation to total HCW. In Brazilian hospitals, this proportion is notably higher at 21% (Ribeiro *et al.*, 2020). However, the increased complexity provided in a hospital compared to drugstores justifies this difference. In Belo Horizonte hospitals, the percentage of hazardous waste reported is 18%, according to Neves *et al.* (2022). The North East region exhibited the highest average of biological waste generation in drugstores in Belo Horizonte, and the South Center region is the region with the highest number of HCWMP that predict generation of this type of waste, the region responsible for 32.3% of the studied plans. However, no significant differences were noted in the rate generation of hazardous HCW between the regions of Belo Horizonte in Kruskal-Wallis test ( $p$  value > 0.05).

While it might be expected that regions with higher concentrations of medical facilities, particularly those in more central areas, would exhibit greater amounts of hazardous waste due to increased healthcare activity, this study did not confirm this hypothesis. The variation in hazardous waste does not appear to be directly correlated with the geographic distribution in the city under investigation.

Chemical waste was the most generated hazardous waste in drugstores in Belo Horizonte, representing 0.71% of drugstore waste and 44.58% of hazardous waste. The total amount of chemical waste in the city was 14.3 kg/day (143 L/day), so it is expected that drugstores generate an average of 0.11 [0.07 - 0.16] kg/day (1.10 [0.67 - 1.56] L/day). Among all HCWMP analyzed, 133 provided information about the generation of chemical waste. Similar results were reported by Oliveira *et al.* (2018) where most of the generated waste in drugstores in Vitória da Conquista, Bahia state, Brazil. Radiological wastes were not listed in any of the analyzed HCWMP of drugstores, which was expected since this type of waste is characterized by contamination with radionuclides (WHO, 201; ANVISA, 2006), and the activities developed in studied establishments do not involve use of such materials. On the other hand, sharps from drugstores amounted to 6.0 kg/day (30.0 L/day) in the city of Belo Horizonte, representing 0.40% of total HCW and 25.00% of hazardous waste. This type of waste was listed in 101 HCWMP.

Non-hazardous waste destined for common collection in Belo Horizonte had an average of 4.56 [3.79 - 5.41] kg/day (30.41 [25.26 - 36.06] L/day). All 134 HCWMP analyzed, predict the generation of non-hazardous waste that is destined for common waste collection in the city. Notably, only 56 HCWMP (41.5% of the evaluated plans) included a forecast for the destination of non-hazardous waste to recycling programs. The average generation of this type of waste in Belo Horizonte was 10.24 [8.60 - 11.83] kg/day (68.27 [57.30 - 78.85] L/day).

## Conclusion

The objective of quantifying and describing the HCW of drugstores within the studied municipality, based on the Healthcare Waste Management Plans, has been archived. It was confirmed that drugstores constitute a category of establishments with low hazardous waste generation, particularly among those generating healthcare wastes. The majority HCW generated by drugstores in Belo Horizonte is comparable to domestic waste, constituting the largest portion of the total generated. However, the description of recyclable waste destined for selective collection is only 41% according to the data from the studied establishments. When evaluating hazardous waste, it was noticed that chemicals represent the highest percentage portion. Encouraging further studies that broaden the understanding of HCW generation in various types of healthcare establishment are crucial. These studies may incorporate new variables, such as the discard behavior over time. Additionally, there is a need for new characterizations in other regions to further enhance the understanding.

## Acknowledgments

*We are grateful to Luiz Gustavo de Oliveira Schenk, for the English grammar review. The authors disclose receiving financial support for the research, authorship, and/or publication of this article from Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).*

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