









Original Research

Spatial analysis of a case of reverse logistics of medicines in community pharmacies in Brazil - a preliminary study

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Abstract

Background: The reverse logistics of medicines consists of the logistical procedure of collection, transport, storage, treatment and final disposal of post-consumer or expired waste. Medicines can be toxic to the environment and affect the health of citizens of the territory. Community pharmacies, as a health facility, play a key role in this process. **Objectives:** Define the spatial analysis and cases of reverse logistics of medicines in community pharmacies in Brazil. **Methods:** This is a cross-sectional study, and the research covered the medicines collected by 400 community pharmacies in the period from 2020 to 2022. To obtain the data, the medicines were collected, weighed, segregated and the weight released on a dedicated waste management platform. All regions of Brazil subject to georeferencing were processed using the free software Geographic Information System (QGIS). Data were expressed as median and range or as frequency of occurrence. Chi-square t-test and Fisher's exact test were used to compare variables. The accepted significance level was 5%. **Results:** Of the five existing regions in Brazil, only three had records of reverse medication logistics. 4,519.74 Kg of products were collected, and the North region of Brazil was responsible for 69.1% of the collection. In the spatial analysis, it was possible to perceive a difference between the areas of concentration of the RDL, that is, locations where collections were carried out in the period from 2020 to 2022. **Conclusion:** The present study preliminarily analyzed the reverse logistics of medicines in Brazil. The data obtained can contribute to the knowledge of this area and to the strengthening of the process. Thus, these places must exercise a task force for the educational process of the population about the risks of incorrect disposal of medicines and that this could harm the environment, economic aspects of society, food and the entire context that involves health and well-being of citizens.

Keywords: reverse logistics; community pharmacy; medicines

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INTRODUCTION

Reverse logistics is the logistical procedure for collection, transport, storage, treatment and final disposal of solid waste and post-consumer products, as an example, we have medicines.¹ The process refers to the movement of goods, from the place of consumption to the point of origin, for the purpose of recovery or adequate destination and aims to minimize the environmental impacts caused by the improper disposal of products and materials, as well as to maximize the use of natural resources and existing products.^{2,3}

Medicines contain chemicals and can be toxic to the environment and human health.⁴ This occurs when they are discarded in an irregular manner, either through direct release into the ground or by disposal in dumps and landfills without proper environmental protection. In addition, soil contamination can affect the local fauna and flora, leading to a reduction in biodiversity and compromising the quality of the ecosystem.⁵ In addition, these products can also cause the death of animals that feed on plants or ingest contaminated water. Therefore, it is important that reverse drug logistics (RDL) is implemented properly and efficiently, ensuring that these wastes are collected and disposed of safely and properly.⁶

In many countries around the world, RDL is already an established practice and regulated by environmental laws and regulations. In Brazil, RDL is regulated by the National Health Surveillance Agency and each state has its own regulations.⁷



Pharmaceutical industries, distributors and retailers are responsible for implementing and maintaining RDL programs and must provide collection points at pharmacies and drugstores so that consumers can return expired or unused drugs.⁸ Collected medicines are sent to specialized companies, responsible for transport, storage, and proper disposal of waste.⁹

Despite the existence of laws and regulations, RDL is still a challenge in Brazil, especially in remote or difficult-to-access regions.^{8,10} It is common for products to be disposed of improperly, which increases the risk of environmental and public health contamination. Therefore, it is important that public authorities, industries, and society work together to ensure that products are disposed of safely and responsibly, through the implementation of public policies and awareness campaigns.⁷⁻¹⁰

Thus, the development of this procedure becomes important in Brazil to ensure the protection of the environment and public health, avoiding soil, water and air contamination by drug residues and reducing risks to the health of the population.^{10,11} In addition, RDL also contributes to the circular economy, promoting the recycling and reuse of materials.

In this context, the objective of the present study was to carry out a preliminary definition of the spatial analysis and the cases of RDL in community pharmacies in Brazil.

METHODS

Study Design

This is a retrospective study, based on quantitative methods, carried out in a community pharmacy network comprising 400 stores. An analysis of the reverse logistics of medicines in Brazil was carried out during the period from January 2020 to December 2022.

The company that distributes and sells pharmaceutical products is among the ten largest pharmacy chains in Brazil, with stores in the North, Northeast, South and Southeast regions.⁵

The sample size was calculated using an online calculator (Sample Size Calculator Creative Research Systems) with 80% power and 95% confidence level. The estimated number of participants was 400.²

Samples Collection Strategies and Inclusion Criteria

Pharmaceutical establishments were recruited using the pre-established sample of 400 stores. That is, the minimum sample size necessary for the results to be considered representative was calculated.

The inclusion criteria were establishments regularly registered with the competent health authorities in Brazil, which already performed the reverse logistics procedure and which had the Health Services Waste Management Plan in operation. In this study, there was previously disclosure to the community that community pharmacies would collect expired and unused medicines. All pharmacy employees received training for the

service.⁶

Data collection was carried out during the period from January 2020 to December 2022 where the drugs were collected, weighed, segregated and the weight released on a dedicated waste management platform. The entire process followed the Health Services Waste Management Plan of each establishment. The separation was carried out by the client and deposited in a specific collector, which contained only the medicine vials, blisters, and tubes. The weights were calculated, and their values stored in an Excel[®] spreadsheet. Packaging and paper were excluded from the measurement and placed in bins available for common waste.^{12,13}

All regions of Brazil that could be georeferenced were processed using the free software Geographic Information System (QGIS), version 3.22, and a georeferenced satellite image showing the urban area of the regions of Brazil.¹⁴

Statistical analysis

Data are expressed as median and range or as the frequency of occurrence. Chi-square t-test and the Fischer exact test were used to compare the variables. The significance level accepted was 5%.

RESULTS

A total of 400 community pharmacies from the five regions of Brazil were included in the study and 4,519.74 kg of medicines were collected in the period (Table 1). Table 1 shows the quantity of medicines collected from pharmacies, where only three Brazilian locations were observed where the reverse logistics service was effective.

| Regions | Year 2020 | Year 2021 | Year 2022 | Total |
|------------|-----------|-----------|-----------|---------|
| North | 994.05 | 1068.51 | 1063.07 | 3125.63 |
| North East | - | 96.9 | 200.25 | 297.15 |
| Southeast | 200.25 | 513.14 | 383.57 | 1096.96 |
| South | - | - | - | - |
| Midwest | - | - | - | - |
| Total | 1194.3 | 1678.55 | 1646.89 | 4519.74 |

The northern region of Brazil was responsible for 69.1% of the entire process, followed by the southeast (24.2%) and northeast (6.5%) regions, respectively. Table 1 describes the values (in Kg) and the regions of the country (Table 1).

Figure 1 shows the spatial distribution of RDL cases in the five regions of Brazil. It is possible to notice a difference between the areas of concentration of RDL, that is, places that carried out collections in the period from 2020 to 2022.

DISCUSSION

The development of RDL is important to ensure its proper disposal, preventing substances present in medicines in



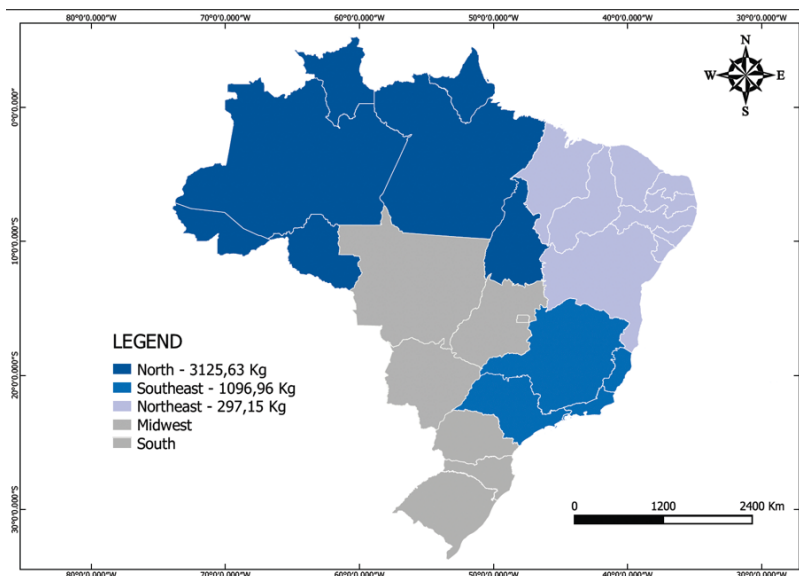


Figure 1. Spatial analysis of the distribution of reverse logistics in Brazil

contact with the environment from polluting groundwater, interfering with flora and fauna and endangering wildlife and human beings.^{15,16} This procedure contributes to sustainable development, process improvement, elimination of pollution and waste, such as the reuse of materials and the manufacture of ecologically correct products.^{16,17}

Pharmaceuticals are responsible for polluting more than a quarter of the world's rivers.¹⁸ Water contamination represents a global environmental threat. Environmental exposure to these substances harms ecosystems and, potentially, human health through mechanisms such as antimicrobial resistance.^{5,7,19} The choice of reverse logistics in community pharmacies in Brazil is mainly due to the expansion of this business in the locality, where the user/pharmacy ratio is in the proportion of 2,217 people for each pharmacy in the country.¹⁷⁻²⁰ In addition, there is great heterogeneity between the different regions of the country in terms of economic development, which directly affects the ability to implement reverse logistics.²¹ Therefore, a spatial analysis and cases of reverse logistics in Brazil should take these factors into account, as well as the particularities of each industrial sector, since different products require specific reverse logistics approaches.^{21,22}

RDL does not occur in all regions of Brazil, corroborating the data found in the study, which is in line with a large survey of reverse logistics carried out in the country.¹⁹⁻²² It identified that the Midwest and the South region still do not have defined policies for the implementation of this procedure in community pharmacies.²³ Additionally, there is a lack of consumer awareness of the importance of proper medication disposal. Many people still throw expired or unused medicines in the common trash or in the toilet, which can contaminate the environment and harm public health.²⁴

To make consumers aware of the importance of proper disposal of medicines, it is necessary to develop information campaigns that show the consequences of improper disposal, as well as

the correct disposal alternatives.^{13, 25} These campaigns can be carried out in different formats, such as videos, posters, information leaflets, among others. In addition, it is important that establishments selling drugs provide clear and accessible information on proper disposal. Therefore, it is necessary to have collectors for the deposit of expired or unused medicines, which are later forwarded to the correct disposal.^{18, 19}

The highest concentration of RDL was reached in the north of Brazil, which is related to the large territorial extension of the region and the high number of pharmaceutical establishments in its territory.^{12,14,19} The Northeast and Southeast regions also have a similar profile. However, the sum of the amount of material collected in these two regions (1,394.11 kg) was still lower than that of the northern part, which obtained 3,125.63 kg. The finding was supported by the 56.6% increase in community pharmacies compared to all regions of Brazil during the period.²⁵

The Midwest and South regions do not show evidence of recall of pharmaceutical products. The difference was notable with other Brazilian regions, which agrees with other studies [4,6,10-12]. The lack of evidence may be related to the lack of adequate structure for RDL in these regions. In addition, the Midwest region occupies the last position in number of community pharmacies in Brazil.²⁶ Therefore, the southern region of the country leads the growth of pharmacies in Brazil, advancing in percentages above the national average. However, the lack of policies for the development of reverse logistics in the region ends up making it impossible for community pharmacies to collect these products, meaning that we have no reports of this practice in this space.²⁵⁻²⁷

When the RDL does not exist or is not well structured, medicines may end up being disposed of incorrectly, increasing the risks of environmental contamination and public health.^{27,28} In addition, economic impacts occur because improper disposal can generate costs for society, such as expenses with

urban cleaning, water treatment and damage to fishing and agriculture, for example.^{10,21}

Furthermore, the concern with the effects of not implementing the RDL in some regions of the country is mainly due to the fact that a large part of the territory is bathed by the sea and/or rivers, where there are numerous riverside and indigenous populations that use these waters for bathing and fishing, which is one of the most important human tasks in the Amazon.^{26,27} Because of this, the incorrect disposal of drugs can cause intoxication in these populations, in addition to affecting the development and reproduction of fish in these places.²⁸

The findings regarding the spatial analysis are in line with the Brazilian scenario, which revealed that the RDL process is more concentrated in large urban centers and their surroundings.^{6,9} On the other hand, studies claim that the RDL process in Brazil is decentralized and can be found both in large urban centers and in smaller cities in the countryside.^{13,28} However, smaller cities in the interior have structural difficulties, access, and lack of awareness of the population and this favors that the practice of RDL is reduced.²⁸

This low rate of collection of pharmaceutical products in Brazil, especially in more remote or difficult to access regions, may indicate a lack of access to medicines and health products, and this may affect the health of the local population and prevent access to treatments and health care. adequate health.

It is therefore important that pharmaceutical companies and drug sales outlets work together with local authorities and the community to implement efficient reverse logistics systems and ensure that drugs are used and disposed of properly and safely.²⁹

Therefore, due to Brazil's territorial magnitude, it is likely that the low rate of collection of pharmaceutical products pointed out in the study causes toxic effects in the territory.^{5,11} The practice of releasing drugs into the environment causes damage to the soil and rivers and/or seas due to the release of harmful chemical substances into the soil, also affecting animals, groundwater or anyone who meets the affected area.^{19,23} However, it is fundamental to strengthen public policies for the implementation of the practice of reverse medication logistics throughout the national territory. In addition, it is necessary to

make the population aware of this practice and its risks.²⁹

The main limitation was the small number of community pharmacies surveyed in relation to the existing number in the country.

CONCLUSION

The present study preliminarily analyzed the reverse logistics of medicines in Brazil. The data obtained can contribute to the knowledge of this area and to the strengthening of the process. Thus, these places must exercise a task force for the educational process of the population about the risks of incorrect disposal of medicines and that this could harm the environment, economic aspects of society, food and the entire context that involves health and well-being. of citizens.

DECLARATION OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest to disclose.

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AUTHOR CONTRIBUTION

The study was conceptualized by LWPS, LPSC and MPMS. CMO and AGNCM contributed to methodology, investigation, data curation, formal analysis of quantitative and qualitative data, validation, visualization, writing of the original draft, review, and editing. CAS and RBCM contributed to methodology, investigation, formal analysis of qualitative data, visualization, writing of the original draft, review, and editing. JLFV, LWPS, MPMS, CHMAR and CMO contributed to the validation, visualization, revision and editing of the manuscript. LWPS contributed, methodology, supervision, validation, visualization, review, and editing.

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