






Reverse Logistics: an approach to raising awareness of the risks caused by the incorrect disposal of expired drugs

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ABSTRACT

The growth in the manufacture of medicines and their consumption has potentiated an exponential growth in the improper disposal of medicines. This improper disposal comes from the population's lack of information or choice to do it the right way, increasing the risks of contamination of the environment and of the human being. This research seeks to contribute to the awareness of the risks that the incorrect disposal of expired drugs produces in the environment. This study was applied to Brazil, specifically to the state of Ceará. A quantitative methodology by questionnaire was developed with the population (N=71) and pharmacies in Ceará (N=7). The main results of this investigation indicate that there is misinformation among most of the population regarding the correct disposal practices and the impact of doing it incorrectly on the environment and the population. As for the establishments that sell medicines, there is a lack of interest in creating policies for the awareness of correct disposal. This study is intended to be of added value to government organizations, the academic community, and all those interested in reverse logistics in health and sustainability.

Keywords: Environmental sustainability, Environmental contamination, Reverse logistics, Drug disposal

INTRODUCTION

After the Industrial Revolution, consumer goods began to be produced on a large scale, and the environment was seen only as a source of raw materials and waste disposal. Due to the worldwide production growth, the environmental impacts of productive actions inevitably began, potentiating unprecedented environmental degradation (Silva et al., 2009). Therefore, sustainability is currently a significant concern for the various organizational sectors, motivated not only by regulatory obligations but by the consumer, who is more concerned about these issues. As a result, organizations feel obliged to reduce the impact of their actions, e.g., production, on the environment and try to be responsible by resorting more often to reverse logistics (Hasan et al., 2022).

One of the biggest problems regarding sustainability on a global level today is solid waste management. Among the various types of waste, medical and medication waste are the most difficult to manage. For this reason, it is fundamental for the health industry to invest in reverse logistics of product disposal to be more efficient and effective (Silva et al.,

2022).

Lima et al. (2022) allude that waste and incorrect disposal of medicines (e.g., through toilets, household waste) is an environmental and public health concern. Rebehy et al. (2019) reinforce the idea that improper waste management can contaminate soil, surface, and groundwater. In addition, in the case of pharmaceuticals, the emergence of antibiotic-resistant super-bacteria can result.

Given these facts, there must be awareness from the general population of the organizations for the disposal of medicines so as not to pollute and bring serious consequences to the environment and the entire population.

According to the Federal Pharmacy Council, Brazil is in the top 10 countries that consume more medicines globally. The consumption of medicines may be related to the difficult access to health services, to the habit of the population to self-medicate, and to the fact that medicine is considered a product that can be acquired and consumed without proper guidance (Conselho Nacional de Saúde, n.d.).

This research aims to contribute to the awareness of the risks that the incorrect disposal of expired medications produces in the environment. In addition, this research proposes to learn more about the behavior of medication disposal by the population and through pharmacies/drugstores.

This article will focus on studying some pharmacies in Ceará and the population that accesses these pharmacies. At the population level, it seeks to understand their habits of medicine consumption, their storage habits, especially those without prescription or expired, and if the population knows and is aware of the impact of incorrect disposal on the environment. At the pharmaceutical level, we intend to know the frequency and form of waste collection, the introduction of collectors for medication disposal, and methods of dissemination and/or encouragement of the population to participate in the collection of disused medications.

This study used a quantitative methodology, using a questionnaire survey to collect data from the population (N=71) and pharmacies in Ceará (N=7).

The insights reached by this article are particularly significant for researchers, governmental organizations, and the population in general, allowing them to understand the impact of the disposal of medications in Brazil, more specifically in the state of Ceará.

This article will initially present a brief introduction to the theme under study. Then, it includes a theoretical framework where logistics is addressed and, more specifically, reverse logistics, the disposal of medicines, and reverse logistics in Brazil. Subsequently, the research methodology chosen for this study is addressed, and an analysis and discussion of the data obtained. Finally, it ends with a brief conclusion of the research.

THEORETICAL FRAMEWORK

Logistics

For Cavalcanti et al. (2021), logistics has a Greek origin. It means accounting and organization and comes from the French *logistique*, denominated as the art that plans and conducts various projects used during wars. Considering the Council of Supply Chain Management Professionals (CSCMP), logistics is "The process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods, including services, and related information from the point of origin to the point of consumption to conform to customer requirements. This definition includes inbound, outbound, internal, and external movements." (CSCMP, 2013).

Logistics can be subdivided into two categories: direct and reverse logistics, which can be combined, keep goods flows separate, or select a position between the two types. Direct logistics corresponds to managing goods downstream in the supply chain (from suppliers to clients). Reverse logistics aims to generate flows of goods that have been returned upstream (Hansen et al., 2018; Hasan et al., 2022). Reverse logistics is that in which the theme of this study is framed. **Figure 1** represents a direct and reverse logistics process and the stages of each.

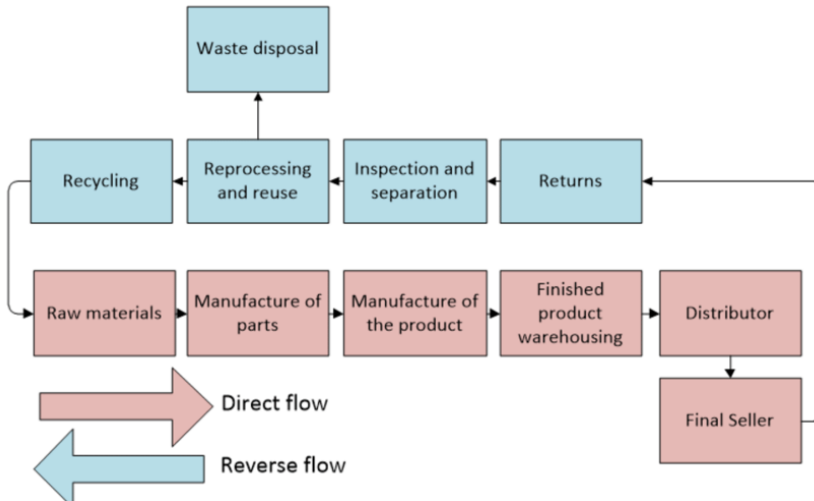


Figure 1. Relation between Forward logistics and Reverse Logistics
 Source: Agudelo et al. (2021)

Before starting concretely in reverse logistics, one must consider its distinction from direct logistics. Krykavskyy et al. (2014) distinguish between direct and reverse logistics presenting their main characteristics as shown in **Figure 2**.

Forward logistics	Reverse logistics
Product quality uniform	Product quality not uniform
Disposition option clear	Disposition not clear
Routing of product unambiguous	Routing of product ambiguous
Forwards distribution costs more easily understandable	Reverse costs less understandable
Pricing of Product uniform	Pricing of Product not uniform
Inventory management consistent	Inventory management not consistent
Product lifecycle manageable	Product lifecycle less manageable
Financial management issues clearer	Financial management issues unclear
Negotiations between parties more straightforward	Negotiations less straightforward
Type of customer easy to identify and market to	Type of customer difficult to identify and market to
Visibility of process more transparent	Visibility of process less transparent

Figure 2. Direct and Reverse Logistics
 Source: Krykavskyy et al. (2014)

Reverse Logistics

Reverse logistics for the CSCMP (2013) is "A specialized segment of logistics focusing on the movement and management of products and resources after the sale and delivery to the customer. Includes product returns for repair and/or credit." Therefore, it is a process where the customer initiates the flow of goods due to, e.g., return for damage, renewal, remanufacturing of packaging materials, and reuse of containers (Hansen et al., 2018). Furthermore, Hasan et al. (2022) allude that this type of logistics is considered a sustainability business practice since managing used products can minimize production costs, obtain a competitive advantage and care for the environment.

Reverse logistics cycle

Figure 3 shows the reverse logistics cycle, where it can be seen that the process begins with the return of a good that can be recycled, and subsequently, the criteria for use or reuse are determined (Agudelo et al., 2021).

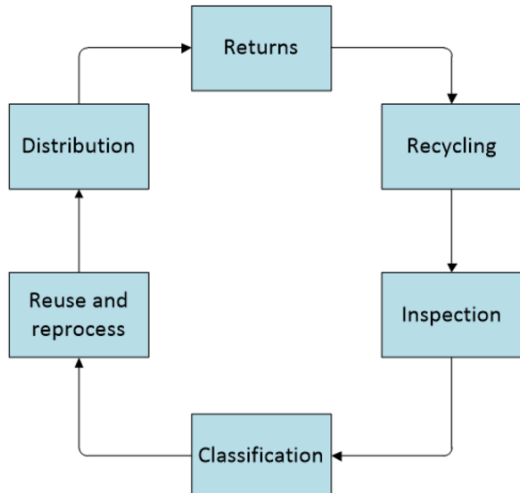


Figure 3. Reverse logistics cycle
Source: Agudelo et al.(2021)

The objective of reverse logistics

The objective of reverse logistics is the recovery of post-sale or consumption goods, and if these goods cannot be reused, perform the correct disposal of them in safe places (Nascimento et al., 2014). Therefore, it is intended for the return of goods to the production cycle, thus reducing the cost of handling and increasing the value of goods or the proper disposal (Kumar & Saravanan, 2016).

Areas of action of reverse logistics

Reverse logistics operates in two areas - post-consumption and after-sale. Post-consumption is the reverse flow of a portion of products and constituent materials originating in the disposal after the end of their original utility, which returns to the production cycle in some way. For example, it can be done by reuse, remanufacturing, and recycling. Post-sale are different forms and the possibility of returning a portion of a product with little or no use (Leite, 2017). **Figure 4** shows the reverse distribution channels.

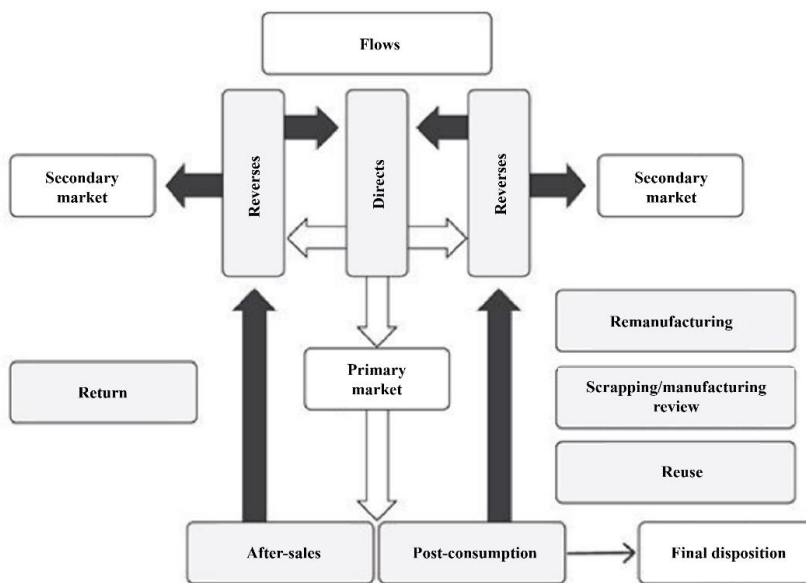


Figure 4. Reverse distribution channels
Source: Adapted from Leite (2017)

Critical factors influencing the efficiency of the reverse logistics process

According to Lacerda (2002), the factors that may influence the efficiency of the reverse logistics process are - good input controls to know the materials that will be returned and avoid rework; standardized and mapped processes for greater control and to obtain improvements; reduced cycle time, i.e., time from identification of the need for recycling to actual processing; information systems, e.g., effective tracking of returns, measurement of cycle times and product malfunctions to achieve improvements; planned logistics network, i.e., need for adequate infrastructure to support inbound flows of used materials and outbound flows of processed materials; and collaborative relationships between customers and suppliers, issues related to the trust of the parties involved (e.g., product damage liability).

Disposal of medicines

Medicines are essential for humans, relieving pain and treating various diseases. Consumers commonly stockpile medicines in their homes for when they need them and when they expire and are discarded erroneously (Brasil et al., 2018). Currently, a large proportion of solid waste is medicines that are out of use or expired that may have occurred due to patient non-adherence to treatment or symptom relief, over-prescription, perceived adverse effects, or change in treatment (Lima et al., 2022). Lin and Gao (2018) report that the recycling of medicines may have to do with, e.g., counterfeit, expired, substandard medicines, motivated by sales strategy adjustment, sample medicines.

Freitas and Radis-Baptista (2021) warn that environmental pollution is a public health concern worldwide due to the increased production and consumption of pharmaceutical and health products. Therefore, the disposal of medicines is central but needs special treatment considering the environment (Kumar & Saravanan, 2016).

There are two main pathways for pharmaceuticals to enter the environment (Figure 5). The first is via the effluent from Waste Water Treatment Works (WWTWs) after excretion from the body. The second is disposing of expired or unwanted medicines, which can occur via the sink or toilet, into household waste directed to landfills or pharmacies. The manufacturer's packaging recommends disposal by returning to the pharmacist; however, disposal in the sink or toilet or normal household waste is common (Bound & Voulvoulis, 2005).

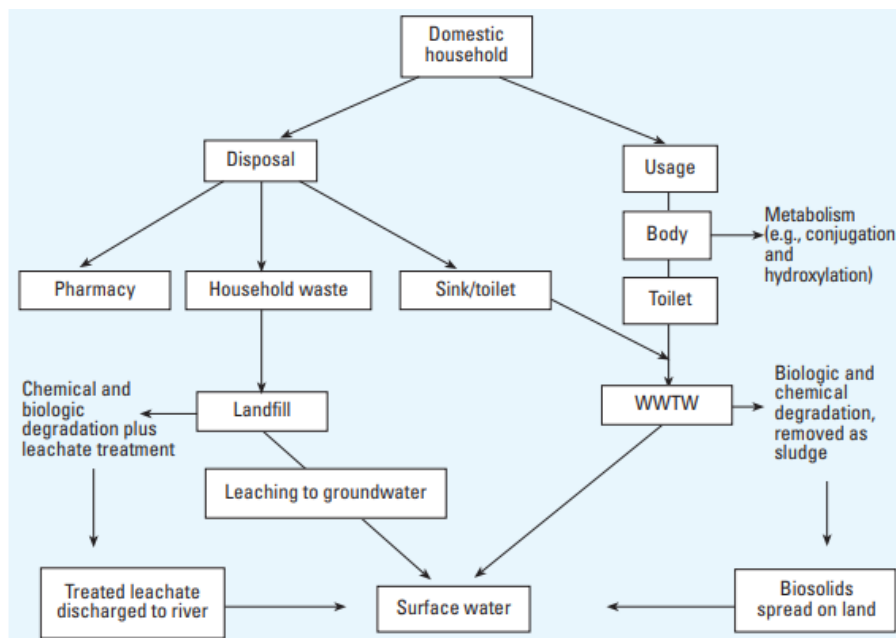


Figure 5. The path that medicines follow after disposal or consumption
Source: Bound and Voulvoulis (2005)

Pharmaceuticals in the environment is an everyday concern of the entire population. When mistakenly discarded, drugs are environmental contaminants and can be detected in water and soil systems, posing risks to humans and wildlife. Harmful and adverse effects can range from the spread of antimicrobial resistance and species survival to interference with reproduction and increased incidence of cancer in humans (Freitas & Radis-Baptista, 2021).

The study found that most consumers stored medicines at home and in refrigerators. However, these same consumers often discard them through household waste. They also found that they had non-prescribed medicines stored mainly as unused or expired medicines at home. The main reason for storing unused/ expired medicines at home was to discontinue the medication after recovery.

The reverse logistics process seeks to address the incorrect environmental impact of discarding medicines in the environment.

Consumer awareness

Inadequate awareness and knowledge are the main reasons for the improper disposal of medicines (Alshehri & Banjar, 2022). Thus, there should be a joint effort of authorities, consumers, and the population and increased awareness of environmental contaminants to avoid pollution and achieve a sustainable environment and society (Freitas & Radis-Baptista, 2021).

Therefore, immediate actions must be taken to reduce the use of medicines, educating the consumer on their correct use and disposal. This can be done by identifying the level of public awareness of the environmental and health effects of the inadequate disposal of medicines (Rogowska et al., 2019). For Campanher (2016), Most consumers dispose of medicines inappropriately, as they do not know how to dispose of them correctly, and there is a need for environmental education (Alshehri & Banjar, 2022).

Althagafi et al. (2022) found that only a small proportion of consumers received education regarding the correct disposal of medicines. The most used method to increase community awareness about the disposal of unused or expired medicines in the study was through social media, still alluding to the provision of clear instructions on the sale and receipt of the medicine by the consumer and by patient education by a health professional.

Orok et al. (2023) mention that one should use government awareness programs, patient education by health professionals, media education, and awareness through local health workers to raise awareness.

Reverse logistics of medicines in Brazil

For the pharmaceutical industry, reverse logistics is important for its economic, environmental, and regulatory character (Kumar & Saravanan, 2016). Reverse logistics in medicines allow them to recover their value when the disposal is done correctly by hospitals, pharmacies, and patients to the manufacturers/suppliers (Lin & Gao, 2018). This type of logistics in this sector is relevant and contributes to reducing the exposure of medicines to other people and the environment (D. P. Ribeiro et al., 2021). Four practices should be stipulated in this sector: donation, disposal, storage, return, and the disposal practices of medicines which are disposal into the rubbish, flushing, e.g., toilet or sink, burying (environment,) and incineration (Kumar and Saravanan, 2016).

Oliveira and Banaszkeski (2020) mention that Brazil is the sixth country globally selling medicines. In Brazil, the disposal of medicines is recurrent. According to data from Abrelpe (2022), expired or unused home medicines are generally classified as hazardous waste (class 1) and have a high potential for environmental contamination when disposed of incorrectly.

Freitas and Radis-Baptista (2021) mention that in Brazil, the federal laws dealing with the management of drug waste are recent, with gaps that can facilitate non-compliance with the law by the population in general or manufacturers in the pharmaceutical sector and industry. They also point out that pharmacies and drugstores are not obliged to collect unnecessary household medicines. Instead, the state laws aim to regionally order the disposal of drug residues since some established pharmacies and drugstores (public or private) must be of the collection of expired, unused or unwanted medicines in the homes of patients and adequately handle these pharmaceutical residues.

In 2010, the Federal Government of Brazil established Law 12.305 of August 2, 2010, which defines the National Policy on Solid Waste (PNRS) and regulates reverse logistics in Brazil. In this law, reverse logistics is "an instrument of economic and social development characterized by a set of actions, procedures and means to enable the collection and return of solid waste to the business sector, for reuse in its cycle or in other production cycles, or other final destination environmentally appropriate" (Governo Federal do Brasil, 2010).

In the State of Ceará, Law No. 15192 of July 19, 2012, is in force, which defines conscious standards for the disposal of expired and/or unused medications, which states that pharmacies, drugstores, medicine distributors, hospitals, and other health units are responsible for receiving expired or unused medications. These will make suitable spaces available in their establishments to receive, on return, medicines with expired or deteriorated dates and unserviceable for use by

the population. Afterward, the medicines will be packed in containers separate from other types of rubbish to be collected by the solid waste collection in the cities and sent for final disposal. The collection spaces must indicate "RETURN OLD OR DETERIORATED MEDICINES HERE. AVOID INTOXICATION OR CONTAMINATION OF THE ENVIRONMENT." (Governo do Estado do Ceará, 2012).

In 2020, the Brazilian Federal Government issued Federal Decree No. 10,388, which regulates the country's reverse logistics system for medicines, determining a new approach. Currently, drugstores and pharmacies will have to provide and maintain, in their establishments, at least one fixed point of receipt for every 10,000 inhabitants (Abrelpe, 2022; Lima et al., 2022).

METHODOLOGICAL APPROACH

The development of this research began with a bibliographic review which is a key element in all research and for the choice of the most appropriate articles for the theoretical framework since it is necessary to know what is already known about the topic, concepts, and theories applied to the topic, which research methods are applied to the topic, existing controversies on the topic, how it is studied, conflicts of evidence that may exist and the main contributors in the research on the topic (Bryman, 2012).

The quantitative approach was chosen as regards the methodological approach of this research. This method involves collecting numerical data and displaying an insight into the relationship between theory and research (Bryman, 2012). When the quantitative methodology is used, the questionnaire survey is the most commonly used instrument for data collection (Sampieri, 2018).

Therefore, the present investigation was developed with the objective of understanding about the awareness of the risks that the incorrect disposal of expired medicines produces in the environment. More specifically, this study sought to learn more about the behavior of drug disposal from the population and those responsible for pharmacies/drugstores. With a sample chosen for convenience, the seven main pharmacies were visited in terms of geographic location and questionnaires were applied to their managers and to customers of different age groups and different social classes of the establishments. As valid responses, 7 questionnaires were obtained from those responsible for the pharmacies, with a response rate of 100% and 71 respondents from customers.

The purpose of the questionnaire was to analyze the disposal of solid waste medicines. It was used closed questions and created from a Likert scale of 5 points (1 - I totally disagree; 2 - I partially disagree; 3 - Indifferent; 4 - I partially agree; 5 - I totally agree). This scale measures the intensity of feelings about the area under investigation. Statements were presented where each respondent indicated the level of agreement with the statement (Bryman, 2012). The results data obtained via a questionnaire were analyzed using the "frequency distribution" technique, and the tabulation was performed with the help of Excel software.

RESULTS ANALYSIS AND DISCUSSION

In this phase, results obtained from data collection in the state of Ceará will be presented to understand the use and disposal of medicines for home use and the conduct of pharmaceutical establishments about the reverse logistics of medicines.

Characterization of the interviewees' profile

In this research, it can be observed through **Table 1** that many respondents are female (62%) and that the age range is between 18 and 33 years (44%) and between 34 and 45 years (37%).

Table 1. Gender and age of respondents

Gender	Frequency	%
Female	44	62%
Masculine	27	38%
Sum	71	100%
Gender	Frequency	%
From 18 to 33 years old	31	44%
From 34 to 45 years old	26	37%
Over 45 years old	14	20%
Sum	71	100%

Medication consumption habits

It was found that regarding drug consumption habits, 92% of respondents have medicines at home and usually use them without a prescription. It was also found that 80% of respondents self-medicate (45% totally and 34% partially) and usually take drugs without the evaluation and prescription of a health professional, despite the inherent risks that can harm individual and collective health. These results are corroborated by Brasil et al. (2018), who state that consumers commonly stockpile medicines in their homes when needed. This also aligns with Althagafi et al. (2022), where non-prescription medicines are stored mainly as unused or expired medicines at home.

Regarding the shelf life of medicines, the respondents answered 52% worry about checking the shelf life of medicines, 15% indicated that it was part, and 20% indicated that they are not in the habit of checking. However, in their research, Koshok et al. (2017) found that 87.5% of respondents usually check the expiry date of medicines before use, and 49.7% added that they always follow the instructions.

The vast majority (87%) reported not having expired medicines at home. Regarding the medication leftovers, 41% mentioned depositing them in the regular trash, and 39% kept them to use at another time. Regarding where they deposit the medicines, this study aligns with Brasil et al. (2018), which expresses in its research that when medicines exceed the expiration date and/or are unused, they are disposed of erroneously.

Disposal of medicines and awareness

56% of respondents, when disposing of medicines, do so in household waste (use of common landfills without adequate treatment contaminating the environment), and only 18% use another form of disposal. These results align with the study of Althagafi et al. (2022).

From the results obtained in the study, the respondents are aware of the environmental problems caused by the disposal of medicines. 48% of respondents totally agree, and 35% partially agree that the disposal of medicines can cause environmental problems. Through the study, it can be verified that they often discard incorrectly because they have no other option and allude that medicines should be sold in the exact dosage as per medical prescription. Regarding the storage and disposal of medicines, 38% of the interviewees indicated not knowing the appropriate places to dispose of medicines. Also, it was found that 44% of the respondents do not know about the risks of incorrect disposal of medicines causing serious contamination in the population. One can verify in the study of Alshehri and Banjar (2022) that inadequate awareness and knowledge are the main reason for the improper disposal of medicines. Althagafi et al. (2022) education for the correct disposal of medicines still does not reach all consumers and is an important element. In their study, Ribeiro et al. (2019) found that most respondents (73%) were unaware of the impacts that incorrect discarding of medicines can have on the environment.

Most respondents (75%) consider it important to have a warning label on medications because although medications are crucial to solve health problems, they damage the environment when disposed of inappropriately. In addition, when administered out of date, they may generate adverse reactions in the individual. This finding is in line with the FDA (Food and Drug Administration), which indicates that in one of its guidelines to encourage the proper use of medication disposal and to reduce the harm caused by accidental exposure or intentional misuse, one should follow all specific disposal instructions in the prescription drug labeling or in the patient information that accompanies the medication (FDA, 2015).

Characterization of pharmaceutical establishments

In the analysis of the data from the pharmaceutical establishments, seven pharmacies from the state of Ceará were involved, where the final disposal of waste was analyzed, 43% (3) pharmacists and 14% (1) clerks (**Table 2**).

Table 2. Type of establishment and respondents' positions

Establishment	Frequency	%
Independent drugstore	3	43%
Chain drugstore	4	57%
Sum	7	100%
Interviewees' positions	Frequency	%
Clerk	1	14%
Pharmacist	3	43%
Manager	3	43%
Sum	7	100%

Collection in pharmacies

According to this study, the collection in pharmacies of discarded medications is mostly done monthly (71%), weekly (14%), and the remaining 14% only, when necessary, by an outsourced company. We sought to investigate whether, at the time of hiring the services of the outsourced company, the establishments sought to be informed about the documentation required in hiring services (e.g., operating and environmental license). Of the seven pharmacies, 6 (85.71%) revealed that they were informed, and only 14.29% (1) said it was indifferent. About the existence of a program for the collection of expired drugs, all pharmacies responded that there were no expired drugs, as an internal collection is made with the pre-expired ones one month in advance. These findings align with Toscano's (2019) which in its research, verified that the frequency of medicine collection is made fortnightly and monthly, depending on the contract established with the company that provides the service. As a result, the product is returned to the distribution center before the expiry date, and it is difficult for the medicine to expire in the establishment. Also, Silva et al. (2014) mention that solid health waste is usually collected fortnightly and monthly. Jankie et al. (2022) alluded in their study that the pharmaceutical distributor or the Medicines Inspectorate disposes of most expired medicines.

Concerning the interest in introducing collectors to perform the correct disposal of medicines, of the establishments under analysis, only two pharmacies (28.57%) totally agree with placing, and five (71.43%) revealed that they had no interest in placing collectors to perform the correct disposal. Toscano and Nóbrega (2021) found in their study that in the interviewed establishments, the majority do not have collectors (visible or non-visible) to collect medicines, which is in line with the results of this study.

It was also possible to verify that none of the establishments have methods to disseminate and/or encourage the population to participate in collecting disused medicines. This conclusion corresponds to that obtained by Silva et al. (2014), which states that establishments do not have any method to disseminate and/or encourage the population to participate in the collection of disused medications. They also add that they only inform customers when requested (32%), carry out the practice through totems in the company itself (12%), through radio advertisements (4%), and 4% said they have others.

About the establishment carrying out the practice of returning medications with expired or out-of-use expiration dates, the majority 71.43% (5), pointed out that they totally disagree, and 28.57% (2) totally agree that they should do so. Despite these results, none of the establishments works on the issue of the return of expired drugs since they reveal that the laboratories do not receive the medication. Toscano (2019) states that the interviewees said that the return of medicines was common practice in the past and that they are currently unaware of it. Still, others mentioned that depending on the laboratory, there might be an agreement between the parties, but these are exceptional cases in the pharmaceutical market.

As for the final disposal of waste, all establishments confirmed that they know the waste's final destination. In the study of Toscano (2019), most interviewees were able to answer what destination was given to the solid waste collected by the specialized company for final disposal.

Regarding the concern in making the customer aware of the correct disposal, if they have leftovers or expired medicines in their homes, it was found that 57.14% (4) of establishments seek to make customers aware of the disposal

and 42.86% (3) responded that they do not inform about the correct disposal of medicines. On the other hand, Silva et al. (2014) found that only 32% of establishments inform customers when requested, 12% perform the practice through totems in the company itself, 4% through radio advertising, and 4% said they have others.

CONCLUSION

The conclusions that can be drawn from this investigation are that the population has medicines at home without a prescription, has the habit of self-medicating, but checks the expiration date of the medicines, and most of them do not have expired medicines. When there are medication leftovers, they dispose of them inadequately through the regular rubbish or keep them for use at another time. Despite knowing the risks associated with the environment, incorrect disposal is performed by most people due to lack of information and lack of disclosure and because they have no other option. Regarding the risks that incorrect disposal entails to the population, e.g., the individuals surveyed were unaware of what could occur. Finally, the respondents think it is important to have information about the correct disposal on the label of the medicines.

At the pharmaceutical level, it was found that reverse logistics is carried out in the main pharmacies visited, and it can be perceived the means used to carry out this process and that there is interest in making the population aware of the correct disposal of medicines.

One can also verify that third-party companies perform reverse logistics that collect and dispose of in authorized locations and according to the need deadlines of each pharmacy (mostly monthly). The establishments seek to know the operating and environmental licenses of these companies. All establishments indicated they know what happens to waste in its final disposal.

All establishments revealed that they do not have any expired medicine because the internal collection is made one month before the expiry date. As regards the introduction of collectors, the majority revealed that they have no interest in placing them in their establishments. Furthermore, it was verified that the establishments do not work on returning expired medications because the laboratories do not receive the medication. Most establishments indicated that they try to inform their customers of disposal.

It is suggested the implementation of collectors in pharmacies, Basic Health Units (BHU), Hospitals, and places of easy access so that the population could provide the correct disposal and the collection of medicines could be performed by those who distributed them.

Although this research has positive results, in the future, it could be contemplated a larger number of pharmacies and surveyed population, as well as extend the study to other states of Brazil. This study will promote knowledge about the reverse logistics of expired medicines for governmental organizations, the academic community, and all those interested in reverse logistics in health and sustainability.

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