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Characterization of medicines discarded at the collection point at a university in northeast Brazil

Caracterização dos medicamentos descartados no ponto de coleta em uma universidade do nordeste brasileiro

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ABSTRACT

Objective: To characterize the profile of medicines discarded by the university community in the collector made available at the Health Sciences Center of the Federal University of Paraíba. **Methods**: The Descarta CIM extension project installed a collector in the Medicines Information Center - CIM of the Department of Pharmaceutical Sciences. From this, discarded medicines were weighed and cataloged over a period of 6 months, followed by detailed analysis of the type of medicine, regulatory category, ATC (Anatomical Therapeutic Chemical) classification, pharmaceutical form, type of packaging and expiration date. **Results:** The data found indicates that generic medicines represent 42.5% of the discarded volume, followed by reference medicines (35.7%) and similar medicines (21.7%). Analysis of the ATC classification reveals a prevalence of medications related to the digestive system and metabolism, followed by the cardiovascular system, nervous system and musculoskeletal system. There is a high percentage of medicines that are out of date (72.8%), raising questions about the practice of self-medication and the need to raise awareness about the rational use of medicines. **Conclusion:** The study has some limitations, especially when it is not possible to determine exactly whether all discarded medications were, in fact, used by members of the university community, their families or people in their social circles. However, the analysis demonstrated that the promotion of educational campaigns and the presence of collectors encourage the proper disposal of medicines and encourage a change in behavior and the practice of environmental protection actions.

Keywords: Medication Disposal; Solid Waste; Public health; Environmental health education; Reverse Logistics.

RESUMO

Objetivo: Caracterizar o perfil de medicamentos descartados pela comunidade universitária no coletor disponibilizado no Centro de Ciências da Saúde da Universidade Federal da Paraíba. **Métodos:** O projeto de extensão Descarta CIM instalou um coletor no Centro de Informações sobre Medicamentos - CIM do Departamento de Ciências Farmacêuticas. A partir disso, foi feita a pesagem e catalogação dos medicamentos descartados durante um período de 6 meses, seguida de análise detalhada do tipo de medicamento, categoria regulatória, classificação ATC (*Anatomical Therapeutic Chemical*), forma farmacêutica, tipo de embalagem e prazo de validade. **Resultados:** Os dados encontrados indicam que os medicamentos genéricos representam 42,5% do volume descartado, seguidos por medicamentos de referência (35,7%) e similares (21,7%). A análise da classificação ATC revela uma prevalência de medicamentos relacionados ao sistema digestivo e metabolismo, seguidos por sistema cardiovascular, sistema nervoso e músculo-esquelético. Observa-se uma alta porcentagem de medicamentos fora do prazo de validade (72,8%), levantando questões sobre a prática de automedicação e a necessidade de conscientização sobre o uso racional de medicamentos. **Conclusão:** O estudo apresenta algumas limitações, sobretudo quando não se pode determinar com exatidão se todos os medicamentos descartados foram, de fato, utilizados por membros da comunidade universitária, por seus familiares ou por pessoas dos seus círculos de convivência. Contudo, a análise demonstrou que a promoção de campanhas educativas e a presença de coletores incentivam o descarte adequado de medicamentos e estimulam uma mudança de comportamento e a prática de ações de proteção ambiental.

Palavras-chaves: Descarte de Medicamentos; Resíduos Sólidos; Saúde Pública; Educação em saúde ambiental; Logística Reversa.

Introduction

In the context of environmental sustainability, there is a growing concern with waste resulting from the consumption of products, among which drug residues stand out. This scenario raises relevant questions about the environmental impact and potential health risks associated with inadequate management of such waste.[1]

According to data from the Brazilian Association of Pharmaceutical Commerce, Brazil has 97,031 pharmaceutical establishments.[1] In addition, in Brazil, the proportion is one pharmacy (or drugstore) for every 2,000 inhabitants, placing the country among the ten largest consumers of medicines globally. The proximity to pharmaceutical establishments and the ease of acquiring medicines are factors that drive the increase in consumption by the majority of the Brazilian population.[2,3]

Drugs, due to their biological activities, can impact aquatic and terrestrial organisms.[4] Improper disposal in sinks, toilets and domestic garbage aggravates the problem, generating environmental impacts on rivers and soils, in addition to threatening health, given the potential hazard. Therefore, drug residues represent a risk to public health and the environment, given the presence of resistant chemical components.[5] We also emphasize that Resolution No. 358/2005 of the National Council for the Environment – CONAMA and the Resolution of the Collegiate Board of the National Health Surveillance Agency – RDC/ANVISA No. 222/2018, classifies pharmaceutical waste as belonging to Group B, which includes chemical waste with risks of toxicity, corrosivity, flammability and reactivity.[6,7]

In addition, aiming at a more accurate classification of drugs, there is the use of ATC (*Anatomical, Therapeutic, and Chemical Classification*), a system widely adopted internationally to categorize molecules with therapeutic action. The importance of the *Anatomical Therapeutic Chemical Code* (ATCC) classification lies in the fact that it provides a systematic standardization and organization of drugs, allowing a better understanding of their characteristics and therapeutic purposes. This classification facilitates the identification of drugs belonging to the same therapeutic class, making it possible to compare different treatment options within the same category. In addition, the ATC classification assists health professionals, researchers, and regulatory authorities in monitoring and analyzing the use of medicines, allowing a comprehensive view of the therapeutic landscape and contributing to decision-making based on scientific evidence.[8]

In addition, legislation such as Federal Law No. 12,305/10[9], Federal Decree No. 10.388/2020[10] and Law No. 14,730/2023[11] of the municipality of João Pessoa, established important regulations for the reverse logistics of medicines, seeking to address the problems derived from the inadequate management of medicinal residues. Reverse Logistics (LR) is a management instrument that allows the return of products discarded by the consumer to the business sector responsible for their final destination. This process occurs after the sale or use of the product and aims to reintegrate this waste into the production chain or send it for proper environmental disposal. In the case of waste such as medicines, Reverse Logistics is essential to avoid risks to public health and the environment.[12]

Decree No. 10,388/2020 also determines the obligation for pharmacies, drugstores, and basic health units to receive expired or unused medicines from consumers, ensuring their proper environmental disposal.[10] Although this measure represents an important advance in the management of pharmaceutical waste, its effectiveness comes up against a series of structural and operational weaknesses. Most establishments, including the public network, do not provide adequate collectors or even accept the return of these medicines, failing to comply with the standard. When the collectors exist, they are often poorly located, without clear signage or accessibility, which makes it difficult for the population to adhere. Added to this is the widespread lack of knowledge on the part of users, who largely do not know that they have the right and duty to dispose of it correctly. Thus, the problem is not restricted to individual behavior, but also reflects the lack of structure, inspection, and investment in environmental and health education, which compromises

the objectives of reverse logistics and perpetuates inappropriate disposal practices.[13]

The lack of adequate guidance to the population contributes critically to the incorrect disposal of medicines, which are often dumped in household garbage or toilets. In places without adequate infrastructure, such as soil waterproofing and leachate drainage systems, the active ingredients present in the drugs can infiltrate the soil and reach the groundwater, contaminating groundwater sources. This process compromises water quality, affects water bodies and ecosystems, and poses a silent but constant threat to public health.[14,15]

In addition to environmental damage, the improper disposal of medicines poses serious risks to the health of waste pickers. Much of this waste is mixed with common garbage and disposed of without any type of sorting or protection, exposing these workers to pharmacologically active substances. Studies show that the reuse of packaging by disposing of its contents directly on the ground or, even more serious, the improper consumption of the drugs found is recurrent. Such practices put not only waste pickers, but also children present in these environments, at risk of accidental poisoning or improper use, highlighting the urgency of public policies that integrate education, sanitation and safe management of pharmaceutical waste. [14,15]

From an ecotoxicological point of view, improperly disposed pharmacological waste travels through the sewage networks of cities until it reaches the treatment plants, which, in turn, are not designed to remove medicinal substances, which require special treatment. From the treatment plant, untreated pharmacological waste is discharged into rivers, lakes and seas, exacerbating environmental pollution.[14] As demonstrated in a study, estrogenic compounds, such as those found in contraceptives, pass through these treatment units and are released into water bodies, where they promote endocrine disorders in aquatic fauna, such as feminization and intersexual development in fish. This contamination is not restricted to aquatic organisms, as such compounds can bioaccumulate along the food chain, even reaching humans.[16]

Unquestionably, self-medication, a common habit among Brazilians, ends up contributing even more to generate an accumulation of medicines in homes through "home pharmacies", as they are popularly known. These are composed of over-the-counter medicines, such as anti-flu, analgesics, antipyretics, among others. As well as leftovers of medicines that need to be retained in prescriptions, such as antibiotics and psychotropics, which remain stored until the expiration date expires or indefinitely.[15] Thus, the practice of self-medication represents a threat to health, being driven by the impact of economic, political and cultural factors on its global spread, turning into a significant challenge for public health. A study conducted by the Federal Council of Pharmacy (CFF), in partnership with the Datafolha Institute, revealed that self-medication is a frequent practice among 77% of Brazilians. About 47% of these people resort to self-medication at least once a month, while 25% do it daily or at least once a week.[17]

Thus, a passive perspective of analysis involves the performance of federative entities in reverse logistics programs for household medicine waste, such as universities, considering it as a topic of public relevance. According to data from the National Institute of Educational Studies and Research (INEP) [18] published in 2018, 63% of enrollments in 106 public universities (federal, state and municipal) are concentrated in the federal network, showing constant growth over the years. That said, the importance of federal universities in promoting programs related to pressing issues of environmental education is evident and significant, aiming to sensitize the community and reduce impacts on the environment and public health. [19]

Objective

The present study aimed to analyze the profile of expired and/or unused medicines discarded by the university community at the collection point installed at the Drug Information Center (CIM) of the Department of Pharmaceutical Sciences (DCF) of the Health Sciences Center (CCS) of the Federal University of Paraíba - (UFPB), Campus I.

Methodology

In the CCS, specifically in the DCF, a collector was installed for the disposal of expired and/or unused medications. The choice of the location considered its strategic location, close to the CIM room, which facilitates access and favors educational actions aimed at raising awareness about proper disposal. The main purpose of the initiative was to offer a safe and environmentally responsible alternative for the disposal of medicines discarded by the university community, contributing to the prevention of environmental pollution and to the minimization of risks to public health.

The expired and/or unused medicine collector was acquired through a partnership with the extension project "Seas without plastic" (Image 1), coordinated by Professor Cláudia de Oliveira Cunha from the Department of Chemistry/UFPB. A notable aspect about the medicine collector is the material used in its production. This device, so relevant for the collection and correct disposal of medicines, it was made from bioplates of waste from toothpaste tubes and plastic bags and later adhesive with guidelines on the proper disposal of medicines. This innovative approach demonstrates a commitment not only to sustainability, but also with awareness about the responsible use of resources. By reusing discarded materials, the medicine collector reinforces the importance of the circular economy and the reuse of products, contributing to waste reduction and environmental preservation in a concrete and tangible way.

After collection, the drugs discarded during the period from August 2023 to January 2024 were weighed and cataloged, followed by detailed analysis of the type of drug, regulatory category, ATC classification, pharmaceutical form, type of packaging and shelf life. The medicines were carefully organized and registered, aiming at the creation of an accurate and detailed inventory. This cataloguing process allowed for a better understanding of the types of discarded drugs and their quantities, providing valuable information for further analysis. Subsequently, the waste was sent to the CCS waste shelter, where it remained temporarily stored until it was collected and incinerated by the outsourced company hired by UFPB.

Image 1: Expired or unused medicine collector

Source: Prepared by the authors

Results and discussion

Approximately 20 kg of expired and/or unused medicines were collected. This significant amount of correctly disposed of drugs resulted in a positive environmental impact, avoiding the improper disposal of these substances in the environment. The collection action proved to be an important measure to promote environmental preservation and public health, contributing to awareness of the risks associated with the incorrect disposal of medicines.

This quantity of medicines collected represents a total of 1,331 units of discarded packaging (Image 2). These packages include several types, such as blister packs or medicine card, plastic or glass bottles with varying volumes, and plastic or metal tubes. It is important to note that this number does not include boxes and package inserts, which are considered secondary packaging. This estimate re-

flects the relevance of the project with regard to the proper management of pharmaceutical waste, because the considerable amount of discarded packaging demonstrates the environmental impact potentially avoided by the correct disposal of these materials.

Image 2: Material collected

Source: Prepared by the authors

To conduct this study, we initially proceeded with the separation, counting and weighing of the drugs and their primary packaging. Subsequently, the medicinal products were classified into appropriate categories in order to enable effective waste management. In the separation of the collected drugs, they were classified according to their pharmaceutical form, covering categories such as liquids, solids, semi-solids and gases. For example, liquid medications, such as syrups and oral solutions, were separated from solid medications, such as tablets and capsules (Image 3).

Subsequently, the drugs were cataloged according to their expiration dates, the active pharmaceutical ingredient, the pharmaceutical form, the type of primary packaging, and the regulatory category of the drug (reference, similar, or generic). Based on this information, it was possible to carry out the ATC/WHO classification. This is an internationally recognized system that categorizes drugs based on their anatomy, therapy, and pharmacological characteristics. This system uses alphanumeric codes to classify drugs at different hierarchical levels, allowing the identification and understanding of the specific therapeutic class to which each drug belongs.[20] The collected information was structured in a database and submited to analysis through descriptive statistics, culminating in the elaboration of graphs and tables.

Image 3: Separation by Phamarceutical Form

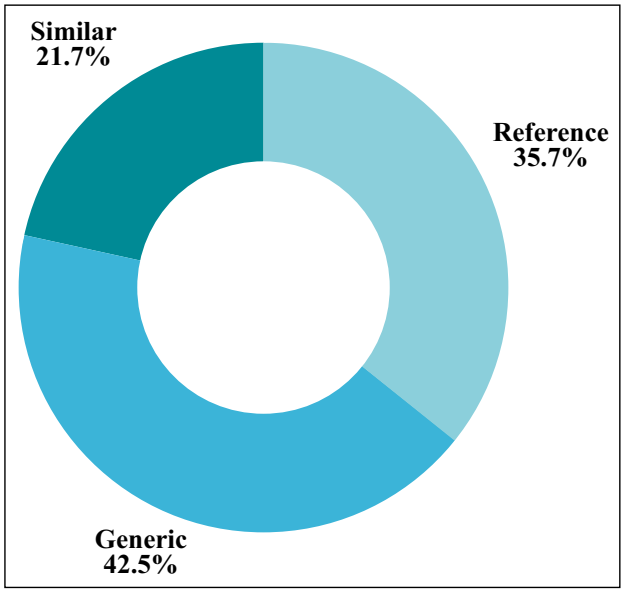
Source: Prepared by the authors

With the results, it was possible to elaborate the profile of the discard of the analyzed population in relation to the regulatory category, that is, whether consumers opt for reference, similar or generic drugs (Graph 1). Generic drugs were the most discarded, totaling 566 cataloged units (42.5%), due to the fact that they have a lower market cost, demonstrating the consolidation of the National Policy of Generic Medicines in the country. Then, the reference drugs were chosen by the patients in a slightly smaller amount, totaling 476 units (35.7%). Finally, similar drugs reached a number of 289 units (21.7%).

In the context of the correct disposal of medicines project, the ATC classification plays an important role in providing additional information on the drug residues collected. From the ATC classification, it is possible to identify which therapeutic classes are most frequently present, assisting in the development of more targeted awareness and management strategies.

Graph 2 shows a comparison between the category of the drug and the ATC code. First, it is possible to observe that the most consumed drugs belong to group "A", representing 24.8% of generic drugs, 32.4% of reference drugs and 30.1% of similar drugs. This category encompasses drugs related to the digestive system and metabolism, such as antacids, antidiabetics, laxatives, antidiarrheals, antiemetics, propulsives, in addition to encompassing vitamins and supplements.

Graph 1: Classification according to regulatory category.



Source: Prepared by the authors.

The analysis of the discarded drugs revealed that group 'C', referring to cardiac therapy, corresponded to 20% of the generic drugs identified. However, this same group had a significantly lower representation among reference (2.8%) and similar (1%) drugs. This difference may be related to the drug distribution policy in the Unified Health System (SUS), which makes several drugs available free of charge for the treatment of chronic diseases, especially cardiovascular diseases.[21]

Among the most recurrent pharmacological groups in this context, diuretics, beta-blockers, and agents that act on the renin-angiotensin system stand out, widely prescribed for the control of hypertension and other cardiac conditions. The predominance of these drugs in generic form can be attributed to the Generic Law (1999), which establishes the obligation to prescribe by the name of the active ingredient within the scope of the SUS and determines the preference for the acquisition of generic drugs whenever there is equivalence of price and conditions.[22]

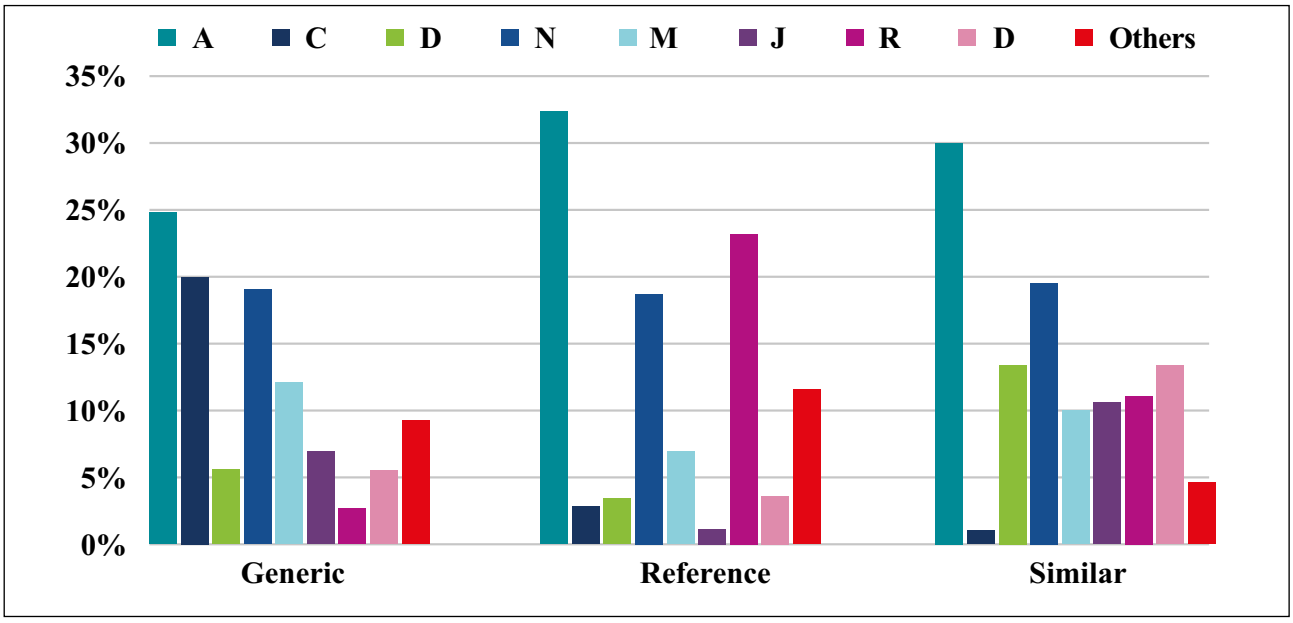
Access to medicines is a commitment of the Brazilian State, supported by constitutional principles that ensure comprehensive therapeutic care, including pharmaceutical services within the scope of the Unified Health System (SUS). This access is made possible by the presence of medicines in health networks, considering their geographical accessibility and acceptability, thus promoting the rational use of these products. Several strategies have been adopted in Brazil to implement the guidelines of the National Drug Policy and the National Policy on Pharmaceutical Services. Among these initiatives, the organization of pharmaceutical services, improvements in regulatory frameworks for access to medicines in the SUS, optimization of public financing of pharmaceutical services and increase of federal resources, among other measures.[23]

By contrast, medications intended for the respiratory system, such as those against obstructive airway diseases, are mostly paid directly by the users themselves. This hypothesis is supported by data indicating that 23.1% of the reference drugs and 11% of the similar drugs are aimed at the respiratory tract, while only 2.6% of the generics meet this purpose, which may reflect low supply in the SUS.

This situation is supported by the National List of Essential Medicines (RENAME), which, according to the ATC classification, has a significantly smaller number of drugs in category R (Respiratory System) compared to other categories such as N (Nervous System), A (Digestive System and Metabolism), C (Cardiovascular System) and J (Systemic Anti-Infectives), which concentrate the greatest diversity of medicines listed and made available by the public system.[24]

The "N" group played a substantial part in all profiles: 19.1% (generics), 18.7% (reference) and 19.6% (similar). This category encompasses drugs related to the nervous system such as analgesics, anesthetics, psycholeptics, antiparkinsonians, and antiepileptics. In relation to group M (Musculoskeletal System) drugs, the profiles include 12.0%, 6.8% and 9.8%, corresponding respectively to generics, reference and similar drugs. It is important to realize that these data bring significant results regarding the practice of self-medication. It should be noted that classes N and M are the most dominant in terms of the theme. Regarding the distribution of drugs according to the therapeutic group of the ATC classification (second level), Analgesics were the most prevalent, followed by muscle relaxants and anti-inflammatory or antirheumatic drugs, totaling the largest share among the drugs consumed in these classes.[25]

Graph 2: Comparison according to ATC classification and category.

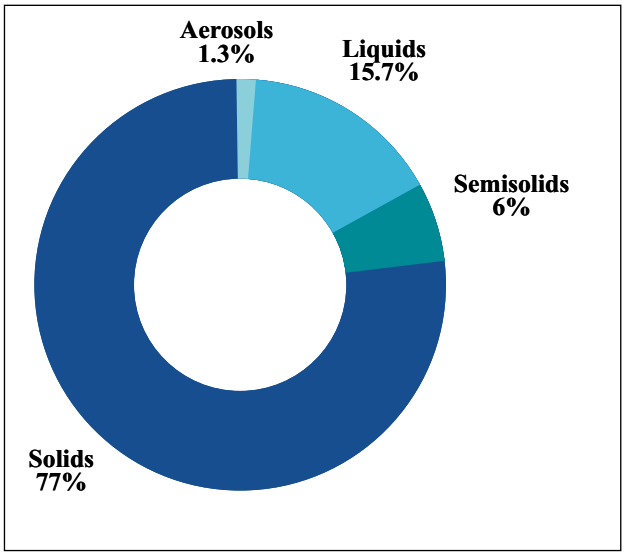


Source: Prepared by the authors.

In addition to these therapeutic groups, the pharmaceutical form of the residues was analyzed (Graph 3). It is noted that the solid pharmaceutical form is the most frequent, representing the share of 77%. This fact can be explained by the fact that solid oral dosage forms are extensively used due to the advantages associated with self-administration, stability, ease of handling, transportation, and high patient adherence.[26] Subsequently, with 15.7%, the liquid presentations that are widely used for pediatric treatment, in addition to presenting some advantages such as dose flexibility and ease of administration.[27] However, the semi-solid (6%) and gaseous (1.3%) formulations do not represent significant portions.

According to Graph 4, a relevant aspect analyzed in this initiative was the type of material used in the packaging of discarded medicines. It was observed that 60.4% of the cataloged drugs were packaged in blister packs, a form of packaging introduced in the 1960s that revolutionized the administration of unit doses.[28] Blister packs consist of individual compartments made of plastic and/or aluminum, responsible for protecting the integrity and stability of tablets or capsules, by offering a barrier against moisture, light, oxygen and contaminants.[29] Next, plastic bottles accounted for 12.3% of the packages, being more common in liquid formulations such as syrups and oral solutions.

Graph 3: Distribution by pharmaceutical form



Source: Prepared by the authors.

When looking at the data, it is noted that more than 70% of the discarded packaging was composed of plastic materials, reflecting a widespread trend in the pharmaceutical industry. It is estimated that about 200 thousand tons of plastic are produced annually for medicine packaging worldwide.[28,30] Plastics such as PE, PVC, PET, and PP are preferred for their high strength and low interaction with the active ingredients. However, flexible packaging, often consisting of multi-material laminates (plastic

combined with aluminum), is extremely difficult to recycle.[30] PVC, which is widely used in blisters, poses a significant environmental risk when improperly disposed of, especially in uncontrolled burning, such as in dumps or domestic burning, and can release highly toxic compounds such as dioxins (PCDDs), furans (PCDFs) and gases such as hydrochloric acid (HCl) and carbon monoxide (CO).[31,32]

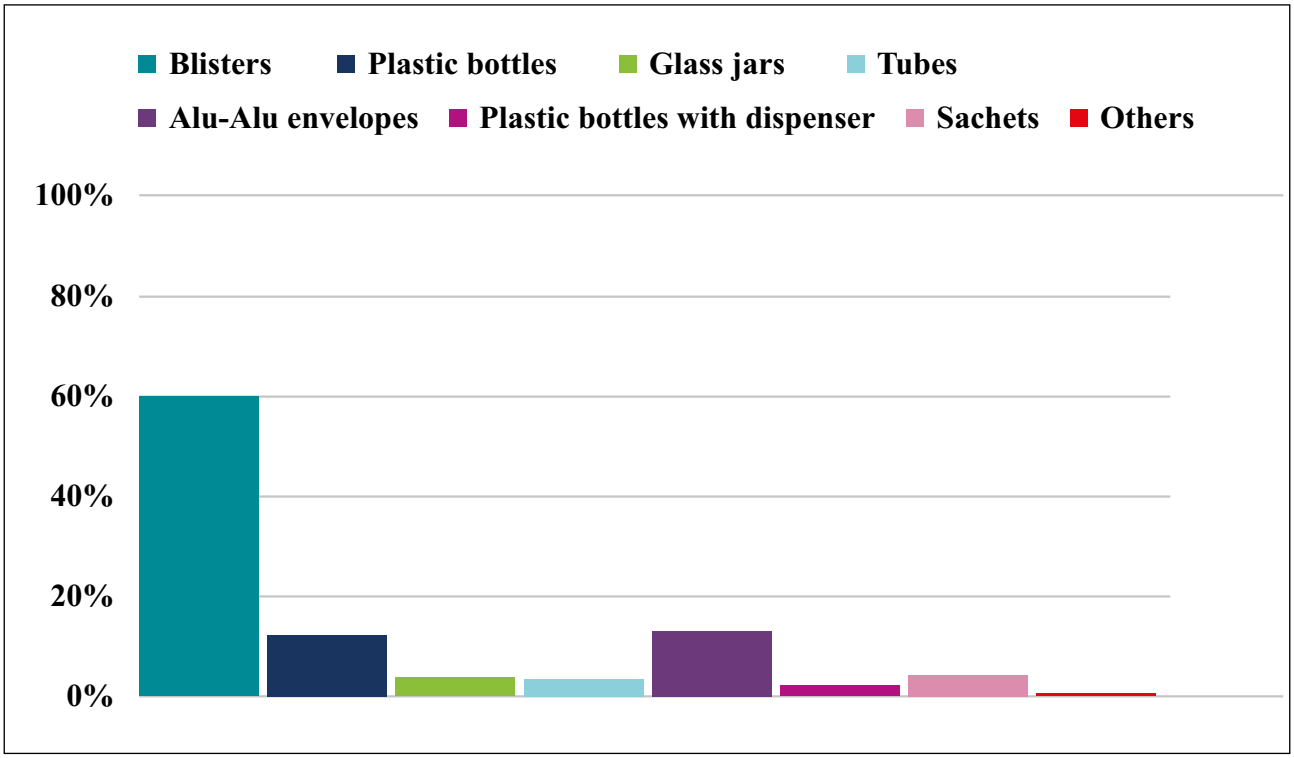
In addition, 13.7% of the packages were identified as aluminum-aluminum (Alu-Alu), composed of two layers of aluminum, offering an excellent barrier against external factors, being especially indicated for drugs sensitive to moisture, oxygen and light. Despite its protective effectiveness, this type of packaging has a higher cost compared to those made with polymers. Tubes, used for topical medications such as ointments and gels, accounted for only 3.5% of the total. These data reveal that the solid dosage form was the most prevalent among the discarded drugs.

While pharmaceutical and medical device packaging accounts for only about 1% of municipal solid waste, their complexity and composition make recycling difficult, and they are often sent to landfills or incineration.[30] This practice not only limits the recovery of materials, but also contributes to the emission of greenhouse gases, reinforcing the need for specific policies for the sustainable management of this waste.

Furthermore, according to the Brazilian Pharmacopoeia (2019)[33], it is necessary to pay attention to the expiration date. Since it is the time interval during which the product maintains its characteristics and can be used, this period is defined as useful life, based on specific stability studies.

As shown in Graph 5, most of the waste (72.8%) had expired, totaling 970 units. On the other hand, 22.5% of the medicines (338 units) were still within the expiration date defined by the manufacturer. This expressive data raises relevant questions, such as the possible abandonment or early discontinuation of prescribed treatments, in addition to the disposal of surplus purchased medications. This surplus can be explained by the fact that many medicines are not made available in fractions, leading users to purchase packages with quantities higher than those necessary.

Graph 4: Type of primary packaging.

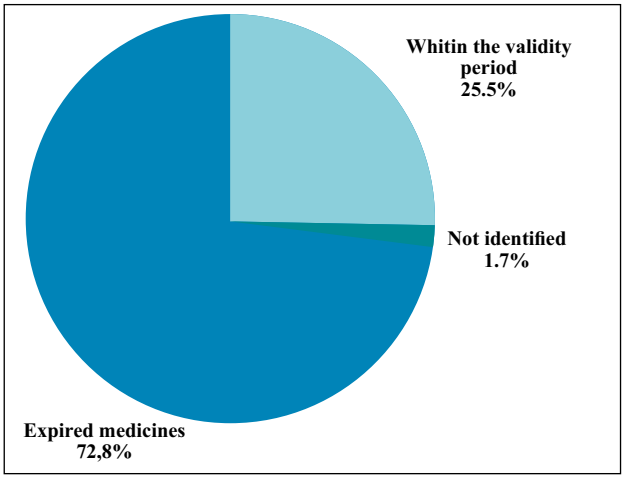


Source: Prepared by the authors.

The fractionation of medicines is a strategy that allows the dispensing of the exact amount according to the medical prescription. This practice contributes significantly to the rational use of medicines, as it avoids the accumulation of surplus medication at home, reducing the risks of self-medication, poisoning and adverse effects.[34] In addition, it contributes to reducing the environmental impact generated by improper disposal.

The data obtained reinforce the importance of the correct disposal of pharmaceutical waste, since the improper disposal of medicines, whether in common garbage or in sewage networks, represents a significant threat to the environment and public health. The active pharmaceutical ingredients present in medicines can contaminate soil, water and affect aquatic organisms, contributing to environmental pollution and microbial resistance. In addition, inadequate domestic storage and sharing of expired or over-the-counter medications can cause intoxication, adverse reactions, and aggravate clinical conditions. Such risks highlight the need to strengthen awareness strategies, expand collection points and implement public policies aimed at the safe management of this waste.

Graph 5: Expiration date of the drugs collected.



Source: Prepared by the authors.

Conclusion

Based on facts pointed out in a study[2], it is possible to reflect on the factors that lead the population to accumulate a considerable amount of medicines at home. Among the main causes identified are self-medication, use without a medical prescription, adjustments or modifications in dosages, leftovers from previously terminated treatments, occurrence of patient death, refusal or interruption of use, polypharmacy, obtaining free samples and the habit of keeping medicines for possible donations to other people.

In summary, the ease of access to pharmacies in Brazil favors the formation of the so-called "home pharmacy", resulting in home stocks of medicines. Although this practice aims at the immediate relief of symptoms through self-medication, it entails potential public health problems. Therefore, it is critical that stored drugs are monitored for quality and shelf life, and when unsuitable for use, they are properly discarded, in order to avoid poisoning and improper sharing among friends or family.[2]

In this scenario, the data obtained at the collection point installed in the CIM of UFPB reinforce the relevance of the debate on the consumption and disposal of medicines. During the six months of operation of the collection point, approximately 20 kg of pharmaceutical waste were collected, totaling 1,331 units of primary packaging. Most of the drugs collected were expired (72.8%) and were for oral use (86.1%), with a predominance of solid forms (77%). Generic drugs accounted for 42.5% of the total, followed by reference drugs (35.2%) and similar drugs (22.3%). Regarding the PCI classification, the most discarded groups were those related to the alimentary tract and metabolism (23.1%), cardiovascular system (19.2%) and nervous system (18.2%). Most of the packages were of the blister type (60.4%).

In addition, the study has relevant limitations, especially when it is not possible to determine precisely whether the medicines discarded by the university community were actually used by their own members, by their families or by individuals in their circles of coexistence. Furthermore, the interpretation of disposal data can be complex, since the amount of discarded drugs may not directly reflect the actual consumption or medical needs of the university community, thus requiring careful analysis and complementation with other forms of data collection to obtain a more accurate view.

Finally, promoting the proper disposal of medicines involves the implementation of integrated

strategies. The creation of collection points in health units and pharmacies, combined with continuous educational campaigns, It is essential to make the population aware of the importance of proper disposal, highlighting the associated environmental and health risks. It is also important to promote programs for the collection of expired or unused medicines, contributing to a safer and more sustainable management of this waste.

Authorship and Author Contributions Statement
SPBR, GRMF and STLJ: Contributed to the design of the project, analysis and interpretation of the data. SPBR: cataloguing of collected waste and writing and review of the article. GRMF: critical review of the content, conceptualization, methodology used and final approval. STLJ: writing and critical review of content, conceptualization, methodology used, editing and final approval.

Conflict of interest
There are no conflicts of interest in this project

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Data Availability Statement
The contents underlying the research text are contained in the manuscript

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