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Environmental Education Strategies in Pharmaceutical Waste Management

Estratégias de Educação Ambiental no Gerenciamento de Resíduos Medicamentosos

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Gislaine Medeiros Gonzales: Universidade Anhanguera Uniderp, Programa de Pós-Graduação em Meio Ambiente e Desenvolvimento Regional. MS, Brazil. E-mail: gimedeiros84@hotmail.com

Rosemary Matias: Universidade Anhanguera Uniderp, Programa de Pós-Graduação em Meio Ambiente e Desenvolvimento Regional. MS, Brazil.

Eduardo de Castro Ferreira: Universidade Anhanguera Uniderp, Programa de Pós-Graduação em Meio Ambiente e Desenvolvimento Regional. MS, Brazil.

Abstract

The article addressed the challenges and environmental impacts resulting from the inappropriate use of medicines and their improper disposal, highlighting the importance of environmental education and the implementation of effective public policies. The research utilized a critical narrative review of the literature, formulating the research question regarding environmental education practices and programs aimed at the proper disposal of medicines, as well as issues related to irrational use and self-medication over the last 10 years. The search was carried out on an academic websites, with inclusion and exclusion criteria, prioritizing studies in Portuguese. Of the articles analyzed, seven studies were selected that highlighted the irrational use of medicines, domestic hoarding, and inadequate disposal as significant problems. The analysis emphasized the need to integrate environmental education into curricula and to promote critical and sustainable awareness about medicine disposal. Educational initiatives and legislation, such as the National Solid Waste Policy, are considered fundamental to mitigating environmental damage and promoting responsible disposal practices. Comparing the results with the theoretical framework allowed for the enhancement of knowledge and the suggestion of directions for future research. Furthermore, raising awareness about the impact of improper medicines disposal is essential to create a society that is more responsible in terms of environmental preservation. Interactive and accessible educational programs can engage different segments of society, from schools to communities.

Keywords: Medicine. Environmental Education. Public Policies. Environment. Sustainability.

Resumo

O artigo abordou os desafios e impactos ambientais decorrentes do uso inadequado de medicamentos e de seu descarte incorreto, evidenciando a importância da educação ambiental e da implementação de políticas públicas eficazes. A pesquisa utilizou uma revisão narrativa crítica da literatura, formulando a questão de pesquisa sobre práticas e programas de educação ambiental voltados ao

descarte correto de medicamentos, além de questões relacionadas ao uso irracional e à automedicação nos últimos 10 anos. A busca foi realizada em sites acadêmicos, com critérios de inclusão e exclusão, priorizando estudos em português. Dos artigos analisados, foram selecionados e analisados sete estudos que evidenciaram o uso irracional de medicamentos, o acúmulo doméstico e o descarte inadequado como problemas significativos. A análise destacou a necessidade de integrar a educação ambiental nos currículos e de promover uma conscientização crítica e sustentável sobre o descarte de medicamentos. As iniciativas educacionais e a legislação, como a Política Nacional de Resíduos Sólidos, são apontadas como fundamentais para mitigar os danos ambientais e promover práticas responsáveis de descarte. A comparação dos resultados com o referencial teórico permitiu melhorar o conhecimento e sugerir direções para pesquisas futuras. Além disso, a conscientização sobre o impacto do descarte inadequado de medicamentos é fundamental para formar uma sociedade mais responsável em relação à preservação ambiental. Programas educativos interativos e acessíveis podem engajar diversos segmentos da sociedade, desde escolas até comunidades.

Palavras-chave: Medicamentos. Educação Ambiental. Políticas Públicas. Ambiente. Sustentabilidade.

1 Introduction

Continuous advancements in health science and the development of new treatments have brought significant benefits to the population by increasing the production and availability of medications for various conditions (Pinto *et al*., 2014). However, these advances also pose considerable challenges regarding the appropriate use and safe disposal of these products. According to the World Health Organization (WHO, 2024), approximately half of all medications are prescribed, dispensed, or used improperly. Furthermore, although self-medication can help reduce the burden on healthcare systems by addressing mild and transient conditions, when done without proper care, it can lead to misdiagnoses, incorrect dosages, and adverse events (Silva; Morgado, 2022).

According to Alencar *et al*. (2014), irrational use, the lack of unit dose sales, the distribution of free samples by pharmaceutical companies, and the media influence in promoting consumption have significantly exacerbated this issue. Despite the importance of medications in healthcare systems, their management faces serious obstacles due to irrational use and the improper accumulation of medicines in households (Barreto, 2017).

Managing solid waste has become a critical challenge due to health and environmental risks, especially regarding the improper medications disposal. These chemical compounds can persist in the environment for long periods, affecting aquatic ecosystems and compromising the quality of drinking water for the population (Ramos *et al*., 2017).

When medications are disposed of improperly, their active ingredients end up contaminating

the environment, primarily through sewage systems that carry these residues into water bodies, resulting in pollution. Drinking water treatment systems are often unable to effectively remove or neutralize these pharmaceutical molecules, which frequently have complex chemical structures that are difficult to degrade (Santos, Machado; Lacerda, 2015).

Specific groups of pharmaceuticals, such as antibiotics and estrogens, require particular attention due to their environmental and health impacts. Recent studies have highlighted how estrogens found in water can induce the phenomenon of "imposex" in mollusks, leading to the development of male sexual characteristics in females and the sterilization of affected populations (Lima *et al*., 2017). The lack of adequate infrastructure for the collection and efficient treatment of these residues also contributes to emergencies such as antimicrobial resistance, further complicating the efforts of health and environmental authorities in Brazil (Faray *et al*., 2020; Tonet *et al*., 2020).

As Barros, Prado and Oliveira (2016) emphasizes, this educational model prepares citizens for critical reflection and for actions capable of transforming the current system. In this context, the effective implementation of the Brazilian National Solid Waste Policy (PNRS) largely depends on environmental education. Educational strategies focused on this issue are essential to raise public awareness about the importance of proper waste management, reinforcing the PNRS's objectives of promoting a more balanced and healthy environment for future generations. Through campaigns, school programs, and community actions, environmental education raises awareness of the risks associated with improper disposal and encourages sustainable practices. By equipping individuals with theoretical and practical knowledge about reducing, reusing, and recycling materials, it directly contributes to reducing the amount of waste generated and facilitates its management. It is essential to invest in educational programs that raise awareness about proper disposal and promote sustainable practices. This includes expanding collection programs in pharmacies and health centers and adopting safe treatment technologies. These strategies can help protect the environment and safeguard public health (Penteado, 2010).

Therefore, the guiding question of this article is: What environmental education practices and programs aimed at the proper disposal of medications have been described in the literature over the past 10 years?

2 Development

2.1 Methodology

This research was conducted through a critical narrative review, focusing on practices related to the disposal of medications and their connection with environmental education. The choice of a critical narrative review was due to its ability to describe, synthesize, and analyze the state of the art regarding the study object of this article, enabling a deep reflection on the existing knowledge (Adams, 2006; Rother, 2007; Green; Johnson).

The study was guided by the following research question: "What environmental education practices and programs aimed at the proper disposal of medications have been described in the literature over the past 10 years?"

To ensure the relevance of the selected studies, inclusion and exclusion criteria were established. Only articles addressing medication disposal practices and environmental education programs, published in Portuguese over the last ten years (from 2014 to 2024), were included.

Duplicate studies, those not directly addressing the topic, or those with unclear methodologies were excluded. The search was carried out using Google Scholar – Health, with the keywords *"descarte correto de medicamentos"* (proper disposal of medications) and *"educação ambiental"* (environmental education), ensuring that the selected materials aligned with the research objective.

The studies selection and analysis followed the PICO protocol (Population, Intervention, Comparison, Outcomes). The population consisted of individuals and communities engaged in medication disposal practices; the intervention involved environmental education programs and actions focused on proper medication disposal; the comparison referred to the analysis of different approaches and programs; and the outcomes considered were the evidence of the impact of the analyzed practices.

After the search, 16 initial studies were identified. Of these, one study was excluded due to duplication, seven were not aligned with the specific objectives of the research, and one could not be accessed.

Thus, seven studies were selected for final analysis, as illustrated in the PRISMA flowchart (Figure 1). During the analysis phase, each study was evaluated for methodological rigor, contributing to the identification of gaps in the literature. A comparative strategy was employed, correlating the extracted data with the existing theoretical framework, allowing for a critical and detailed discussion

on medication disposal practices in the context of environmental education. The data analysis aimed to provide support for future research and the development of effective public policies in this area.

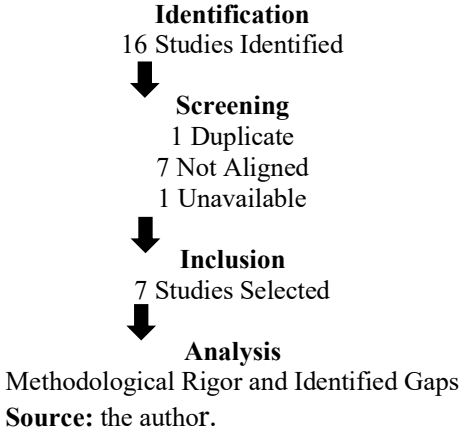

Figure 1 - PRISMA flowchart, adapted for the narrative review, used to illustrate the study selection process, ensuring transparency and clarity in the methodological design

Source: the author.

2.2 Discusion

The first study analyzed (Table 1) was conducted by Alencar *et al.* (2014), who investigated healthcare workers' perceptions regarding the disposal of medications and examined how this practice takes place in family health units in a municipality in the interior of Bahia, Brazil.

The research, which was qualitative and exploratory in nature, involved nurses, nursing assistants, community health agents, and pharmacists linked to Pharmaceutical Assistance and Health Surveillance services. The methodologies adopted included semi-structured interviews, systematic observation, and the use of pre-developed scripts. Content analysis was used for data evaluation.

The results revealed a limited understanding among healthcare workers about the proper disposal of medications, inconsistent practices in the implementation of regulations, and communication failures between Health Surveillance and other health services.

The study emphasized the need to develop effective strategies that encompass the entire process - from management to prescription and use of medications - requiring greater political, economic, and social engagement. It became evident that in order to mitigate inadequacies in medication disposal, it is essential to implement environmental education in the workplace.

Table 1 - Data from the selected and analyzed studies

Title	Year	Type	Author(s)
1. Medication Disposal: An Analysis of the Practice within the Family Health Program	2014	Article	Alencar *et al*. (2014)
2. Environmental Education and Solid Waste: Medication Disposal as a Public Health Issue	2016	Article	Viana, Viana, and Viana (2016)
3. Inadequate Disposal of Expired Medications: Harmful Effects on Health and the Population	2019	Article	Almeida *et al*. (2019)
4. Medication Disposal: Reverse Logistics	2022	Article	Guimarães *et al.* (2022)
5. Public Knowledge in Itapetininga – SP about Medication Disposal	2022	Article	Silva and Morgado (2022)
6. The Role of the Pharmacist in the Reverse Logistics of Medications in Brazil: An Integrative Review	2022	Article	Oliveira *et al*. (2022)
7. Perspectives of Health Professionals and Students on the Health–Environment Interface	2024	Article	Brandi, Pinheiro, and Castilho (2024)

Source: the author.

The article entitled "Environmental Education and Solid Waste: Medication Disposal as a Public Health Issue" by Viana, Viana, and Viana (2016) highlighted the importance of Critical Environmental Education in promoting reflection on the socio-environmental impacts of the improper medications disposal. The study explored legislation on solid waste, emphasizing the role of environmental education in raising awareness within society regarding the sustainable management of such waste. The results indicated that medications are considered chemical substances that cause negative environmental impacts. Population contributes to this issue by disposing of medications improperly, directly affecting the environment through water and soil pollution.

The study conducted by Almeida *et al*. (2019), titled "Inadequate Disposal of Expired Medications: Harmful Effects on Health and the Population," revealed that a large portion of the population is unaware of the correct procedures for medication disposal. Typically, these products are discarded with household waste, especially when expired, as they are seen as no longer useful.

Although the methodology presented in the study proved relevant, its effectiveness depends on the implementation of continuous and adaptable strategies. The analysis of collected data, along with the development of thematic categories, significantly contributed to understanding participants' perceptions on the topic. However, the complexity involved in learning processes and behavior change suggests the need for a more dynamic and personalized approach.

In this context, integrating Environmental Education (EE) into Pharmaceutical Assistance emerges as a promising strategy, capable of fostering behavioral change and mitigating the negative environmental impacts associated with the improper medications disposal . However, to ensure the sustainability of the outcomes, it is essential to recognize and address the challenges and resistance that may arise during the educational process (Almeida *et al*., 2019).

The studies emphasized the importance of incorporating educational practices that promote critical awareness and the adoption of responsible behaviors regarding medication disposal, aiming

to reduce environmental harm and encourage a sustainable approach to both health and education.

Penteado (2010) discussed global initiatives and commitments made by states, NGOs (Non-Governmental Organizations), and documents resulting from major conferences such as ECO-92, including Agenda 21 and the Biodiversity Treaty. These initiatives aim to expand the dissemination of information on environmental issues and mobilize efforts to increase environmental awareness.

The study "Medication Disposal: Reverse Logistics" by Guimarães *et al*. (2022) addressed the issue of improper disposal of expired or unused medications, which are often thrown in household trash due to the lack of specific collection points and public unawareness of associated risks. The research was conducted with 300 adult individuals aged 18 or older, residents of São João da Boa Vista. They answered a questionnaire assessing their knowledge on medication disposal and were subsequently instructed on the correct method and location for proper disposal.

The study also revealed that despite regulations on medication disposal, such as the 2010 National Solid Waste Policy and Federal Decree No. 10.388/2020, most participants still practice self-medication, store drugs improperly, and dispose of them incorrectly. Many were unaware of proper disposal sites in the municipality and reported never having received information on the subject. The findings demonstrated the need to expand the number of collection points and adopt educational measures, which are fundamental to the decree implementation.

These results pointed to the need for public education and awareness regarding proper medication waste management. The study emphasized that, despite legislative advancements, public authorities must take effective steps to inform and educate society to ensure the implementation and enforcement of reverse logistics for medications (Guimarães *et al*., 2022).

Given these findings, it is important to discuss specific measures to reduce improper medication disposal and thus mitigate its impact on public health and the environment.

Studies by Aragão *et al*. (2020) in the Southeast Region of Brazil identified two major regulatory gaps in proper medication disposal: the appropriate handling of household-generated waste and the treatment of different pharmaceutical classes. These gaps highlight the need for stronger regulatory efforts and enforcement of disposal practices.

Therefore, raising user awareness about the environmental and health risks associated with improper medication disposal is recommended. Measures such as unit dose dispensing, where only the exact prescribed quantity is sold to the patient, can help reduce waste and improper disposal.

In addition, the single-dose system - where patients receive medications in precise doses and schedules and hospitals provide unit doses based on patient's needs - has proven effective in countries such as the United States, Canada, and across Europe. This system minimizes waste and ensures that patients receive only what is necessary, reducing the risks of self-medication and improper storage (Aragão *et al*., 2020).

The study by Silva and Morgado (2022) in Itapetininga, São Paulo, Brazil, addressed the issue of improper medication disposal and its contribution to environmental contamination. The results showed an alarming scenario, with only 2.7% of participants reporting proper medication disposal practices.

The high frequency of storing medications for future use or donation to third parties highlights the urgency of educating the public on responsible disposal. The study also provided solid support for the development of public policies and educational programs aimed at reducing environmental impacts and promoting responsible practices in medication waste management within the Itapetininga community.

Oliveira *et al*. (2022) investigated the role of pharmacists in the reverse logistics of medications in Brazil through an integrative literature review on the return process of expired or unused medications. The findings indicated that the country faces significant challenges regarding the collection, treatment, and final disposal of biological and chemical waste, which significantly impacts public health and the environment.

Additionally, the study emphasized the need to install medication disposal bins in healthcare facilities, particularly in pharmacies and drugstores. Pharmacists must take ownership of this issue and act as agents of change—not only by influencing public behavior but also by raising awareness among public and private managers about the importance of reverse logistics in Brazil and globally.

The research highlighted the urgent need for investment in environmental education campaigns and improvements in collection infrastructure to mitigate the adverse impacts of improper medication disposal on public health and the environment.

Finally, the study by Brandi, Pinheiro, and Castilho (2024) reviewed national classroom-based experiences related to medication use. The authors conducted a literature search in the PubMed, BVS, Scielo, and Google Scholar databases, selecting 22 articles for reading and data analysis. The analysis revealed that most studies focused on activities with students, mainly in public high schools. The main topics covered were: concepts, self-medication, disposal, and antibiotic use—typically linked to Biology, Chemistry, and Natural Sciences subjects.

The reviewed studies emphasized the need for broad awareness—both in the training of healthcare professionals and in basic education—to promote responsible practices. There is a need for more public initiatives focused on health education related to medication use.

Although the studies addressed different aspects of the issue, they converged in identifying gaps in training and regulation, suggesting that strong educational efforts and public policies are essential to mitigate the environmental and public health impacts of improper medication disposal.

Educational initiatives such as those proposed by Brandi, Pinheiro, and Castilho (2024) and Alencar *et al*. (2014) demonstrated that raising awareness among healthcare professionals and the

public can lead to positive behavioral changes and more responsible practices in medication waste management. However, the studies also highlighted ongoing issues such as insufficient infrastructure for reverse collection of expired medications and low public adherence to safe disposal practices.

The research by Silva and Morgado (2022) and Oliveira *et al*. (2022) stressed the need to improve the implementation of reverse logistics policies and ongoing education about proper disposal methods.

Furthermore, integrating environmental education, as proposed by Brandi, Pinheiro, and Castilho (2024), has proven promising for fostering greater awareness of the environmental issues related to pharmaceutical waste in schools. This approach provides tools for individuals to reflect critically on their consumption and disposal behaviors.

Environmental education is a key strategy to reduce the impacts of improper medication disposal on human health and the environment. There is an urgent need to raise public awareness and promote the sustainable management of pharmaceutical waste. To achieve this, it is essential to strengthen public policies, expand collection infrastructure, and invest in ongoing educational programs.

Recent literature shows significant progress in raising awareness about the environmental and health risks related to incorrect medication disposal. Initiatives in schools, universities, pharmacies, and among healthcare professionals have proven effective in promoting responsible use and safe disposal, especially when aligned with public policies.

The establishment of the National Reverse Logistics System for Medications (Decree No. 10.388/2020) represents an important regulatory milestone, reinforcing the shared responsibility among the government, private sector, and society.

However, challenges remain, such as the lack of nationwide coverage of collection points, the need for professional training, and the absence of broader and more accessible communication campaigns. Addressing these gaps requires integrated and collaborative actions across all sectors of society.

3 Conclusion

Although significant progress has been made, strengthening environmental education as a permanent tool for social and cultural transformation remains essential to ensure the consolidation of sustainable practices in medication disposal.

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