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Storage and disposal of pharmaceuticals at home: a systematic review

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Abstract *This study's objective was to analyze Brazilian and international scientific evidence on the reasons people store medication at home and the disposal methods used. This systematic literature review includes studies published from 2001 to 2016 and indexed in PubMed, Lilacs and Elsevier's Scopus Database, using the following key words: Disposal of medicines in household, Disposal of drugs expired, Residential expired drugs, Management of expired medications in household. Thirty-three studies were selected after applying inclusion and exclusion criteria. The studies reveal that the main reasons people keep a stock of medicines at home include the possibility of future use, leftovers from previous treatments, and self-medication. Inappropriate disposal methods prevail, such as throwing medicines in the household trash or flushing them into the sewer. Some countries have adopted programs to educate on proper storage and disposal of medicines, though only one study describes a national program guiding these practices that is free of charge. Evidence shows there is a need to implement public policies intended to provide guidance on the proper storage and disposal of medicines at home.*
Key words *Medication storage, Solid waste collection, Collection routes, Housing*

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Introduction

Technological development has enabled various advancements in the sciences, especially in the field of health. In this context, advancements in the fields of pharmaceutical sciences and medicine stand out because they expanded the possibilities and quantity of medications available for commercialization and consumption[1].

Medications are efficacious in treating numerous diseases and are essential to care for the health of the population. Estimates of the World Health Organization (WHO), however, indicate that 50% of all medications are prescribed, administered or used wrongly[2]. According to the Centers for Disease Control and Prevention (CDC), approximately 80 million antibiotic prescriptions are inappropriately prescribed every year[3].

In 2016, the Pan American Health Organization issued new guidelines on the rational use of medications, including how to store medications at home[4]. Even though these guidelines propose the rational use of therapeutic products, the storage of medications at home is still a common practice. In various countries around the world, the culture of keeping a supply of medications at home leads to the irrational use of medications, favoring self-medication, the occurrence of accidents, and consequent accumulation of several chemicals at home[5,6].

The National Medicines Policy is currently in force in Brazil. Its objective is to ensure the population has access to essential and quality medications and it promotes the rational use of medicines[7]. Criteria for the prescription, dispensing, control, packaging and labeling of medicines were established by resolutions RDC 20/2011 and RDC 68/2014, ANVISA (National Agency of Sanitary Surveillance)[8,9]. Despite regulations concerning the rational use, control and dispensing of medications, accumulation of medications and inappropriate disposal are still a concern for public health and the environment[10-12].

Various Brazilian and international studies report the presence of pharmaceuticals and active principles that contaminate the soil and water[13,14]. There are, however, gaps that hinder understanding the reasons the population stores medications and methods commonly used to dispose of medications[1,15,16]. In this context, this study's objective was to analyze Brazilian and international scientific evidence addressing the reasons people store medicines at home and how they usually dispose of them.

Method

This Systematic Literature Review adopted the methodological approach described by Olsen[17] and adapted by Ferreira et al.[18], which includes: the establishment of the research problem; a relevance test establishing inclusion and exclusion criteria; the databases and key words; and a subsequent process to select studies.

The following guiding question was adopted: What scientific evidence do Brazilian and international studies report in regard to the reasons people store medications at home and the disposal methods used?

The following inclusion criteria were established in the Relevance Test (RT)[17,18]: a) Studies addressing the storage and discarding of medications; b) Studies addressing medications at home; c) Studies addressing leftover medications, whether they are expired of not; d) Studies published from 2001 and 2016; and e) Studies written in English, Portuguese or Spanish. Reviews, case reports, communications, monographs and abstracts were excluded.

The search for papers was conducted in June 2017 in the following databases: Latin American and Caribbean Health Sciences Literature (LILACS), U.S. National Library of Medicine and the National Institutes Health (PUBMED) and Elsevier's Scopus Database, using the following key words: Disposal of medicines in household OR Disposal of expired drugs OR Residential expired drugs OR Management of expired medications in household.

The search in the databases, application of RT, and selection of the full texts of papers were independently performed by two researchers in order to verify the method's objectivity, while divergences were settled by a third researcher.

As shown in the flowchart in Figure 1, consulting the databases resulted in 268 papers, 47 of which were excluded because they appeared twice. RT was then applied to the abstracts and a total of 63 papers remained. RT was applied a second time, now using the full texts, and 33 studies remained. A qualitative analysis of these 33 papers is presented here.

Results

Thirty-three studies were included in this review, 9 (27.3%) of which were conducted in Brazil; 4 (12.1%) in the United States of America; 3 (9.1%) in the United Kingdom; 2 (6.1%) in New

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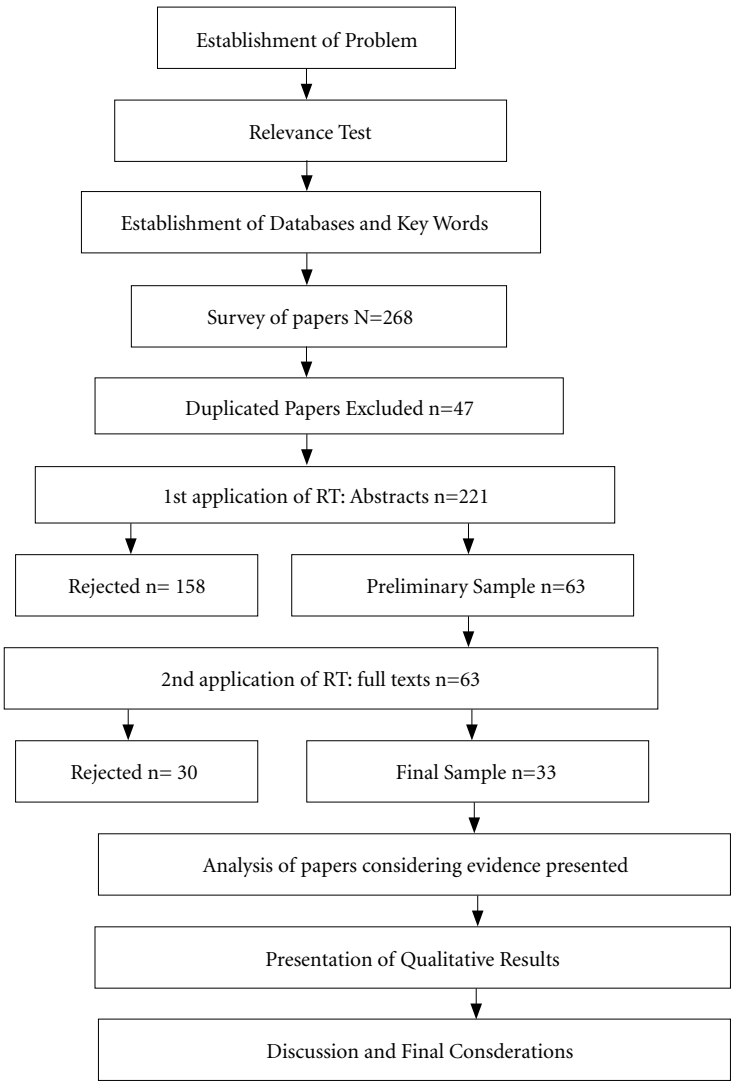

Figure 1. Flow diagram for conducting a Systematic Literature Review (RSL).

Source: Adapted from Olsen[17].

Zealand and Serbia; and 1 (3.0%) study was conducted in India, Mexico, Qatar, Kuwait, Africa, Costa Rica, Ireland, Colombia, Portugal, Nigeria, Australia, and Venezuela.

Evidence was organized in a synoptic table according to author(s), year, periodical, geographical location, reasons people store medicines, and disposal methods (Chart 1).

As shown in Chart 1, the studies show that the main reasons to store medication include: keeping for future use 12 (36.4%); leftover from previous treatment 12 (36.4%); and self-medication 9 (27.3%). The disposal routes more frequently mentioned were: household trash 22 (66.7%) and the sewer 21 (63.6%).

Discussion

Household storage of medicines

The reasons people store medicines at home are diverse, among which, the following stand out: potential use in the future; acquisition without medical prescription; change of treatment or change in dosage; leftover from previ-

Chart 1. Synopsis of studies addressing the reasons people store medications at home and disposal methods.

Author(s) (Year) Periodical	Geographical location	Reason to store medications	Disposal methods
Bound; Voulvoulis[19] (2005) Environ Health Perspect	United Kingdom	Did not address the storage of medications	Household trash; flushed into the sewer; pharmacies/health facilities.
Fanhani et al.[20] (2006) Arq. Ciênc. Saúde UNIPAR	Brazil	Self-medication; leftover from previous treatment	Did not address disposal methods.
Ekedahl[21] (2006) Pharm World Sci	Sweden	Expired medication; death; leftover from previous treatment; clinical improvement; change of treatment.	Did not address disposal methods.
Jiménez et al.[22] (2006) Rev. costarric. salud pública	Costa Rica	Keep for future use; lack of adherence to treatment.	Regular trash flushed into the sewer; disposed in the soil; pharmacies/health facilities
Seehusen and Edwards[23] (2006) J Am Board Fam Med	United States of America	Did not address the storage of medications	Household trash; flushed into the sewer; pharmacies/health facilities
Abahussain et al.[24] (2006) Med Princ Pract	Kuwait	Changed or abandoned treatment.	Household trash; flushed into the sewer; pharmacies/health facilities.
Bound et al.[25] (2006) Environ Toxicol Phar	United Kingdom	Keep for future use.	Solo; flushed into the sewer; pharmacies/health facilities; and donations.
Musson et al.[26] (2007) J Air Waste Manag Assoc	United Kingdom	Did not address the storage of medications	Household trash; flushed into the sewer; pharmacies/health facilities.
Margonato et al.[27] (2008) Cad Saúde Pública	Brazil	Excess purchase/ Self-medication.	Did not address disposal methods.
Bueno et al.[28] (2009) Rev Ciênc Farm Básica Apl	Brazil	Keep for future use; donation; self-medication.	Household trash; flushed into the sewer; disposal in the soil; pharmacies/health facilities.
Braund et al.[29] (2009) Pharm World Sci	New Zealand	Change of treatment; lack of adherence to treatment.	Did not address disposal methods.
James et al.[30] (2009) Ann Pharmacother	New Zealand	Excessive supply; change of treatment; lack of adherence to treatment; death; leftover from previous treatment.	Did not address disposal methods.
Kotchen et al.[31] (2009) J Environ Manag	United States of America	Did not address the storage of medications	Household trash; flushed into the sewer; pharmacies/health facilities.
Gupta et al.[32] (2011) Int J Pharm Sci Res	India	Did not address the storage of medications	Household trash; flushed into the sewer.
Kheir et al.[33] (2011) Drug Healthc Patient Saf	Qatar	Did not address the storage of medications	Household trash; flushed into the sewer; pharmacies/health facilities.
Sasu et al.[34] (2012) Waste Manag Res	Africa	Keep for future use.	Household trash; flushed into the sewer; heat; pharmacies/health facilities.
Beckhauser et al.[35] (2012) Rev Ciênc Farm Básica Apl	Brazil	Leftover from previous treatments	Did not address disposal methods.
Laste et al.[36] (2012) Ciênc Saúde Colet	Brazil	Self-medication	Did not address disposal methods.
Kusturica et al.[37] (2012) Int. J. Clin Pharm.	Serbia	Did not address the storage of medications	Household trash; flushed into the sewer; burned; pharmacies/health facilities.
Wieczorkiewicz et al.[38] (2013) Ann. Pharmacother.	United States of America	Did not address the storage of medications	Household trash; flushed into the sewer; pharmacies/health facilities.

it continues

Chart 1. Synopsis of studies addressing the reasons people store medications at home and disposal methods.

Author(s) (Year) Periodical	Geographical location	Reason to store medications	Disposal methods
Iob et al.[39] (2013) Infarma - Ciências Farm.	Brazil	Leftover from previous treatment; keeps for future use.	Household trash; flushed into the sewer; burn; pharmacies/health facilities.
Vellinga et al.[40] (2014) Sci. Total Environ.	Ireland	Keeps for future use; lack of knowledge about proper disposal; donation.	Household trash; flushed into the sewer; pharmacies/health facilities.
Lehardt et al.[41] (2014) UNOPAR Cient Ciênc Biol Saúde.	Brazil	Keeps for future use.	Household trash; flushed into the sewer; pharmacies/health facilities.
Gracia-Vásquez et al.[42] (2014) Int J Clin Pharm	Mexico	Excessive prescription; self-medication; free samples; change of treatment or non-adherence to treatment; death.	Household trash; flushed into the sewer
Pinto et al.[43] (2014) Eng. Sanit. Ambient.	Brazil	Did not address the storage of medications	Household trash; flushed into the sewer; pharmacies/health facilities; recyclable waste.
Lystlund et al. [44] (2014) J Am Pharm Assoc.	United States of America	Clinical improvement; change of treatment; free samples.	Household trash; flushed into the sewer; dispose in the soil.
kusturica et al.[45] (2015) Cent. Eur. J. Public Health	Serbia	leftover from previous treatment; self-medication.	Did not address disposal methods.
Piveta et al.[46] (2015) Semina: Ciências Biológicas e da Saúde	Brazil	Keep for future use.	Household trash; collection sites; flush into the sewer.
Bergen et al.[47] (2015) Australian Prescriber	Australia	Death; change of treatment; lack of confidence in the safety and efficacy of treatment.	Proper disposal: National take-back program and elimination of unwanted pharmaceuticals.
Quijano-Prieto et al.[48] (2016) Rev Salud Pública	Colombia	Clinical improvement; treatment was suspended.	Household trash; collection sites.
Dias-Ferreira et al.[49] (2016) Waste Manag Res	Portugal	Keep for future use; leftover from previous treatment; excessive prescription.	Pharmacies/health facilities; household trash; flushed into the sewer; recyclable waste.
Banwat et al.[50] (2016) Trop J Pharm Res	Nigeria	Self-medication; leftover from previous treatment; keep for future use.	Household trash; flushed into the sewer; burned.
Correia; Marcano[51] (2016) Rev Int Contam Ambie	Venezuela	Self-medication; leftover from previous treatments; keep for future use.	Household trash; flushed into the sewer.

ous treatment; patient's death; lack of adherence or treatment abandonment; excess supply and prescription of excessive dosage; free samples; and the possibility to donate to other people[20-22,24,27-30,34-36,39,40,42,44,46-51].

The accumulation of medicines at home may lead to misuse and expose the population to the potential toxicity of pharmaceuticals[26,41,43,51]. Such behavior reflects a persistent culture in different regions of the world in which the risk arising from inappropriate use of active principles and/or adverse responses associated with the intake of certain medications is trivialized[39].

The sale of medications in quantities greater than that specified by medical prescriptions also induces people to store medicines at home. Strategies encouraging the fractional sale of medications, according to dosage prescribed, are necessary given the generation and accumulation of residue and contamination of the environment[13,35,39,43,52-54].

Other determinant factors are prescription and dispensing errors or successive changes of treatments that force patients to make excessive purchases of medications and the need felt to keep them afterwards because of economic costs,

intending to use them in the future or give them to others in order to avoid waste of money.

Intense publicity campaigns encourage the purchase and storage of medicines because they create expectations of cure and relief[39]. The distribution of free samples as provided by pharmaceutical labs is also a preponderant factor leading to the maintenance of "small pharmacies" at home[13,43,52,55-59]. Keeping pharmaceuticals at home is a public health problem that should be discouraged to minimize potential disease in the population[20,22,27,32,35-40,44,60].

Educational actions implemented among the population are measures that can discourage the maintenance of medicines at home and self-medication[39]. In this sense, qualified healthcare workers can provide guidance as to the correct use and storage of medications at home and help educate the population[21,23,25,27,34,36,40,44].

Disposal of medicines at home

The studies listed in this review indicate that the main methods used to dispose of medications at home are: the household trash; flushing into the sewer; returning to pharmacies/healthcare facilities; disposing in the soil; and burning them[19,22-26,28,31-34,37-44,46-51].

The management of household pharmaceuticals disposal is a world challenge. Tons of residue are collected daily and most are improperly managed, causing undesirable and irreversible effects on the environment[16,51,52,59,61]. Disposing of medications in the sewer or in the soil, by combining them with urban waste, represent a threat to human health, to the integrity of the environment and biodiversity of the planet[1,25,33,41,49,51,62].

The presence of pharmaceuticals in the soil and water, especially antibiotics, estrogen, antineoplastic and immunosuppressant agents, may generate potentially toxic byproducts that do not easily decompose, with teratogenic, mutagenic, and carcinogenic effects in animal and human populations[19,22,35,37,38-40]. Disposal by fire, a common procedure in rural households, also represents risks to human health and to the environment due to the emission of pollutant toxic gases[37].

In an attempt to decrease the environmental impact caused by the inappropriate disposal of residues in Brazil, ANVISA implemented RDC 222 in 2018 to regulate good practices of Health Services Residue Management and determined that the residues of pharmaceuticals disposed by (or seized from) health services, pharmacies, drug stores, and distributors of medicines need to be treated or discarded in hazardous waste landfills – Class I[63]. However, there is no national public policy regulating the collection and the household disposal of pharmaceuticals. Such regulation is individually implemented by some cities and states, such as in Rio Grande de Sul (in the cities of Passo Fundo and Porto Alegre), Amazonas, Paraíba, Mato Grosso (in Cuiabá), Acre, and Paraná, or through educational actions and specific strategies, such as the Shared Conscious Disposal Program adopted by companies, consumers, and public agents that establish collection sites, where the population can discard medications[64-66].

International studies report programs intended to collect and properly dispose of medicines, such as the "Take-back Program" developed and implemented in New Zealand, Ghana, the United States, Ireland, and Sweden. These programs are intended to sensitize the community about the importance of choosing environmentally-friendly options to dispose household medicines, as well as encourage the return of expired and/or unused medications[21,26,30,34,44]. Only Australia adopted a public policy to appropriately dispose of medications at a national level free of charge, the so-called National Return and Disposal of Unwanted Medicines (NATURUM), which was implemented in 1998 and is available in all Australian pharmacies[47].

The findings reveal that simply implementing collection sites or take-back programs is not sufficient if the population is not educated to change its perceptions and day-to-day habits[1,25,39,43,49]. The population needs to receive health education to learn and recognize proper practices for keeping and discarding medicines. Practices that favor ecologically proper methods to dispose of medicines should be encouraged in the population not only for today's but also future generations[25,41,50].

Final considerations

The studies show that the storage of medications at home is a common practice in various countries, a situation that facilitates self-medication. The methods used to dispose of pharmaceuticals present risks to public health, considering that the main routes used to discard medicines include throwing them in the household trash and flushing them into the sewer.

The expansion of health education programs is essential to sensitizing the population regard-

ing safe ways to store and discard medicines, given the challenge these problems represent for human health and the environment.

Collaborations

VM Constantino, BM Fregonesi, KAA Tonani, GS Zagui, APC Toninate, ERS Nonose, LA Fabriz and SI Segura-Muñoz participated in all stages and relevantly in the design and development of the text.

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