



Leftover and expired medicines in households: Is their storage and disposal a public health problem?

Medicamentos sobrantes y caducados en el hogar ¿su almacenaje y desecho representan un problema de salud pública?

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ABSTRACT Leftover and expired medicines in households must be disposed of in such a way as to ensure the population's safety, while generating the lowest possible negative impact on the environment. In this context, the aim of this study was to explore drug disposal practices related to home medicine cabinets among medical students in Quito, Ecuador. Between December 2018 and January 2019, 498 students from different semesters were surveyed. Data show that up to 30.3% of students had flushed their medicines down the toilet at least once, while 7.2% acknowledged that they had removed the medicines from their packaging to deposit them in a household garbage disposal. A secondary aim of the study was to analyze expired and leftover drugs in participants' medicine cabinets. Metformin was the most common medication found, followed by acetaminophen, spironolactone, and ibuprofen. This study shows the urgent need to develop multisectoral strategies for the implementation of policies on pharmaceutical domestic waste, which will make it possible to control and reduce the negative impact on both the environment and public health.

KEY WORDS Drug Residues; Ecotoxicology; Pharmacovigilance; Pharmacoepidemiology; Drug Storage; Ecuador.

RESUMEN Los medicamentos sobrantes y caducados en el hogar deberían ser eliminados de una manera que garantice la seguridad de la población, y que tenga un impacto negativo mínimo en el medio ambiente. Desde esta perspectiva se desarrolló el presente estudio cuyo objetivo fue conocer las prácticas de desecho de medicamentos del botiquín familiar en estudiantes de medicina en Quito-Ecuador. Entre diciembre de 2018 y enero de 2019, se encuestaron 498 estudiantes de diferentes semestres, y se evidenció que hasta un 30,3% de estudiantes alguna vez desechó los medicamentos a través del inodoro, y un 7,2% reconoció que sacaba los medicamentos del empaque primario, para depositarlos en la basura común. Como objetivo secundario se analizaron los medicamentos caducados y sobrantes del botiquín familiar de los encuestados. Se encontró que los medicamentos más frecuentes fueron metformina, seguido por acetaminofén, espirolactona e ibuprofeno. El estudio muestra la necesidad de desarrollar estrategias multisectoriales para la implementación de políticas sobre el desecho doméstico, las cuales permitirán controlar, y en el mejor de los casos, disminuir el impacto negativo tanto ambiental como en salud pública.

PALABRAS CLAVES Residuos de Medicamentos; Ecotoxicología; Farmacovigilancia; Farmacoepidemiología; Almacenamiento de Medicamentos; Ecuador.

INTRODUCTION

Family medicine cabinets provide the necessary elements to treat minor ailments, and may include over the counter medications to be used while waiting to receive medical attention.^(1,2) However, they frequently contain medications leftover from prior treatments or other medications that have been purchased by family members. This problem is even more evident when the household includes individuals with chronic diseases or elderly members,^(3,4,5) in which case family medicine cabinets may contain inappropriate medications stemming from changes in chronic treatments.⁽⁶⁾

Studies both in Latin America and other regions show that it is impossible to identify the expiration date of some leftover medications stored in households because they lack secondary packaging (bottles or boxes). In other cases, package inserts or patient information leaflets are missing; while in some more extreme cases, medication is stored outside of its primary packaging (blister packs), or the packaging has been altered such that information related to its expiration date is missing, rendering the medications unsuitable for consumption.^(2,5,7)

In this context, leftover or expired medicines should be disposed of in a manner that ensures the health and safety of the population, and that generates the smallest possible negative impact on the environment. Medicines intended for final disposal are referred to as unwanted pharmaceuticals, and their adequate management requires a series of controlled steps to ensure their safe disposal.^(8,9,10)

European countries have developed strategies to foster the safe disposal of medicines. Employing these strategies, leftover and expired medicines of domestic origin are handled in a specific and differentiated manner.⁽¹¹⁾ One such strategy is Spain's Integrated System for the Management of Pharmaceutical Containers and Waste (SIGRE, from its Spanish acronym). SIGRE collection points can be found in pharmacies throughout the

country, allowing citizens to take an active role in the managed disposal of leftover and expired medicines.^(12,13)

Latin American countries still lack national strategies for the safe disposal of leftover or expired medicines. In Ecuador, since 2017 the Metropolitan Public Sanitation Company (EMASEO-EP), in conjunction with the Secretary of the Environment and the Metropolitan Public Integrated Solid Waste Management Company (EMGIRS-EP), has coordinated and implemented the "Quito Recycles" campaign, a differentiated waste collection program that operates only in Quito. The program consists of differentiated domestic waste collection for special or hazardous items – such as energy-saving light bulbs, lacquers and aerosol paints, and expired medicines – such that they may be given a safe and adequate final disposal. Up to 2019, the campaign included 449 waste collection points in Quito, 25 of which were exclusively for expired medicines.^(14,15)

Despite efforts to establish strategies for the elimination of expired and leftover medicines, improper disposal practices persist both in urban and rural settings: medicines are thrown out along with household garbage, are flushed down the toilet, or are poured down the drain. Recent studies suggest that pharmaceutical waste disposed of in this manner generates a severe environmental impact, and has come to be considered an emerging contaminant.^(16,17,18,19)

In Ecuador, an undergraduate thesis that surveyed 110 engineering students and 330 medical students in 2017 showed that 50% of those surveyed reported having a household medicine cabinet in their homes and 59% of those surveyed used the medications it contained only very sporadically, in comparison with 13% that used them at least twice a month.⁽²⁰⁾ Nonetheless, the authors did not report data on expired or leftover medicines. On the other hand, a study published in the same year carried out in Cuenca (the third largest city in Ecuador) found that 70% of those surveyed disposed of medications that they considered unnecessary or no longer useful along with the rest of their

household waste. Up to 12% reported having expired medicines in their home and 8% were unaware of the expiration date.⁽²¹⁾

The main objective of this study was to identify the most common disposal practices related to expired and leftover medicines in the family medicine cabinets of medical students at the Universidad Central del Ecuador, and a secondary objective was to describe the (expired and leftover) medications that could be found in them.

METHODOLOGY

Online survey

A cross-sectional study was carried out in the city of Quito, Ecuador from December 2018 to January 2019 with medical students at the Universidad Central del Ecuador's School of Medical Sciences. An anonymous online survey was developed containing questions about the storage and disposal of medicines in the home. Social media campaigns were used to recruit participants, which included students ranging from the pre-university level through the tenth semester of the medical program. Those who chose to participate in the study granted consent for their responses to be used in data analysis.

The first section of the survey collected demographic data. The second section contained seven questions on attitudes regarding the disposal of medications in the home. The survey was created using Google Forms. In order to avoid missing data, all questions were compulsory.

One of the conditions to participate in the survey was that students would be required to turn in any medications leftover from previous treatments or expired medications at a special collection point managed by the Pharmacology Department. Participants who did not fill out the online survey or who did not turn in the medications from their family medicine cabinets were excluded from the analysis. This study was

approved by the chairs of the Pharmacology Department as part of a final capstone project in fulfillment of medical degree program requirements. Based on the number of students enrolled in the program, and assuming a 50% response rate, the sample size was calculated as 339 students with a confidence interval of 95% and a 5% margin of error calculated in EpilInfo.

Data collected on expired or leftover medicines

A database was created to catalogue leftover and expired medicines (pharmaceutical waste). This database included information on the number of medications turned in by each participant; the number of leftover or expired doses, or those with an unknown expiration date; the expiration date of medicines, when available; the corresponding Anatomical Therapeutic Chemical (ATC) classification; the pharmaceutical dosage form (solid, liquid, semisolid); medications distributed free of charge by the national health system or the Ecuadorian Social Security Institute (IESS); and those that were drug samples. Additionally, medications were categorized as over the counter or prescription drugs based on the guidelines of the Ecuadorian pharmaceutical regulatory agency.⁽²²⁾

Once the analysis was completed, the household pharmaceutical waste collected was handed over to the municipal program for the management of hazardous household wastes.

Methods

Descriptive analysis of responses to the seven questions contained in the online survey was carried out, along with the household pharmaceutical waste turned in at the Pharmacology Department. Results were calculated and reported as absolute values and percentages.

RESULTS

Demographics

A total of 498 students completed the survey and handed in their household pharmaceutical waste. The characteristics of those surveyed are reported in Table 1. The majority of respondents were women (308) and first-year students enrolled in the medical program. The average age of respondents was 20.9 years old (range of 17-38). A total of 49.2% of students had at least one family member with a chronic disease living in their household. Among the most common diseases were hypertension, type 2 diabetes mellitus, and thyroid diseases.

Table 1. Students' characteristics and family information (n=498). Quito, Ecuador, 2019.

Characteristics	Values	
	n	%
Students		
Gender		
Female	306	61,5
Male	191	38,3
No response	1	0,2
Semester		
Pre-university	34	6,8
First	159	31,9
Second	64	12,9
Third	12	2,4
Fifth	59	11,9
Sixth	51	10,3
Seventh	29	5,8
Eighth	49	9,8
Ninth	10	2,0
Tenth	31	6,2
Students with family members who have a chronic disease		
No chronic disease	253	50,8
With chronic disease	245	49,2

Source: Own elaboration.

Attitudes on the disposal of expired and leftover medicines in the home

Regarding disposal practices related to leftover and/or expired medicines in the home, out of 498 respondents, 7.2% disclosed having removed medications from their primary packaging and depositing them in the household garbage disposal at least once, and 30.3% reported having flushed them down the toilet at least once. Of the students surveyed, 83.3% stated that they disposed of medications along with household garbage, and 86.3% considered medication to be harmful to the environment (Table 2).

Regarding municipal containers exclusively used for the disposal of expired medicines, 79.9% (n=398) of those surveyed were unaware of their existence or did not know about the municipal program. Only 20.1% (n=100) of those surveyed were aware of their existence, and among them only 29 students had used them at least once.

Disposal of expired or leftover medicines in the home

The 498 students who participated in the study handed in 24,681 units of leftover or expired medicines in different dosage forms, in quantities ranging from 1 to 1,842 doses. On average, each student handed in 40 doses (Table 3).

Of the 498 students surveyed that handed in medications, 448 (89.9%) handed in at least one expired dose, 163 (32.7%) handed in at least one medication with an unknown expiration date, and 171 (34.3%) handed in at least one medication that was a drug sample.

Of the 24,681 total doses collected, 17,082 (69.2%) were expired doses, 5,578 (22.6%) were unexpired doses, and 2,021 (8.1%) had an unknown expiration date. Out of the medications collected, 34.4% (8,484)

Table 2. Survey on attitudes regarding the disposal of expired and leftover medicines in the home (n=498). Quito, Ecuador, 2019.

Questions	Indicators	n	%
Indicate the frequency with which you dispose of medications leftover from previous treatments or expired medications by flushing them down the toilet.	Very frequently	1	0.2
	Frequently	21	4.2
	Occasionally	55	11.1
	Rarely	74	14.8
	Never	347	69.7
Indicate the frequency with which you dispose of medications leftover from previous treatments or expired medications with the rest of your household garbage.	Very frequently	52	10.4
	Frequently	87	17.5
	Occasionally	151	30.3
	Rarely	125	25.1
	Never	83	16.7
Have you ever removed pills from their aluminum blister packs to mix them with soil and dispose of them in the household garbage can?	Yes, at least once	36	7.2
	No	462	92.8
Did you know that in Quito there are containers for the safe disposal of expired medications managed by the Municipality of Quito?	Yes	100	20.1
	No	398	79.9
Have you ever disposed of expired medications in the containers managed by the Municipality of Quito?	Yes	29	5.8
	No	80	16.1
	No response	389	78.1
How often have you used these containers for expired medications?	Frequently	5	1.0
	Occasionally	17	3.4
	Rarely	14	2.8
	Never	71	14.2
Do you agree that the inadequate disposal of medications has a negative effect on the environment?	Agree	430	86.3
	Neither agree nor disagree	54	10.8
	Disagree	14	2.9

Source: Own elaboration.

Table 3. Pharmaceutical dosage forms collected per semester, by expiration date (n=24,681). Quito, Ecuador, 2019..

Semester	Total survey participants	Expired doses	Unexpired doses	Doses with unknown expiration date	Total
Pre-university	34	1,084	212	216	1,512
First	159	4,995	1,046	957	6,998
Second	64	1,275	227	91	1,593
Third	12	272	157	86	515
Fifth	59	4,463	2,076	343	6,882
Sixth	51	912	1,122	135	2,169
Seventh	29	1,112	161	87	1,360
Eighth	49	1,084	284	76	1,444
Ninth	10	773	3	0	776
Tenth	31	1,112	290	30	1,432
Total	498	17,082	5,578	2,021	24,681

Source: Own elaboration.

Table 4. Distribution of collected medications (N=24,681), by Anatomical Therapeutic Chemical (ATC) Classification System. Quito, Ecuador, 2019.

ATC Code	Doses		Name	Frequency
	n	%		
A Alimentary tract and metabolism	6,203	25.1	Metformin	918
			Omeprazole	483
			Multivitamins	437
N Nervous system	4,467	18.1	Acetaminophen	681
			Acetylsalicylic acid	368
			Acetaminophen + caffeine	218
C Cardiovascular system	3,937	15.9	Spironolactone	682
			Enalapril	445
			Simvastatin	374
J Antiinfectives for systemic use	2,513	10.2	Amoxicillin	396
			Ciprofloxacin	224
			Amoxicillin + Clavulanic acid	221
M Musculo-skeletal system	1,978	8.0	Ibuprofen	614
			Diclofenac	306
			Naproxen	207
R Respiratory System	1,244	5.1	Loratadine	345
			Dimenhydrinate	104
			Tiotropium	90
B Blood and blood forming organs	1,161	4.7	Folic acid	490
			Clopidogrel	191
			Ferrous sulfate	151
G Genito-urinary system and sex hormones	744	3.1	Ethinylestradiol + levonorgestrel	251
			Tamsulosin	200
			Isoxsuprine	70
L Antineoplastic and immunomodulating agents	570	2.3	Mycophenolic acid	570
			Levothyroxine	182
			Prednisone	120
H Systemic hormonal preparations, excluding sex hormones and insulins	317	1.3	Methylprednisolone	5
			Artemether + lumefantrine	79
			Nitazoxanide	47
P Antiparasitic products, insecticides and repellents	274	1.1	Quinine	34
			Miconazole + Tinidazole	26
			Terbinafine	25
D Dermatologicals	234	0.9	Betamethasone	13
			Artificial tears and other indifferent preparations	5
			Sulfacetamide	3
S Sensory organs	33	0.1		
Various	43	0.2		
Natural	44	0.2		
Unknown	919	3.7		

Source: Own elaboration.

had labels indicating that they had been distributed free of charge by the Ministry of Public Health or the Ecuadorian Social Security Institute, 14.8% (3,651) were drug samples, and 50.8% (12,546) had no label indicating that they were distributed free of charge.

In terms of ATC classification, the majority of medications were group A (alimentary tract and metabolism), with the most common active ingredient being metformin (918 doses), followed by omeprazole and multivitamins. Group N (nervous system) was the second most common drug class, with acetaminophen as the most common active ingredient. The third most common group was cardiovascular drugs, and the fourth was group J (anti-infectives for systemic use). All ATC groups and their respective frequencies can be found in Table 4.

Of the medications collected, 23,497 (95.2%) were solid pharmaceutical dosage forms, with tablets being the most common form. The most common active ingredients found in tablets was acetylsalicylic acid, followed by metformin and ibuprofen. Liquid dosage forms accounted for 3.6% (887) of collected medications, and semi-solid forms accounted for 1.2% (297).

Out of the total number of doses collected, 7,198 (29.2%) were medications cataloged as over the counter (OTC) by the Ecuadorian pharmaceutical regulatory agency. A total of 16,961 (68.7%) were cataloged as prescription drugs, and in 522 (2.1%) cases it was impossible to determine this because the name of the drug or active ingredient was unknown. Regarding those cataloged as prescription drugs, the most common was metformin with 707 doses (2.9%), followed by mycophenolic acid with 570 (2.3%), folic acid with 490 (1.9%), and simvastatin with 414 (1.7%).

Of the 17,082 expired doses, 32.3% had labels indicating that they were distributed free of charge by the Ministry of Public Health (1,655) or the Ecuadorian Social Security Institute (3,870). In descending order, the most common were: spironolactone with 425 doses, metformin with 400, and acetylsalicylic acid with 311. Drug samples accounted

for 16.9% (2,891) of expired doses. The remaining 50.7% of expired doses (8,666) had been private household purchases.

Regarding doses with an unknown expiration date (2,021 doses), it was possible to identify that the most common active ingredient was acetaminophen with 126 doses.

DISCUSSION AND CONCLUSIONS

In this study, 83.3% of those surveyed reported having discarded medications in their original packaging along with household garbage at least once, 7.2% reported having removed medications from their primary packaging and discarding them in the household garbage, and up to 30.3% had flushed them down the toilet or poured them down the drain at least once. Furthermore, 89.9% of those surveyed had at least one expired medication in their family medicine cabinet, and up to 32.7% of family medicine cabinets had medications with unknown expiration dates due to improper storage in the home.

Disposal practices related to unused medications are influenced by environmental awareness as well as social and cultural attitudes. Studies estimate that over half of unused medications are disposed of in an improper way. A Costa Rican study showed that 84% of those interviewed said that the primary means of discarding medications in the home was to deposit them in the household garbage disposal, while 17% flushed them down the toilet.⁽²³⁾ Similar findings were reported in Colombia; in fact, in the case of expired medications, 64% of those surveyed reported throwing them out along with household garbage, while only 26% of those surveyed did so with leftover medications. The authors of the Colombian study also pointed out that only 9% of respondents reported flushing medications down the toilet, regardless of whether or not they were expired.⁽²⁴⁾ These findings from Latin America are consistent with results that have been reported in Asia.^(25,26)

In Latin American countries, a variety of strategies exist to improve final disposal methods for expired and leftover medicines in households.^(16,24,27,28,29) Nonetheless, these strategies are still in early stages of their implementation, and therefore despite efforts to improve this situation, the issue remains a public health problem with an environmental impact.

It should be noted that up to 50.7% of the medications collected during the study were private purchases; it was possible to estimate this due to the fact that medications distributed through programs that provide them at no cost carry labels on both their primary and secondary packaging to indicate that the medication is free of charge. These findings allow us to consider the hypothesis that there is a high degree of spending related to medication on the part of Ecuadorian families, particularly related to chronic diseases. Furthermore, our findings suggest that there is likely a need for stricter control regarding the sale of prescription drugs in the country. In Ecuador, Article 153 of the Organic Health Act – the piece of legislation that regulates the country's health system – stipulates that a medical prescription is required for the purchase of all medications, except for those cataloged as over the counter.⁽³⁰⁾ There are two types of medical prescriptions: those that prescribe medications for general human use; and special prescriptions, which are only used for medications that contain controlled substances (narcotics and psychotropics).⁽³¹⁾

Nevertheless, despite this legislation, 67.8% of medications observed in family medicine cabinets were prescription drugs, especially drugs that treat chronic diseases such as diabetes and dyslipidemia, and in some cases much more specific uses (mycophenolic acid). This finding could be justified by the presence of one or more chronic diseases among students' family members; however, these findings conflict with other studies that have more frequently observed a higher presence of analgesics and anti-inflammatory drugs in family medicine cabinets (over the counter medications).^(2,32)

Furthermore, this study has provided evidence of high levels of medication storage in family medicine cabinets, as each student handed in on average 40 doses of expired or leftover medicines. This is cause for alarm, given that the high availability of medications might predispose individuals to engage in risky self-medication, a problem with international relevance.^(33,34,35) In this context, the notable presence of antibiotics in family medicine cabinets might lead to the indiscriminate use of antibiotics through self-medication, which can also contribute to antimicrobial resistance, as discussed in the meta-analysis carried out by Torres *et al.*⁽³⁶⁾

Another relevant finding was the fact that 32.2% of expired medications had been distributed through the country's health system free of charge, and in many cases were the same medications used for treating chronic diseases, such as metformin. This could signal the need to implement a drug recycling system for unused medications due to changes in treatment, coordinated by the Ministry of Health and associated networks, given that the storage of medications in households and their eventual expiration not only poses a threat to families, but also elevates health system expenditures.

Adequate disposal practices and the final disposal of expired and leftover medicines in households constitute a social problem that can be primarily attributed to the lack of local and national intersectoral strategies for the safe disposal of these medicines. Commitment is needed on the part of all involved actors in order to face this problem – environmental protection institutions, public health institutions, the pharmaceutical industry, scientific organizations, and citizens at large – to develop educational programs and at the same time implement coordinated strategies that would make it possible to resolve this issue as quickly as possible.

Several European countries have put coordinated strategies into place in order to control and reduce the negative impact of improperly disposed medicines. These strategies have been the result of multisectoral efforts. Community pharmacies have been

the starting point for these strategies, given that these healthcare establishments often possess containers to receive expired medicines. Other institutions that form part of the health system engage in drug recycling for patients who have leftover medications due to changes in treatment, particularly in the case of chronic diseases. It should be noted that these strategies have also been successful because of policies that promote the rational use of medicines, which control purchases and sales without a medical prescription.⁽¹¹⁾

To conclude, this study confirms the urgent need to develop intersectoral policies for awareness and implementation of safe disposal practices for expired and leftover medicines in households. As the country's capital possesses a plan for the disposal of expired medicines, analyses of this project might contribute to an understanding of the issue in the local context in order to propose

solutions that could potentially be extended to the rest of the country. Based on a review of the literature, aside from the study carried out in the city of Cuenca, no other studies on this issue have been published in Ecuador, suggesting the need for further research in order to produce knowledge regarding disposal practices in rural communities and diverse populations (given that this study focused on a population of medical students). Additionally, further research is needed on the environmental impact of this problem, as well as the potential health consequences of inadequate household disposal of medicines. On the other hand, the findings of this study point to the need for further controls on medication sales in pharmacies, given that the accumulation of medicines in the home can lead to risky self-medication practices among household members, and can also be a potential source of poisoning.

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CONFLICTS OF INTEREST

Although the authors of this article study and work at the same institution that provided the analyzed data, all necessary precautions were taken in order to ensure that this relationship would not constitute a conflict of interest or condition the type of analysis or conclusions contained in the article.

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