

Reducing Waste to Create a Sustainable Supply and usage of Pharmaceuticals

Prof. Pooja Pawar, Prof. Suresh Reddy, Dhananjay Bharat Gaikwad, Rushikesh Arjun Yevale, Pruthviraj Rangrao Sankpal, Tejraj Harishchandra Kakade

Department of Computer Engineering

Suman Ramesh Tulsiani Technical Campus, Faculty of Engineering, Khamshet, Pune, Maharashtra, India

Abstract: *Both the environment and the healthcare budget are negatively impacted by medication waste. Therefore, one intriguing strategy to promote sustainable medicine supply and utilization is to stop the medication from going unused along the pharmaceutical chain. The goal of this scoping assessment is to determine how interested parties might work together to stop the waste of potentially useful medications. Manufacturers may help ensure a sustainable supply and usage of drugs by increasing the shelf life of their products, selecting the most environmentally friendly storage options, and modifying the size of their packaging. Distributors are responsible for optimizing stock management and relaxing shelf-life regulations. Prescribers can respond by agreeing to sensible prescribing practices, which may include taking prescription quantity and shorter length into account. Pharmacists can help by dispensing, improving pharmaceutical preparation procedures, streamlining the dispensing process, and maintaining proper stock management.*

Keywords: Medication waste, Unused medication, Sustainability, Pharmacy.

I. INTRODUCTION

Unused medications may accumulate in home medicine cabinets due to a variety of reasons including overprescribing, elimination of need for the medication, noncompliance to the regimen, or medication expiration. People with access to medicine cabinets can divert medications for use by someone other than the patient or use the medications for unintended purposes. Medications may also be disposed of into the trash, toilet, or sink, risking the safety of others and damaging the environment. Even when there is no intention for mishandling, patients may retain medications due to the high cost of the medication, lack of disposal method, or the possibility of needing these medications again in the future. Accessible storage of these medications poses a particular threat to children and elders, who may not understand the dangers of medications and may inadvertently ingest these medications, with consequences ranging from stomachache to death. In 2011, more than 68,000 children in the US suffered from medication poisoning and were seen in emergency departments, with 86% of these cases involving children ingesting adult medicine [1]. The most common places children found medications included on the ground, in purses or bags, on counters or nightstands, in pillboxes, and cabinets or drawers [1]. Out of the more than two million calls made annually to poison control centers regarding unintentional child poisonings, nine out of 10 involve poisonings at home [2]. More common than accidental ingestion is the misuse of medications by young adults and adolescents with 21.7% and 13.0% of 12th graders in the US admitting to medical misuse of prescription medications and narcotics, respectively, as surveyed by the National Institute of Drug Abuse in 2014 [3]. Nationally, 4.5 million people over the age of 11 reported being current nonmedical users of prescription pain relievers, tranquilizers, stimulants, and sedatives based on the 2013 National Survey on Drug Use and Health [4]. Fifty-three percent of these nonmedical users stated they received analgesics for free from a friend or relative [4]. The reported 6.5 million Americans abusing prescription drugs in 2013 is more than double the number of those who have admitted to using heroin, cocaine, and hallucinogens combined [4]. With this high prevalence of medication being used for unintended persons or purposes, it can be deduced that, for many patients, the quantity of medications prescribed must far exceed the quantity needed for intended treatment. The public media and scientific community have also highlighted the environmental impact of disposed medications. Flushing medications down the toilet or sink, disposal in household trash, and normal human and animal excretions containing

pharmaceutical ingredients can all lead to medications being released into the environment [5]. On a list of more than 100 active ingredients found in the environment, amoxicillin, acetaminophen, and metoprolol stand at the top [6]. Unfortunately, some of these drugs that have seeped into the sewage system have failed to be eliminated through conventional sewage treatment, rendering the public and the environment more susceptible to contaminated water and antibiotic resistance [6,7]. Studies examining the effects of medication-contaminated drinking water have not yet produced reliable results. Additionally, there is a lack of information regarding the biodegradation of these chemicals in soil environments, further providing concern for public and environmental safety. To help relieve these concerns, the Drug Enforcement Administration (DEA) sponsored a National Prescription Drug Take-Back Day biannually where the public can bring their unused medications to designated sites. This program collected 309 tons of unwanted medications at 5495 locations during the most recent Drug Take-Back Day in September 2014, with each year's collections reported greater than the previous year's [8]. While this event cleared out medicine cabinets of many patients across the country, the increasing utilization of these types of events shows that there are still homes with unused or expired medications and an ongoing accumulation through new prescriptions. In response to the Secure and Responsible Drug Disposal Act, enacted by Congress in 2010, the DEA implemented new disposal regulations that allow retail pharmacies to register to become authorized collectors of controlled medications, replacing the biannual take-back events [8]. Because of the growing concern of accumulating unused medications, this study was initiated to assess the quantity of medications gathered in homes by determining the ratio of medication units remaining versus dispensed and identifying the therapeutic classes with greater ratios of remaining medication units

II. METHOD

Data was gathered during a four-hour medication take-back event on September 10, 2013. The occasion was a part of the annual Pharmacy Day at the Capitol hosted by the Michigan Pharmacists Association (MPA). Faculty and student chemists from Ferris State University volunteered for the event. Wayne State University, University of Michigan, and others present at the Capitol for Pharmacy Day as MPA employees. Because this operation involved controlled substances, local law enforcement officials oversaw every facet of the incident, including the gathering of medications and their disposal and burning. It was open to the public to drop off any unused prescription drugs. These pharmaceuticals were then tallied, and the data below was noted and entered into Microsoft Excel.

spreadsheets: name of the medication, potency, quantity left, amount prescribed, generic or name, and the origin (drugstore in the area, online, or sample). Medication collections were removed from the location. intended to be burned after the event.

Along with gathering the medications, volunteers for the event requested that all donors respond to an optional anonymous nine-question web survey (Appendix) by the end of the next week to learn more about how they dispose of their medications. To minimize wait times and enable donors to donate their medications quickly, the survey was not conducted on-site.

The statistical analysis was limited to prescription drugs in the form of tablets or capsules. The following therapeutic classes were used to group medications: allergy (antihistamines), cardiovascular, dietary (associated with vitamin or electrolyte imbalances), endocrine (such as hypothyroidism, diabetes, hormone replacement therapy for reproduction), gastrointestinal, immunologic (such as cancer, rheumatoid arthritis, infections, immunosuppression, mental health conditions (such as depression, bipolar disorder, schizophrenia, nausea, pain/spasm, respiratory, anxiety, attention deficit disorder, insomnia, seizure disorder, and elderly/other (such as benign prostate cancer, osteoporosis, dementia, Parkinson's disease, and urinary incontinence) erectile dysfunction, prostatic hyperplasia). Among the exclusion criteria were drugs never made available in the United States, prescriptions for pets, drugs in opaquely labeled containers, and containers containing more medication left in them than was dispensed—possibly as a result of patients mixing drugs in one container. Drugs that weren't packaged as tablets or capsules were excluded as well because small package sizes could lead to patients receiving more than they require. For instance, Although amoxicillin suspension is produced in formulations of 100 and 150 mL, a patient might only need To finish the therapy, using 120 mL of the 150 mL formulation.

Except for the geriatric/miscellaneous group, medications examined in this study were categorized according to therapeutic classes. The average ratio of the number of units left over from the total amount dispensed was used to

quantify medications. To compare the averages, a one-way analysis of variance (ANOVA) and an unpaired two-sample Evaluation of the student's t-test with the Bonferonni adjustment of the statistical disparity between each therapeutic class's average and its peers. p-values smaller than It was decided that 0.05 was statistically significant. To keep things clear, the word "container" will be used to describe the container—a box, bottle, or other piece of packaging—that the drugs came in.

III. RESULT

The event gathered 3633 containers of medications, including over-the-counter, prescription, and pet medications. Out of 2,830,094 units (tablets or capsules) originally dispensed in these containers, 1,824,854 units of medications were collected. The top 15 most commonly returned out of the 348 different prescription drugs collected are listed in Table 1. The majority of the medications were generic products, composing 69.0% of all medications collected. Most were obtained at local pharmacies (89.4%), compared to mail orders (5.7%), or samples from physician offices (4.8%). Table 1. Quantities of most commonly returned medications

	Medication	Quantity of Containers	Percentage of All Containers Returned
1	Acetaminophen/hydrocodone	110	4.4
2	Ibuprofen	73	2.9
3	Tramadol	44	1.8
4	Acetaminophen/codeine	42	1.7
5	Naproxen	42	1.7
6	Prednisone	41	1.7
7	Amoxicillin	37	1.5
8	Omeprazole	37	1.5
9	Levothyroxine	35	1.4
10	Aspirin	32	1.3
11	Acetaminophen/propoxyphene	27	1.1
12	Cyclobenzaprine	27	1.1
13	Cephalexin	26	1.1
14	Lisinopril	26	1.1
15	Warfarin	26	1.1

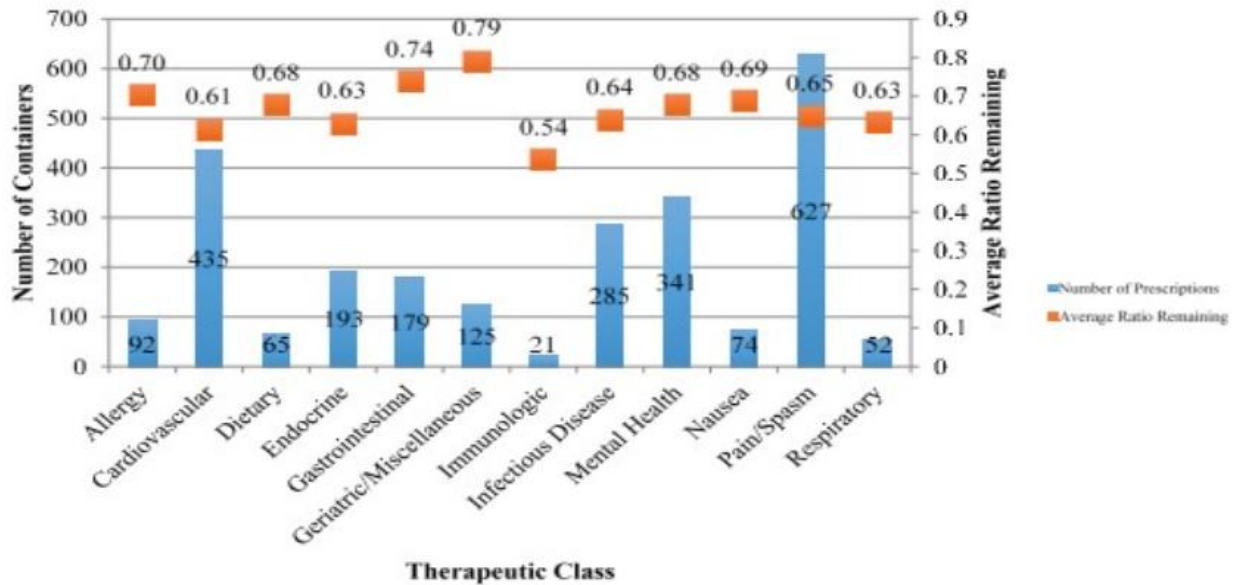
For this study, 2459 containers were analyzed, with 304 of them holding controlled medications (excluding tramadol as it was not a controlled substance in the state of Michigan at the time of the event).

Figure 1 displays the number of containers collected at the event and the respective average ratio of remaining units of medications per container, grouped by therapeutic drug class. The pain/spasm therapeutic class accounted for the largest number of containers collected with 615 containers, followed by 431 containers of cardiovascular medications, and 341 containers of mental health medications

The overall ratio of remaining medication units to units dispensed was 0.66 for all medications included in this study. A one-way ANOVA was calculated on the average ratios, grouped by therapeutic class. The analysis revealed a significant difference among the therapeutic groups' ratios of remaining units, $F(11, 2447) = 3.37, p < 0.001$. The average ratio remaining for each therapeutic drug class was compared to that of the other therapeutic classes utilizing Student's t-tests with Bonferroni adjustment. Six pairs showed a significant difference, five of which included the geriatric/miscellaneous therapeutic class: geriatric/miscellaneous > cardiovascular ($p < 0.001$), geriatric/miscellaneous > endocrine ($p < 0.001$), geriatric/miscellaneous > infectious diseases ($p < 0.001$), geriatric/miscellaneous > mental health ($p = 0.027$), geriatric/miscellaneous > pain ($p < 0.001$), and gastrointestinal > cardiovascular ($p = 0.001$). Seventy participants responded to the online survey. Fifty of the seventy respondents were female, and nearly 60%

were adults above the age of 50. Over 75% of respondents reported returning a family member's medication(s), and 67% reported returning their own.

Figure 1. Quantities of containers collected and average ratios remaining categorized by therapeutic class



Medication expiration was the most common reason for medication disposal at the event, while discontinuation of the medications due to side effects or lack of necessity without professional recommendation were the least common reasons (Figure 2). Nearly 59% of respondents cited drug take-back events as their usual method for disposing of unused medications, while over 25% stated they disposed of them in the garbage and 14% flushed medications down the toilet or sink.

IV. DISCUSSION

345 different prescription drugs were collected for this event, but pain relievers accounted for the top five most popular medications. Over 25% of all the containers analyzed belonged to the pain/spasm therapeutic class, which had the highest number of containers gathered. Similarly, comparable medication take-back campaigns in Findlay, Ohio, and rural Appalachia revealed high usage of painkillers, with Three of the most popular drugs containing hydrocodone, propoxyphene, and codeine. pharmaceuticals gathered [9, 10]. Researchers surveyed Cook County, Illinois, residents. According to University of Illinois data, the first and fifth most popular types of medications taken at home were 82.5% of respondents used over-the-counter painkillers, and 39.2% used prescription painkillers [11]. These studies' similarities support the general worry that patients are accruing painkillers in the house, which offers the potential for misuse, distraction, and unintentional consumption.

In addition to raising concerns about possible abuse, the high percentage of unused painkillers in homes also raises questions about possible overprescription of these medications. Thirty-seven percent of Cook County survey respondents said they had unused prescription drugs from a past illness [11]. The most frequent explanations for this were that they felt better or that the instructions said to follow them as needed. The medication was no longer required. Individuals who are prescribed analgesics for brief periods are guided to take them as needed; however, some of the amount returned during the event was because a higher dosage was prescribed. more analgesics than what the patients thought were necessary Nine out of the twelve therapeutic categories fell between the range of 60% and 70%, indicating a fairly consistent percentage of remaining medications across all categories. There is also a lot of worry about patient nonadherence because of this small range. The data indicate that the remaining proportions remain consistent despite variations in either short-term or long-term use, for example, between antiemetic drugs (0.69) and endocrine illnesses (0.63).

Interestingly, this class had a relatively high ratio of remaining medications and was included in five of the six comparison groups that reported a statistically significant difference in average ratios, even though the medications

included in the geriatric/miscellaneous class are not limited to the elderly population. The elderly population's high use of these drugs may be due to their having more time to amass unneeded prescriptions, possibly as a result of changing therapy or dosage, or medication disposal by family members or carers following a patient's passing.

Medication expiration was given as the reason for medication disposal by 80% of survey participants. This high figure could be attributed to the survey's provision for donors to list several explanations. For instance, if his doctor instructed him to stop taking medication, the patient might have chosen two responses. doctor and stored it at home for a few years before throwing it away at this function. Given that The majority of respondents stated that their typical method for disposing of medications is at drug take-back events. concerning since locals are only able to attend these events on a few if any, days of the year for some sections of the nation. Given the continuous accumulation of medications, the DEA's intention to permit pharmacists must register to retrieve controlled and Uncontrolled drugs would provide opportunities for increased availability of environmentally friendly medicine disposal

This study was limited in several ways. Medicines are not always used for the intended purposes, despite overprescribing and non-adherence being two major causes. Patients may not have been able to take the entire dosage due to allergies or intolerances, ineffective therapy, or changes in diagnosis. medicine is given out. Medication take-back day data only represent a small portion of the overall proportion of people in Lansing, Michigan, and the surrounding areas who voluntarily gave up their drugs that are not used. The majority of participants were older adults, as would be predicted given this demographic tends to have a higher prevalence of illnesses and conditions requiring medication. The entire quantity of Due to the operational logistics of this medication take-back event, participant information was not recorded; however, the the quantity of survey participants represents a tiny portion of this entire.

V. CONCLUSION

About two-thirds of the total amount prescribed remained of all the medications gathered at the medication take-back event. While the most frequent reason for donating medications to the event was medication expiration, only 17% of survey respondents admitted to stopping the use of the medication on their initiative because they thought it was unnecessary. There aren't many published studies at the moment that describe which drugs are gathered during take-back events. Our research, which focused on the large amounts of analgesics and cardiovascular agents gathered during the event, broadly matches the data collected by groups in rural Appalachia, Ohio, and Findlay, Ohio [9, 10]. To better evaluate the prevalence of drug accumulation and patients' reasons for disposal, more research is necessary. Medication take-back events have gained popularity because they allow patients to get rid of unwanted prescriptions without addressing the root causes of the problem, which are overprescribing and patients not finishing their entire prescribed course of treatment. Prescribers can lessen medication accumulation by writing more cautious prescriptions, even though medical professionals should still emphasize the value of patient adherence. Local drugstores can also help lower accumulation by registering with the DEA as approved medication return sites, which would provide patients with an eco-friendly way to dispose of their medications almost every day of the year.

ACKNOWLEDGMENT

We would like to acknowledge the support and guidance received from the following organizations and individuals: **[Prof. Pooja Pawar & Prof. Suresh Reddy]**: for Their invaluable mentorship and advice. **Dhananjay Bharat Gaikwad, Pruthviraj Rangrao Sankpal, Rushikesh Arjus Yevale, and Tejraj Harishchandra Kakade** for their collaborative efforts. Their insights, expertise, and contributions have been crucial in shaping this work and making it possible.

REFERENCES

- [1]. Reitsma M, Brabers A, Korevaar J, et al. One-third of the medicine users have medicines left unused [Dutch]. NIVEL.
- [2]. Trueman P, Lowson K, Blighe A, et al. Evaluation of the Scale, Causes and Costs of Waste Medicines: London

- [3]. Bekker CL, Melis EJ, Egberts ACG, et al. Quantity and economic value of unused oral anti-cancer and biological disease-modifying anti-rheumatic drugs among outpatient pharmacy patients who discontinue therapy. *Res Social Adm Pharm.*
- [4]. Mackridge AJ, Marriott JF. Returned medicines: waste or a wasted opportunity? *J Public Health* 2007;29:258–62
- [5]. Abbasi, G., Gay, E., 2017. Impact of sterile compounding batch frequency on pharmaceutical waste. *Hosp. Pharm.* 52 (1), 60–64. <https://doi.org/10.1310/hpj5201-60>.
- [6]. Afanasjeva, J., Gruenberg, K., 2019. Pharmacists as environmental stewards: strategies for minimizing and managing drug waste. *Sustainable Chemistry and Pharmacy* 13, 100164. <https://doi.org/10.1016/j.scp.2019.100164>.
- [7]. Alhamad, H., Patel, N., Donyai, P., 2018a. Beliefs and intentions towards reusing medicines in the future: a large-scale, cross-sectional study of patients in the UK. *Int. J. Pharm. Pract.* 26 (Suppl. 1), 12–13. <https://doi.org/10.1111/ijpp.12442>
- [8]. Alhamad, H., Patel, N., Donyai, P., 2018b. How do people conceptualize the reuse of medicines? An interview study. *Int. J. Pharm. Pract.* 26 (3), 232–241. <https://doi.org/10.1111/ijpp.12391>.
- [9]. Ferguson, R.W.; Mickalide, A.D. An In-Depth Look at Keeping Young Children Safe Around Medicine. Available online: <http://www.safekids.org/medsreport>.
- [10]. Consumer Product Safety Commission. CPSC warns that 9 out of 10 unintentional child poisonings occur in the home. News from CPSC, 18 March 2009. Available online:
- [11]. <http://www.cpsc.gov/cpscpub/prerel/prhtml09/09159.html>
- [12]. National Institutes of Health. Monitoring the future. January 2015. Available online: <http://www.drugabuse.gov/related-topics/trends-statistics/monitoring-future>.