

# Survey of medication disposal: Patient views and awareness

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## SUMMARY

The improper disposal of medication poses potential environmental and health problems. When medications are disposed of improperly, they can enter the water supply and other parts of the environment. This can lead to unintended ecological and health consequences. Proper disposal is one of the best ways of preventing this. In this study, we characterized the attitudes and preexisting knowledge of proper disposal of unused medications in endocrinology patients in Southern California. Our hypothesis was that people would be willing to drive to properly dispose of medications if they were aware of proper medication disposal practices. The respondents overwhelmingly indicated that they would be willing to properly dispose of unused medication but reported that they were unaware of the procedures, and would be willing to properly dispose of their unused medications given the appropriate education. These results have applications for future efforts such as increased education or awareness of medication disposal procedures to limit improper drug disposal.

## INTRODUCTION

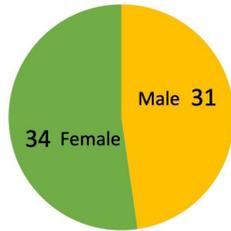
Medications are prescribed to millions of Americans. According to the U.S. Centers for Disease Control and Prevention, approximately 860 million prescriptions were provided during physician office visits alone in 2018 (1). Millions of bottles of over-the-counter medications are purchased and consumed by U.S. residents annually, in addition to hundreds of millions prescribed during hospital emergency department visits (1). Often, medications are discarded in the garbage or sewage. This is a local and global issue with long-term environmental consequences, which include impacts on non-target organisms (2). These drugs meant for therapeutic use on humans unfortunately do cause unintended consequences and even death in non-target organisms across all trophic levels from primary producers like algae to top predators like fish. Due to unique chemical characteristics, these medications can then bioaccumulate in different organisms (3). These unique characteristics include factors like hydrophobicity where the hydrophobic nature of the compounds leads to longer retention in organismal tissue and thus greater potential for long-term toxicity. Bioaccumulation occurs when chemical compounds are not easily expelled by the organism and collect in the body over time. This can negatively impact the organism by impairing its normal behavior, as well as negatively impact public health through human consumption of contaminated organisms.

For example, fillets from fish drawn from polluted waters in the U.S. can carry a multitude of common pharmaceuticals, such as psychoactive medications, which were found in up to 58% of samples (4). Measurable concentrations of pharmaceuticals in such a commonly consumed fish portion reveals the potential of exposure to the public.

Other public health concerns related to improper drug disposal include rising antibiotic resistance. Improper disposal of antibiotics can also lead to the development and spread of antibiotic-resistant pathogens (5). The decreased effectiveness of antibiotic medication poses severe risks to patients who have bacterial infections, which if not treated effectively can result in significant illness and even mortality. Similarly, there are many households that store their expired medications at home, which raises the potential for accidental ingestion or abuse (6). Expired medications that are taken mistakenly or abused can result in serious health consequences with potential for loss of life (7).

Proper methods of medication disposal include returning them to take-back bins, which are often found in pharmacies and law enforcement agencies. Other ways include obtaining drug mail-back envelopes and attending drug take-back events. The collected medications are then transported to facilities where they are processed, typically by incineration, so that they cannot enter the environment. These programs have even been shown to successfully remove commonly abused medications from homes (8).

Although there are studies that have evaluated the medication disposal habits of individuals, most of them have been based on surveys collected from individual households or pharmacies. Nevertheless, the details of this important topic are still not common knowledge, even among those living in a metropolitan area. The aim of this study was to gauge the knowledge of and willingness to practice proper drug disposal among patients attending an outpatient medical office located in Los Alamitos, Orange County, California. The motivation for this study was rooted in the relationship between willingness to properly dispose of medications and prior instruction of drug disposal. Individuals seemed to be open to properly dispose of medications in order to benefit the environment, but there appeared to be a lack of knowledge regarding this topic. Our hypothesis was that people would be willing to drive to appropriately dispose of medications if provided the proper instructions. Around half of the survey respondents were aware of proper medication disposal methods. Similarly, half of the respondents had access to/stored medications in their homes. More than 90% of respondents were willing to drive in order to dispose of their medications at appropriate locations and bins.

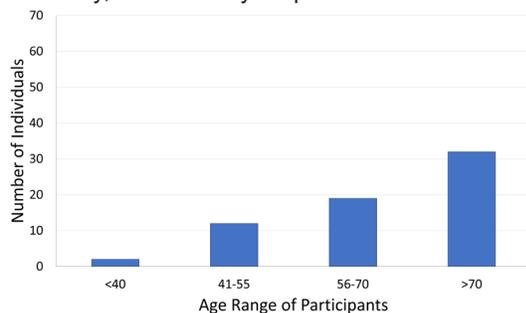


**Figure 1. Gender Distribution of Respondents.** Gender of questionnaire respondents is recorded. The bar graph indicates our sample population has a gender ratio. Patients were asked to list their gender on the questionnaire.

## RESULTS

Surveys were distributed at an endocrinology office in Los Alamitos, California. All 65 patients (n = 65) who visited the office from March to August in 2021 received and willingly responded to the survey. Of those surveyed, 31 were male and 34 were female (**Figure 1**). The age range of respondents was as follows: 49.2% (n = 32) were over 70 years old, 29.2% (n = 19) 56-70 years, 18.5% (n = 12) of respondents were 41-55 years of age and 3.1% (n=2) of respondents were younger than 40 (**Figure 2**). Of those surveyed, 52.3% (n = 34) reported possessing unused/expired medications at home (**Figure 3**) and 56.9% (n = 37) were aware of proper drug disposal methods (**Figure 4**). Approximately 92.3% (n = 60) were willing to drive to drop off locations to dispose of medications (**Figure 5**).

Additionally, three survey respondents were not aware of



**Figure 2. Age of Respondents.** The proportion of respondents across multiple age categories is illustrated. The bar graph shows the general age distribution of respondents. Individual ages were binned into four age ranges.

proper medication disposal yet would be willing to drive and drop off unused medications. They specifically commented that this information should be made more available to the public. One individual stated they would not be willing to drive to drop off unused medications because they are unable to drive and rely on a family member to drive.

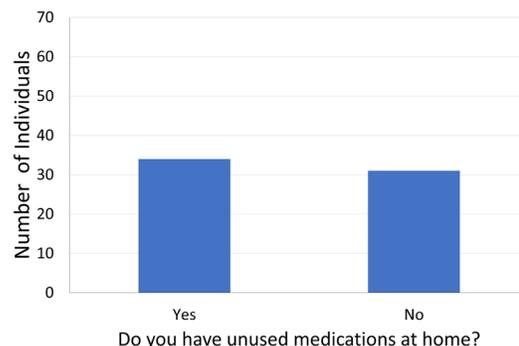
## DISCUSSION

We found that a high percentage of respondents have unused/expired drugs at home and that general awareness of proper drug disposal was relatively low, but that willingness to properly dispose of medication was relatively high. This opens up the potential for proper drug disposal education to greatly reduce the health and environmental risks associated with improperly stored and disposed drugs. The majority of unused and expired medications are disposed of in the

trash or flushed into the sewer system. Globally, a large portion of medications are improperly disposed (6). Of these medications, a measurable portion has been found to enter municipal waste streams (9). Pharmaceuticals found in landfills indicate that their source likely comes from individual households rather than larger production facilities that have specialized waste streams. Alazmi *et al.* reported up to 79% of respondents disposed of unused medications in the trash in a large middle Eastern city and Kristina *et al.* reported similar findings in a large city in Indonesia (10, 11). Previous studies within the U.S. have reported 45% of the respondents stored unused and/or expired medications at home while 52.3% of respondents in our study reported the same (12).

Our study, although small, is representative of the medication consumer population. The respondents were about equal in proportions of male and female with an age range that skewed older (**Figure 1** and **2**). The gender ratio of this study (47.7% Male, 52.3% Female) is relatively reflective of the overall gender breakdown of Orange County, U.S. (49.4% Male, 50.6% Female) where the study was conducted (12).

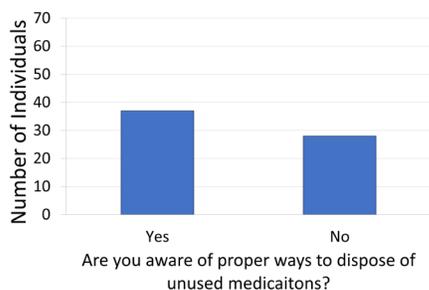
In this study, 52.3% of respondents possessed medications at home that were either not going to be used or expired (**Figure 3**). This raises the potential for accidental ingestion of these medications as well as intentional ingestion and abuse. There are consequences in the short term that can result in immediate harm and sometimes, loss of life. Additionally, the high cost of the healthcare associated with the treatment of these ingestions poses a separate issue itself. Schillie *et al.* estimated that at least 70,000 U.S. emergency department visits each year are children < 18 years of age being treated for unintentional overdoses with the majority of these cases involving children under the age of 6 years (13).



**Figure 3. Survey of Unused Medication.** The proportion of participants who currently have unused medication is shown. The data shows that a majority of patients have unused medications.

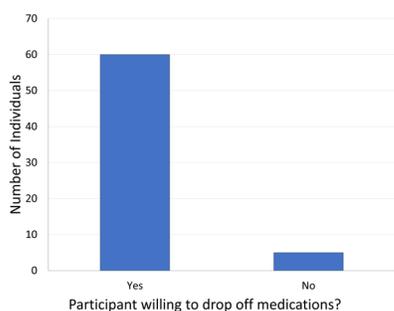
Improper drug disposal is potentially a result of patients being unaware of how to properly dispose of unused pharmaceuticals. Only 56.9% of respondents were aware of proper disposal methods and this level of awareness (**Figure 4**). Though our study is small, it reveals a potentially widespread attitude among the public in proper drug disposal. Most respondents in this study, 92.3%, were willing to drive to a separate location to properly dispose of unused medication (**Figure 5**). This comparison illustrates that there is a willingness, but a lack of proper instruction regarding drug disposal. As our data suggests, there is a significant opportunity to decrease the number of medications that end

up in our landfills or water system through proper education. Limitations to our study included the limited sampling of patients at this medical office due to the COVID-19 pandemic. Many patients remained at home and chose to have virtual appointments, rather than come into the office in person. There could have additionally been more detailed survey questions regarding the extent to which individuals would be willing to travel in order to properly dispose of medications on their own, such as how far in miles they would be willing to drive. Quantifying the willingness to travel in order to dispose of medications could help determine where medication sites could be effectively installed. Additionally, questions regarding race and educational background could have provided further insight. Lastly, there could also have been more patients surveyed in order to reduce the potential variability in the responses among survey takers.



**Figure 4. Awareness of Proper Drug Disposal.** The proportion of respondents who were aware of proper drug disposal for their specific medication is illustrated. Data shows the majority of patients are aware of proper drug disposal. Responses gathered from a questionnaire administered to patients.

Future studies should build on the patient’s willingness to properly dispose of unused medication. Efforts to characterize different types of incentive to encourage proper disposal of unused pharmaceuticals may prove incredibly effective in decreasing the overall amount of pharmaceuticals that enter the environment. This could include publicizing drug take-back programs, increasing convenience of dropping off or mailing back unused medications, and educating people on the potential environmental and societal health impacts of improper drug disposal. Furthermore, brochures advertising proper medication disposal could be created in different languages to reach individuals of different communities and backgrounds. Lastly, there could be more digital presence of resources regarding drug disposal to make this topic easily searchable online.



**Figure 5. Willingness to Participate in Proper Drug Disposal.** The number of respondents who were willing to drive to drop off unused medication as a means of proper disposal is illustrated. Responses gathered from a questionnaire administered to patients.

## MATERIALS AND METHODS

The study was conducted from March to August in 2021 in an adult endocrinology office in Los Alamitos, Orange County, California. Patients were provided a physical copy of the survey. A total of 65 surveys were collected. The sampling method implemented was a convenience sampling, which targeted every patient that came to the endocrinology office. Every patient given a survey voluntarily consented and completed the survey. A section for written comments was also included.

Most patients at this endocrinology office are prescribed one or more medications. The respondents were asked about their gender, age, and knowledge of proper medication disposal. Specifically, surveyees were asked of their awareness of proper drug disposal, if they have unused medications at home, and if they are willing to properly dispose of medications. For the question regarding gender, surveyees were given the choice of selecting male, female, or other. For the question regarding age, surveyees were given the choice of selecting from 4 age categories, “Under 40”, “41-45”, “56-70”, and “Over 70”. All other questions had either “Yes” or “No” as options.

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## REFERENCES

1. “National Ambulatory Medical Care Survey: 2018 National Summary.” *Center for Disease Control and Prevention*. [www.cdc.gov/nchs/data/ahcd/namcs\\_summary/2018-namcs-web-tables-508.pdf](http://www.cdc.gov/nchs/data/ahcd/namcs_summary/2018-namcs-web-tables-508.pdf). Accessed Jan. 2022,
2. Isidori, Marina, *et al.* “Toxic and genotoxic evaluation of six antibiotics on non-target organisms.” *Science of the Total Environment*, vol. 346, no.1-3, 15 Jun. 2005, pp. 87-98. doi.org/10.1016/j.scitotenv.2004.11.017
3. Muir, Derek, *et al.* “Bioaccumulation of pharmaceuticals and personal care product chemicals in fish exposed to wastewater effluent in an urban wetland.” *Scientific Reports*, vol. 7, no. 1, 5 Dec. 2017, pp. 1-11, doi.org/10.1038/s41598-017-15462-x
4. Huerta, Belinda, *et al.* “Presence of pharmaceuticals in fish collected from urban rivers in the US EPA 2008–2009 National Rivers and Streams Assessment.” *Science of The Total Environment*, vol. 634, 1 Sept. 2018, pp. 542-49. doi.org/10.1016/j.scitotenv.2018.03.387
5. Wu, Dong, *et al.* “Relationships between antibiotics and antibiotic resistance gene levels in municipal solid waste leachates in Shanghai, China.” *Environmental Science & Technology*, vol. 49, no. 7, 7 Apr. 2015, pp. 4122-8. doi.org/10.1021/es506081z
6. Makki, Mutaseim, *et al.* “The prevalence of unused medications in homes.” *Pharmacy*, vol. 7, no. 2, 13 Jun. 2019, p. 61, doi.org/10.3390/pharmacy7020061
7. Hodges, Nichole L., *et al.* “Non-health care facility medication errors resulting in serious medical outcomes.” *Clinical Toxicology*, vol. 56, no. 1, Jan. 2018, pp. 43-50.
8. Simons, Tanya Elaine. “Drug take-back programs: safe disposal of unused, expired, or unwanted medications in North Carolina.” *Coastal Coalition for Substance Abuse*

- Prevention*, vol. 10, 10 Oct. 2010,
9. Musson, Stephen E., and Timothy G. Townsend. "Pharmaceutical compound content of municipal solid waste." *Journal of Hazardous Materials*, vol. 162, no. 2-3, 15 Mar. 2009, pp. 730-35. doi.org/10.1016/j.jhazmat.2008.05.089
  10. AlAzmi, Aeshah, *et al.* "Patients' knowledge and attitude toward the disposal of medications." *Journal of Pharmaceutics*, vol. 2017, 10 Oct. 2017, doi.org/10.1155/2017/8516741
  11. Kristina, Susi Ari. "A survey on medicine disposal practice among households in Yogyakarta." *Asian Journal of Pharmaceutics*, vol. 12, no. 03, 5 Nov. 2018, doi.org/10.22377/ajp.v12i03.2633
  12. Bureau, U. S. C. (n.d.). Age and Sex- Orange County. Explore census data. data.census.gov/cedsci/table?q=orange+county&t=Populations+and+People&tid=ACSST5Y2020.S0101. Accessed Jan. 2022.
  13. Schillie, Sarah F., *et al.* "Medication overdoses leading to emergency department visits among children." *American Journal of Preventive Medicine*, vol. 37, no. 3, Sept. 2009, pp. 181-7. doi.org/10.1016/j.amepre.2009.05.018

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