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Tossing Your Tylenol: Supporting Sustainable Behavior in Medication Disposal Through Label Design

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Abstract

Pharmaceutical waste has proven harmful to society and the environment either stagnating in home medicine cabinets or seeping back into the ecosystem. This points to an unsustainable pattern of disposal of pharmaceutical waste. This paper presents the implementation of a user-centered design process paired with a sustainable behavior paradigm to address barriers to the proper disposal of pharmaceutical waste. The design process revealed that a lack of awareness of proper disposal methods is a contributing factor to improper disposal. Labels with images highlighting different strategies for the proper disposal of medication were prototyped. A message meant to motivate the user to properly dispose of medication accompanied the images. Three types of motivational messages (eco-affective, norm-based, and social implication based) were presented to assess their effectiveness and preference. User testing revealed issues with label interpretability and a preference for social-implication-based motivational messages. A final prototype incorporating user feedback is presented.

Keywords

design strategies, tools, sustainability, usability/acceptance measurement and research

Introduction

The United Nations has identified unsustainable patterns of consumption and production as one of the root causes of planetary crises, such as climate change, biodiversity loss, and pollution. While existing practices and literature have addressed food and electronic waste, limited attention has been drawn to household pharmaceutical waste (Daughton & Ruhoy, 2011; Kozak et al., 2016). Waste pharmaceuticals include over the counter and prescription medications, controlled substances, etc., Medicine waste, such as expired or unused medications, can often end up in landfills or waterways, where it can have negative impacts on ecosystems and wildlife. In addition, improper disposal of medical waste can also lead to the accumulation of toxins and chemicals in soil and water sources, posing risks to human health. Moreover, the lack of proper disposal methods can also lead to the misuse or abuse of medications, which can have serious consequences for individuals and communities. Considering these challenges, this paper explores the use of a user-centered design process to understand barriers to the proper disposal of medication waste and offers a simple label-based solution to promote the proper disposal of medication waste. In other words, we hope to help users when they are faced with the decision to toss a bottle of long-expired Tylenol. The following sections first provide a background of the consequences of improper medication disposal, an overview of current disposal practices in the United States (US), and research highlighting the lack of awareness of the proper disposal methods. Following this, we present the user-centered design process adopted to address the issue.

Background

Consequences of Improper Medication Disposal

In addition to prescription and over-the-counter drugs for humans, pet medications also contribute to medication waste. Many of these drugs often expire or go unused due to a surplus of purchased medication, non-adherence to prescription instructions, or betterment of symptoms. A 2015 survey of Hong Kong residents estimated that there are 1017 tons of unused medication kept in the household at the time of the survey (Chung & Brooks, 2019). Most respondents indicated

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that they dispose of unused medication in ordinary trash bins. In the United States (US), it is estimated that two out of three dispensed medications were unused. These numbers indicate an unsustainable pattern of pharmaceutical consumption. Improper disposal of this medication waste poses many risks. One is the risk it poses to children, and pets due to unintended consumption. Research has shown that medications are one of the leading causes of accidental poisoning-related deaths in the US (www.asthealth.org, 2012). Another consequence of improper medication waste includes undesired environmental effects. A 2016 study discovered that 631 pharmaceuticals have been detected in the environment in 71 countries which could pose health threats to society (aus der Beek et al., 2016). Such consequences point to the need for interventions that support the proper disposal of medication waste.

Current Medicine Disposal Practices

In the US, the Food and Drug Administration (FDA) provides guidelines and recommendations for safe at-home disposal and instructions for medication drop-off (Center for Drug Evaluation and Research, 2021). Medication drop-off is recommended at specified permanent collection sites which can be a business or facility registered with the US Drug Enforcement Agency (DEA). However, when this is not an option, at-home suggested alternatives include throwing medication away or flushing them. When throwing away medication, it is recommended users mix the medication with unappealing substances like dirt, cat litter, or coffee grounds, place them in a plastic bag, and then place them in the trash. While some medication can be flushed down the toilet, the FDA states that while the risk this poses to the environment is thought to be negligible, "additional data would be helpful" to support this finding. In addition to the FDA's recommendations, there are businesses with separate drop-off locations and practices. The organization MedDrop by Safe Communities specifies that all medication should remain in the original container, inside a resealable plastic bag until it is dropped off at one of the specified police MedDrop locations (*MedDrop | Safe Communities Madison, WI*, 2023). Only then should they be emptied into the plastic resealable bag. This organization specifies that only prescription medicine, over-the- counter medicine, vitamins, nebulizer solution, and inhalers may be dropped off at their locations.

Awareness of Medicine Disposal

While there exist some guidelines for medication disposal, prior research indicates that a lack of unawareness regarding medication disposal options is prevalent among consumers leading to improper disposal practices. One option for prescription drug disposal in the United States is National Prescription Drug Take-Back Day, a DEA-supported biannual event. A survey conducted among students from a US University showed that only 24% of respondents (n = 358) had heard about the event (Vatovec et al., 2017). However, awareness of disposal options alone appears to be insufficient for promoting proper disposal behavior. For example, 40% of community pharmacy patients (n = 200) surveyed in the US state of Indiana indicated they were aware of medication take-back locations in the community but only 15% reported using this option to dispose of medication (Kozak et al., 2016). In addition to consumers, research also indicates that there exists a lack of knowledge among medication prescribers such as physicians about safe disposal practices. For instance, 67% of New Jersey physicians (n = 112) that were surveyed were unaware of disposal guidelines (Wilson et al., 2011).

Methods

This paper aims to use a user-centered design (UCD) process to analyze the problem and then generate a solution that can promote safe medication disposal practices. The UCD process adopted here is the British design council's double diamond approach which comprises four stages: Discover, Define, Develop, and Deliver (*Framework for Innovation*, 2023; *The Double Diamond Design Thinking Process and How to Use It*, 2023). Figure 1a shows the design approach. The first two stages are termed the problem phase and this phase focuses on understanding the problem. The outcome of this phase is a problem statement and a design brief. The last two stages are called the solution phase. This phase focuses on addressing the problem statement and the design brief with the outcome being the proposed solution and testing of the user solution. The following sections provide an overview of each stage, methods adopted within this stage of the design process, and the outcomes.

Results

Discover

The discovery stage involves exploratory research about the problem. Our goal was to understand the issue of medication disposal by engaging with people who know about the issue and are also affected by it. To achieve this, the strategies adopted in this study involved conducting desk research and field research. Desk research involved conducting literature reviews and exploring online resources available regarding medication disposal. Field research was conducted through semi-structured interviews with subject matter experts and user research surveys.

Before conducting field research, the outcomes of the literature review (reported in the Background section) and the brainstorming session helped identify three categories of subject matter experts – pharmacists, law enforcement officers, and physicians. Due to the lack of availability of law enforcement officers and physicians, only pharmacist

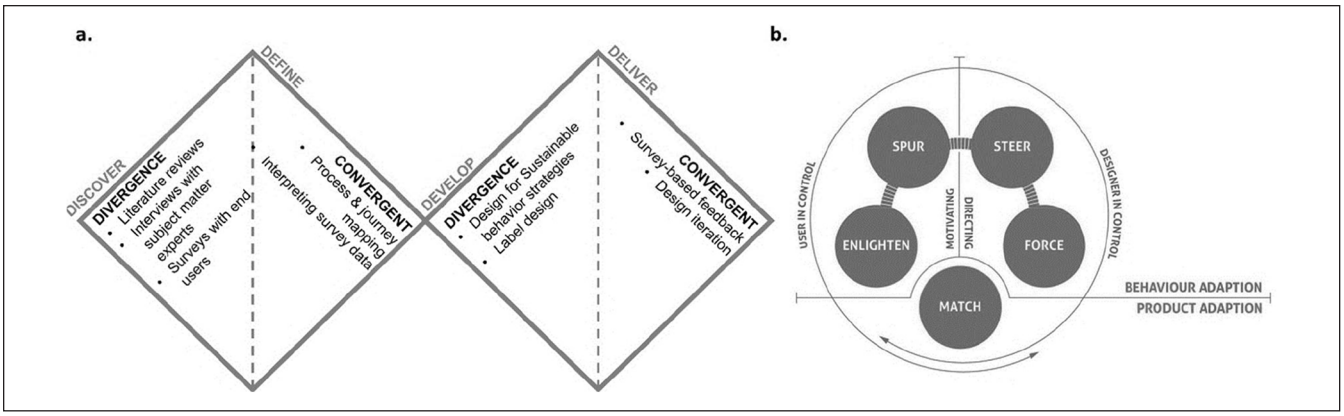

Figure 1. (a) British design council's double diamond approach to user-centered design (The Double Diamond Design Thinking Process and How to Use It, 2023). (b) Design for sustainable behavior strategies (Lidman & Renström, 2011).

interviews were conducted. Interview guides were developed to help researchers conduct the interview and included questions that asked about how unused medication was collected, how often collection occurred, and insights about the disposal process.

User research was conducted through surveys that were developed and deployed using Qualtrics. The outcome of the literature reviews also helped develop survey questions. User survey data consisted of a brief demographic questionnaire that assessed age, gender, and number of people in the household. Following this, additional questions assessed the quantity of unused medication in the household, what respondents did with unused medication and expired medication, and awareness of existing guidelines for medication disposal. The survey assessed whether people believed that improper medication disposal could have adverse effects on human and environmental health. At the close of the survey, respondents were allowed to leave comments regarding any incidents they experienced regarding medication disposal.

Define

Data gathered from expert interviews and user surveys are analyzed here. This helps to clearly define the problem statement and develop a design brief.

Interviews with subject matter experts. Two pharmacists were interviewed. The first pharmacist interviewed was employed in a hospital. The interview with the hospital pharmacist revealed that there are differences in how different institutions (hospitals vs pharmacies) and different states handle unused medication. For example, to help with tracking and auditing controlled substances, hospital pharmacists only take-back medications that are prescribed and dispensed from the hospital. Third-party pharmaceutical waste collectors are briefed regarding the medications collected before hand-off. Medications that are not dispensed by the hospitals are rejected and patients are advised to find an alternative disposal method, e.g., DEA drug take-back day.

The second interview revealed how drugs were disposed of at retail pharmacies. When pharmacists dispose of unused medications that are not sold, it is segregated into two containers: Drugs considered hazardous to the environment (e.g., warfarin) are segregated from other drugs. When collection containers are full pharmacists notify offsite vendors to collect and dispose of the drugs. Drop-off boxes may be available in some retail stores for visitors to drop their unused medications without the need to pass the unused medications to the pharmacist. The pharmacist revealed that there was no drop-off box available in the store they were employed in and was therefore unaware of the procedures involved with drop-off boxes. Using the information from both pharmacist interviews, a process map was developed (see Figure 2).

User surveys. User surveys were created using Qualtrics and distributed through online platforms (Slack channels, Reddit, Nextdoor) In total, 62 participants (26 male, 28 female, and 8 non-binary) completed the survey. Data showed that 75.8% of participants were between 18-34 years of age and 88.7% of participants had unused medicine in their homes.

Table 1 shows the results of the questions related to medication waste. Results revealed that 37.1% of participants usually retained unused medication without disposing of it, and 32.3% threw it away in household garbage. A small percentage of participants would attempt to promote the reuse of the medication by donating to a hospital (8.1%) or giving to friends or relatives (6.5%). When asked about the consequences of medication disposal, 79.1% of participants acknowledge potentially harmful consequences to society and the environment. Results also showed that only 17.7 % of participants were aware of government guidelines for medication disposal. Finally, when prompted to discuss any experiences with medication disposal, some participants

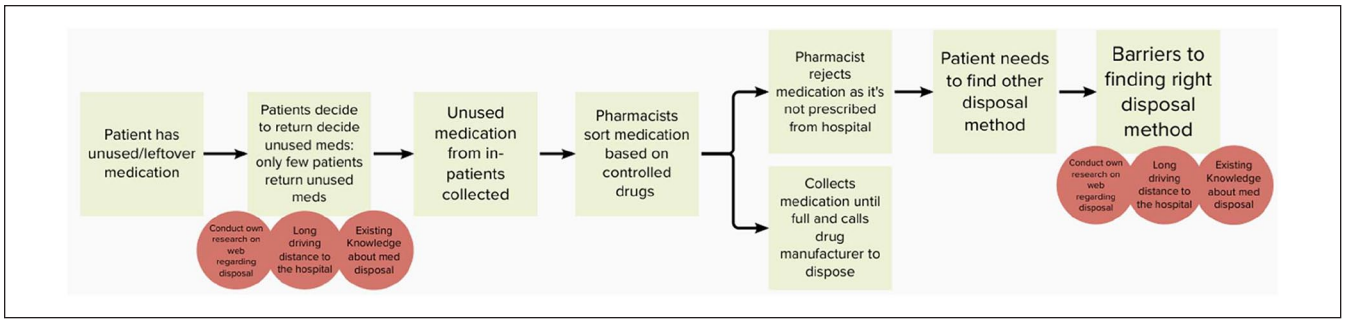

Figure 2. Process map of medication disposal process developed from interviews with pharmacists. The round sticky notes depict barriers for patients to find the right disposal method.

Table 1. Participant knowledge of unused and expired medication in the household.

Survey question	N	%
Does any quantity of purchased medicine remain unused in your home?		
Yes	55	88.7
No	4	6.5
I don't know	3	4.8
What do you do with any unused medication?		
Keep at home	23	37.1
Throw away in household garbage	20	32.3
Donate to hospital	5	8.1
Give to friends or relatives	4	6.5
Flush in the toilet or sink	2	3.2
Other	8	12.9
What do you do with expired medication?		
Flush in the toilet or sink	22	35.5
Nothing	15	24.2
Return to a medical store	9	14.5
Give to friends or relatives	1	1.6
Other	15	24.2
Are you aware of any local, state, or federal guidelines for the proper disposal of unused or expired medication? If yes, please describe.		
Yes	11	17.7
No	51	82.3

mentioned local medical disposal programs or opportunities to return drugs to the police department.

Develop

One strategy for promoting safe medication disposal is by targeting solutions that can support more sustainable behavior from the user. Thus, in developing a solution we leveraged principles outlined in the design for sustainable behavior (DfSB) strategy (Lidman & Renström, 2011). DfSB posits that designers can promote sustainable behavior through the products they design. To develop a solution, we rely on the design strategies provided in DfSB strategies. The design strategies consist of five categories: (1) Enlighten, (2) Spur, (3) Steer, (4) Force, and (5) Match (see Figure 1b). Enlighten includes strategies that aim to motivate user behavior change by influencing the user's knowledge, attitudes, and norms. A common strategy to achieve this is by providing feedback to the user on the consequences of their action or providing information that can support the behavior change. Spur achieves behavior change by using reward structures such as incentives or penalties to spur behavior change. Steer suggests strategies that are less resource intensive for the user to implement. Force aims at using strategies that introduce friction in the interactions that lead to undesirable behavior. Finally, match aims at adapting products and services to adapt to the current user behavior. For our design, we opted to implement an Enlighten-based strategy. We implemented to two-prong approach to implementing this intervention: (1) developing the enlighten-based message, (2) delivering the enlighten-based message.

Designing and delivering the enlighten-based message. Our messages aimed to induce sustainable behavior by (1) instructing the user on an appropriate method of medication disposal and (2) providing information that could motivate the desired behavior for medication disposal. Appropriate methods of medication disposal identified in the problem phase include (1) disposing of medication in household trash, (2) flushing medication down the toilet, or (3) taking-back medication to approved locations. These messages were shortened as (1) landfill, (2) flush, and (3) local take-back respectively, and were accompanied by a relevant descriptive image.

Different strategies can be implemented to motivate desired user behavior. We constructed three types of messages. The first is a positively framed eco-affective strategy that highlights the positive outcome of performing the recommended action. This message was framed as "Safely dispose of meds to save the planet." The second message was a

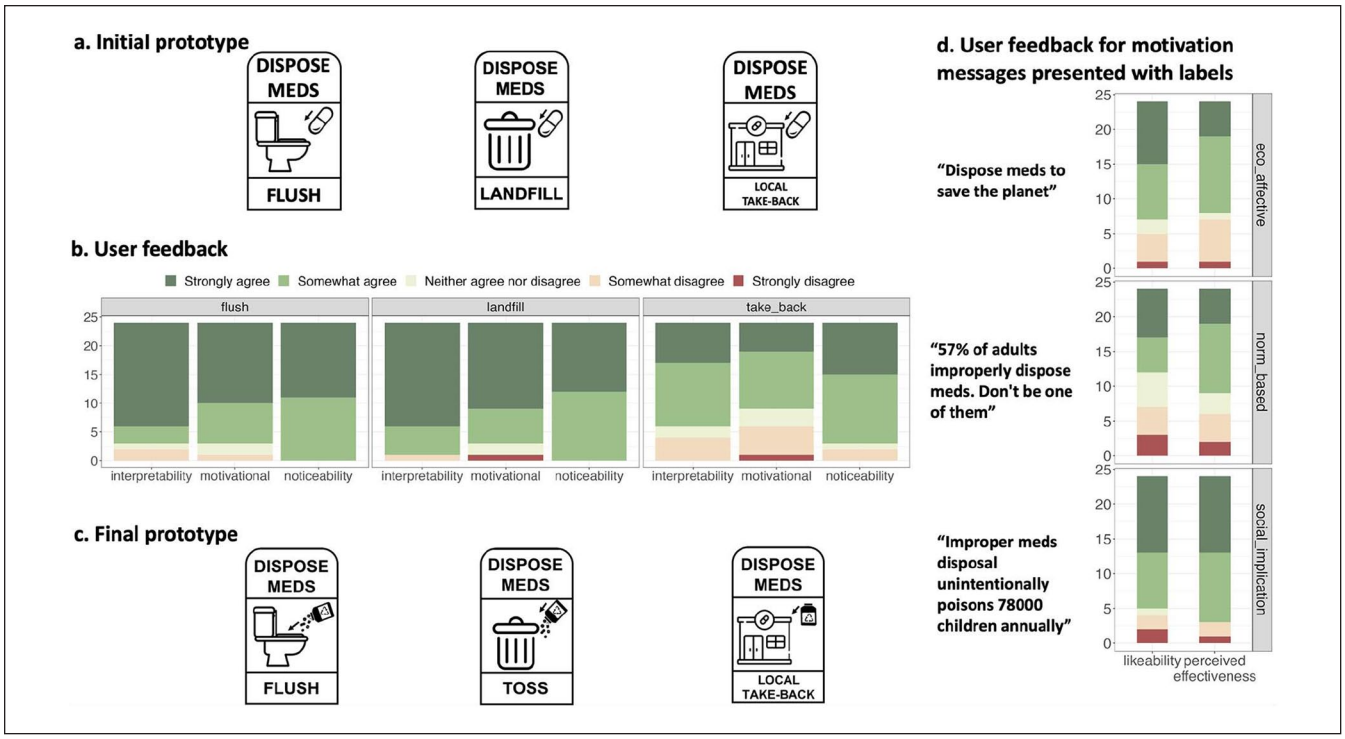

Figure 3. (a) Initial prototypes of labels designed to instruct users on appropriate disposal methods. (b) User feedback on the label was assessed for interpretability, motivational aspect, and noticeability. (c) The final prototype of the label was updated based on user feedback. (d) User feedback on motivational message types.

negatively framed social-implication strategy that highlights the negative outcomes of not performing the behavior. This message was framed as "Improper meds disposal unintentionally poisons 78000 children annually." The final message leverages a normbased strategy that relies on social expectations rather than on the consequences of the action. This was framed as "57% of adults improperly dispose of meds. Don't be one of them."

Once these messages were designed, the next design decision involved determining the best method to deliver this information to the user. To address this, we implemented the use of labels on pill bottles. Implementing these messages on pill bottles ensures that the information is readily available to the user thereby reducing the friction in obtaining the information. Figure 3 shows examples of the instruction and motivation messages implemented on a pill container.

Deliver

In the final stage of the design process, the goal was to collect user feedback on the design intervention. Surveys were designed to collect feedback on the three image-based instructions and the three motivational messages. Twenty-four participants (11 male, 10 female, 3 other; Age M = 28.83, SD = 4.1) completed the survey. To assess what action participants would be inclined to take upon seeing each label, they were "If you found a bottle of expired medicine in your medicine cabinet with the label shown above, what would you do?" Additionally, three items assessed the interpretability (I think this label is easy to understand), motivational aspect (I think this label would prompt me to dispose my medicine properly), and noticeability (I think this label would draw my attention) of the label on a 5- point Likert scale ranging from strongly disagree (rated 1) to strongly agree (rated 5). Based on the survey results (see Figure 3b), we found that the image of the proper disposable method was mostly interpretable. All participants correctly interpreted the image instructing people to flush medication down the toilet. The landfill image was interpreted correctly by 83.33% of participants and the rest had difficulties differentiating if the pills or the pill containers must be disposed of in a landfill and commented on the use of the term "Landfill". The "take-back" image was interpreted correctly by 75% of participants. However, while it was interpreted correctly, some participants commented that they would ignore the message, potentially due to the additional work involved with finding local take-back programs and dropping medication off at locations that may not be convenient to the participants. Based on this feedback, changes were made to all images depicting a bottle of pills being disposed instead of a single pill (see Figure 3a and Figure 3c). Additionally, the word "landfill" was replaced with "toss" to indicate the action recommended for disposal. Based on the feedback from messages, most participants found the social implication-based message to be most agreeable in terms of

effectiveness and acceptability (Figure 3d), which was implemented in our final prototype.

Discussion

Our solution of adding instructional images and motivational messages for the proper disposal of medication has the potential to improve awareness about appropriate disposal methods. We believe the implementation of these images and motivational messages could be effective in supporting sustainable choices for safe medication disposal. The research presented here only explored the design of the label and accompanying messages. Future work will need to examine label placement i.e., where on pill bottles these labels can be placed. Additional insights from users and stakeholders such as healthcare practitioners and police officers will also need to be collected.

Future implementations of the prototypes should be studied in context to evaluate its effectiveness.

Conclusion

With our user-centered design process and design for sustainable behavior process, we designed medication labels for promoting sustainable behavior of safe medication disposal practices. Our solution aims to promote awareness among people that purchase over-the-counter medication and prescription medication, which was highlighted as the largest need in the process of medication disposal by our stakeholders. We believe this work can promote sustainability by supporting responsible consumption and production of pharmaceuticals.

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