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RESEARCH ARTICLE

Pharmacy student's awareness and perception of pharmaceutical disposal and its level in tap water

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Abstract

Background: Improper disposal of pharmaceuticals can harm humans, animals, and the ecosystem, with studies finding residues in tap water that may affect drinking water safety. Therefore, this study aims to examine pharmacy student's disposal practices and the association between the Respondents' Disposal Practices (RDP) with Demographic Factors (RDF), their knowledge of the impact of improper disposal on tap water quality (KII), awareness of proper disposal practices (KPD), and the availability and accessibility of disposal facilities (AAD). **Methods:** The questionnaire consisted of a question on RDP as the dependent variable and fifteen questions from four independent variables, namely, RDF, KII, KPD, and AAD. It was distributed online using Google Forms. Descriptive data was analysed using SPSS to investigate the association between dependent and independent variables. **Results:** There were 175 respondents, and 76.6% of them kept unused or expired medications. The analysis revealed that the RDP were unrelated to the RDF. However, KII and KPD were partially associated with RDP. Lastly, the AAD was strongly associated with RDP. **Conclusion:** Most respondents were unaware of the proper disposal of unused or expired drugs. The study recommends incorporating proper medication disposal into the pharmacy curriculum and strengthening the medication take-back programme by encouraging community pharmacies to participate in the Medicine Return Programme.

Introduction

Pharmaceuticals are chemical substances produced for medicinal purposes to treat a variety of diseases. However, improper pharmaceutical or medicine disposal negatively impacts humans, animals, and the environment (Wilkinson *et al.*, 2022). The emergence of pharmaceutical contaminants in water sources is a growing global concern. Their presence has been detected worldwide, especially in low- to middle-income countries, including regions in Africa and Asia (Wilkinson *et al.*, 2022). The pharmaceutical residues in water sources have become a potential threat to human health and the ecosystem, which includes endocrine disruption in humans and animals, antibiotic resistance issues, and toxicity to marine life (Liu *et al.*, 2019). A study by Wee et al. (2022) found different types of drugs, such as anti-inflammatories, antibiotics, antiepileptics, beta-blockers, psychoactive stimulants, and antiparasitic drugs in tap water at low concentrations ranging from less than 0.03 ng/L to 21.39 ng/L. Jureczko and Kalka (2019) also reported the presence of chemotherapeutic agents such as cyclophosphamide, ifosfamide, fluorouracil hydroxycarbamide, and tamoxifen in groundwater, surface water, rivers, and drinking water. These

substances can cause harmful effects on non-patients because they can damage cells, genes, and the endocrine system. Although many studies reported trace levels of pharmaceutical residues that do not cause immediate significant effects on humans and the environment, long-term continuous exposure to the contaminants is still a concern (Wee *et al.*, 2020).

Having access to safe drinking water is essential to human daily life, whether it is used for drinking, food preparation, domestic use, or recreation. The World Health Organization (WHO) Guidelines for Drinking-water Quality define safe drinking water as water that does not pose a significant risk to health for a lifetime, including different sensitivities that may develop between life stages (WHO, 2004). However, the incidence of pharmaceutical residues in tap water affects the accessibility to safe drinking water.

In the United States, the Food and Drug Administration (FDA) recommends disposing unused or expired medicines through a medication take-back programme (Lucca *et al.*, 2019). Consumers can return their unused or expired medicines safely and legally to designated locations or facilities. However, suppose the take-back programme is unavailable at their location. In that case, unused or expired medications are discarded according to the recommendation of the United States FDA, depending on the type of drug. If the medication is listed in the FDA flush list, such as opioids, sodium oxybate, diazepam, and methylphenidate, it is flushed down the toilet or sink (Wilcox., 2013; Hajj *et al.*, 2022). Medications not listed in the FDA flush list can be thrown into household garbage but must be mixed with undesirable substances, placed in a sealed container, and thrown in the trash (FDA, 2024). Some countries have introduced the safe disposal of pharmaceuticals, but the community is unaware of the policy. For example, a previous study by Ayele and Mamu (2018) revealed that 66.9% of the Harar City, Eastern Ethiopia community was unaware of the medication take-back programme. This finding is consistent with a study conducted by Vatovec et al. (2017), where only a small percentage (24%) of university students in developed countries were aware of the programme, and an even smaller percentage (4%) of students utilised the programme. They discarded their medication in the garbage or flushed it down the toilet.

In Malaysia, the Medicine Return Programme (MRP) was initiated by the Ministry of Health in 2010 to safely dispose of unused or expired medications, thereby preventing environmental contamination and public safety (Foon *et al.*, 2019). The MRP service is available at all public hospitals and health clinics, allowing the public to conveniently return unused or expired medications to the pharmacy counters. A recent study indicated the lack of clear guidelines and high operational and incineration costs are major drawbacks to this programme (Chong *et al.*, 2022). The discovery of pharmaceutical residues in tap water fourteen years after the launch of MRP is alarming. Addressing the impact of pharmaceutical residues in tap water is critical, as they affect non-patients health.

Therefore, this study serves as a baseline study to understand pharmacy students' disposal practices and the association between the respondents' disposal practices (RDP) with their demographic factors (RDF), knowledge of the impact of improper disposal on tap water quality (KII), awareness of proper disposal practices (KPD) and the availability and accessibility of disposal facilities (AAD). This study specifically focuses on pharmacy students, as the authors anticipate their increased awareness of these programmes. This research also examines their awareness of the negative consequences of improper medicine disposal in tap water. Consequently, this study provides new insights into the potential role of future healthcare professionals in advocating for safe medication disposal practices.

Methods

Study design

A quantitative, cross-sectional, self-administered online questionnaire was conducted in 2023 among pharmacy students. This study was carried out with ethical approval (048/2023) by the Research Ethics Committee. Students in the Faculty of Pharmacy at Universiti Teknologi MARA were invited to participate in this survey since this university has the highest number of pharmacy students. The survey was conducted online using Google Forms. Based on the Raosoft sample size calculator, the recommended sample size for this study was 244 respondents. The sample size was determined with a population size of 710, 95% confidence interval, 5% margin of error, and 50% response distribution. The recommended sample size was 250.

Questionnaire

The questionnaire was adapted with permission from a previous study investigating the knowledge and barriers to the safe disposal of pharmaceutical products entering the environment (Fidora, 2017). The questionnaire consists of 16 variables on the respondents' sociodemographic background, knowledge and beliefs, awareness, availability of disposal facility, and disposal practice of unused or expired medication. Additionally, the questionnaire's pilot testing was conducted,

demonstrating good face and content validity. The face validity that involved assessing the readability, length, and relevance of the online questionnaire was done by three senior pharmacy lecturers who had been trained in questionnaire design. Pre-testing was also conducted, where 38 students were involved. The final questionnaire's internal consistency or content validity was determined using the SPSS software, resulting in a Cronbach's alpha coefficient of 0.81.

Data collection and analysis

The questionnaire was distributed and collected using Google Forms through a convenient probability sampling method. Informed consent was requested in the introductory part of the questionnaire, and the survey response was kept anonymous. The data collected from the survey was analysed using IBM Statistics Package for Social Sciences (SPSS) software version 27. The questionnaire was disseminated through various channels, including social media, email, and word of mouth, to reach the target audiences. Respondents were not provided with any incentives for their participation to ensure that their responses were voluntary and unbiased. The data were collected electronically using a web-based form that required the respondents to answer every question; hence, there was no missing data. Descriptive data was analysed using frequency and percentages. The Chi-square test was used to explore the association between dependent and independent variables with at least two categories for each variable. A p-value of < 0.05 was considered significant. A reliability test was conducted on the 16 constructs by 175 respondents who were evaluated with the SPSS software and were shown to have high reliability with Cronbach alpha of 0.995.

Results

A total of 209 pharmacy students participated in this online survey. However, the analysis excluded 34 responses due to their contradictory responses. Thus, the final sample consisted of 175 respondents. Among the 175 respondents, 85.1% had taken prescription or over-the-counter (OTC) medicine in the past two years, and 76.6% kept unused or expired medications in storage.

The variable of interest in this study was the respondent's disposal practice (RDP). Most respondents (81.7%) improperly disposed of unused or expired medication by throwing it in the trash, flushing it down the toilet or sink, or storing it for later use. The remaining respondents (18.3%) followed disposal instructions in the medication leaflet, returned it to the pharmacy, or mixed it with dirt, ground coffee, or kitty litter.

The respondent's demographic factors (RDF) assessed in this study were gender, location, ethnic background, family income, and pre-university background. Most of the respondents who participated in this study were females (84%) and Malay (97.7%) (Table I) since the university undergraduate programmes can only enrol "*Bumiputera*". Most respondents (96.0%) lived in the West Malaysia region. A relatively higher percentage of respondents reported a monthly income of less than RM4850 (40.2%), followed by between RM4850-10960 (35.6%) and more than RM10960 (24.2%). Students enrolled in the Bachelor of Pharmacy programme were from pre-university programmes, namely Diploma in Pharmacy (27.4%), Foundation in Science (55.4%), and Matriculation (17.1%). At the time of the survey, all respondents were actively enrolled in the Bachelor of Pharmacy. From the analysis of the Chi-square test in Table I, no significant correlation was observed between disposal practices and demographic factors, namely, sex, location, ethnic group, household income, and pre-university background. Although 27.4% of students completed their diploma in the pharmacy programme, no significant correlation was observed in their proper disposal practices. The respondent's knowledge and belief on the impact of improper disposal on tap water quality (KII) was represented by three variables from the questionnaire (Table II). The respondent's disposal practice was significantly associated with their belief that pharmaceutical contaminants may be present in tap water ($p = 0.018$). However, they do not know the names of pharmaceutical contaminants in tap water.

Table I: Chi-square test between disposal practices (RDP) and demographic factors (RDF)

No	Demographic factors	Description	N (%)	p-value
1.	Sex	Male	28 (16)	0.639
		Female	147 (84)	
2.	Location	West Malaysia	168 (96)	0.780
		East Malaysia	7 (4)	
3.	Ethnic group	Malay	171 (97.7)	0.725
		Other	4 (2.3)	
4.	Household monthly income	<RM4850	71 (40.2)	0.520
		RM4850-10960	62 (35.6)	
		>RM10960	42 (24.2)	
5.	Pre-university background	Diploma	48 (27.4)	0.389
		Foundation	97 (55.4)	
		Matriculation	30 (17.2)	

Table II: Chi-square test between disposal practices (RDP) and knowledge and beliefs on the impact on tap water quality (KII)

No	Descriptions	Yes N (%)	No N (%)	*p*-value
1.	Do you believe that improper medicine disposal in the environment could have negative consequences on tap water quality? (KII1)	156 (89.2)	19 (10.8)	0.508
2.	Do you believe that pharmaceutical contaminants may be present in tap water? (KII2)	116 (66.3)	59 (33.7)	0.018*
3.	Do you know what pharmaceuticals may be present in tap water? (KII3)	38 (21.7)	137 (78.3)	0.017*

*$p < 0.05$ significant difference

The respondents were also evaluated based on their knowledge and awareness of proper disposal practice (KPD), represented by five questionnaire variables (Table III). The respondent's proper disposal practice was partially associated with their knowledge and awareness of proper disposal practices. Most respondents received information on proper medication disposal practices (64.9%), but most were unaware of local or federal guidelines for disposing of unused or expired medications (61.5%). Healthcare providers did not inform respondents (97.7 %) about properly disposing of unused or expired medications. There was a significant correlation between the disposal practices and availability of state or federal guidelines on the disposal of unused or expired medications ($p = 0.045$), availability of promotional material on proper disposal of unused medications ($p = 0.014$), receiving information about proper medication disposal practices ($p = 0.041$) and receiving the information from a healthcare provider on the proper way to dispose of unused medications ($p = 0.001$).

Table III: Chi-square test between disposal practices (RDP) and knowledge and awareness of proper disposal practice (KPD)

No	Descriptions	Yes N (%)	No N (%)	*p*-value
1.	To your knowledge, are there any local state, or federal guidelines for the proper disposal of unused or expired medications? (KPD1)	68 (38.5)	107 (61.5)	0.045*
2.	Do you know what the official recommended disposal practices are? (KPD2)	136 (77.7)	39 (22.3)	0.317
3.	Are you aware of any promotional material (such as pamphlets, posters, and web info) that deals with the proper disposal of unused or expired medications? (KPD3)	86 (48.8)	89 (51.1)	0.014*
4.	Have you ever received information about proper medication disposal practices? (KPD4)	114 (64.9)	61 (35.1)	0.041*
5.	How often has a healthcare provider informed you about the proper way to dispose of your unused or expired medications, in the past two years? (KPD5)	4 (2.3)	171 (97.7)	0.001*

*$p < 0.05$ significant difference

The availability and accessibility of disposal facilities (AAD) were represented by two variables (Table IV). The Chi-square test revealed a strong correlation between disposal practices (RDP) and disposal facilities (AAD) (Table IV). Thus, both location ($p = 0.001$) and convenient accessibility ($p < 0.001$) were significantly associated with disposal practices. This showed that the location and convenient accessibility to disposal facilities affected the disposal practices.

Table IV: Chi-square test between disposal practices (RDP) and availability and accessibility of disposal facility (AAD)

No	Description	Yes N (%)	No N (%)	Not applicable N (%)	*p*-value
1.	In your area, is there a designated collection location where you can dispose of your unused or expired medication? (AAD1)	28 (16)	147 (84)	0	0.001*
2.	Is it convenient for you to reach the designated disposal location? (AAD2)	14 (8.0)	24 (13.7)	137 (78.3)	< 0.001*

*$p < 0.05$ significant difference

Discussion

This cross-sectional study aimed to investigate the correlation between disposal practice (RDP) with four respective parameters, namely, demographic factors (RDF), knowledge and beliefs of improper disposal on tap water quality (KII), awareness of proper disposal practice (KPD) and availability or accessibility of disposal facility (AAD).

An earlier study by Leong et al. (2021) found that 84 % of respondents in Malaysia had unused medications, which is consistent with the current data showing 76.6% of respondents possessing unused medications. Despite the introduction of the MRP fourteen years ago in 2010, most pharmacy students remained unaware of the proper disposal of unused pharmaceuticals, which can contaminate tap water and endanger the lives of healthy citizens. An understanding of the Sustainable Development Goal (SDG) is an essential component of embracing the initiative by the United Nations in 2015 to promote both global prosperity and environmental sustainability. The SDG specifically outlined Goal 6, which aims to ensure people's access to clean water and adequate sanitation services. The present research has shown that improper handling of unused or expired pharmaceuticals is not limited to Malaysia; similar issues have been reported in Bangladesh (Shakib *et al.*, 2022) and Indonesia (Kusuma *et al.*, 2023), despite Malaysia and Indonesia having guidelines for proper disposal. Such accumulation ultimately contributes to the inaccessibility of clean water. Therefore, the inclusion of the United Nations SDG into the present curriculum will expose student pharmacists to real environmental issues and their responsibility towards the community.

No association was found between disposal practice and demographic factors. Thus, student's disposal practice was independent of their demographic background. This finding was similar to another study conducted by Fidora (2017) that found that demographic variables among residents of the northeast United States do not impact their disposal behavior.

However, disposal practice (RDP) was partially associated with knowledge and beliefs on the impact of improper disposal on tap water quality (KII) and awareness of proper disposal practice (KPD). Students need to be informed of the MRP in cases where it is unavoidable to have unfinished medication. Since disposal practice is partially associated with knowledge and beliefs about the impact of improper disposal on tap water quality, it is important to improve their awareness of proper medicine disposal practices and their impact on the quality of tap water following improper disposal practices.

This may be achieved by incorporating proper disposal of medication into the pharmacy curriculum. This can be in the form of lectures, workshops, or community outreach programmes. To conduct community outreach programmes, students have to be taught the proper disposal practices or guidelines to inform the public of the impact of improper pharmaceutical disposal on this tap water and create awareness of the MRP, which may be included in their curriculum. Additionally, universities should include training sessions for students to participate in the drug take-back programme. For instance, universities may collaborate with government or private healthcare facilities to allow students to work with professionals and experience the proper procedures for managing returned medicines according to the guidelines. Furthermore, the responsible parties, such as the Pharmacy Board, could create an examination that assesses the pharmacy students' knowledge and proficiency in proper medicine disposal practices. This examination could become a mandatory requirement for them to qualify as a registered pharmacist

The disposal practice (RDP) was found to be strongly associated with the availability and accessibility of disposal facilities (AAD). According to the survey, less than 20% of the respondents were aware of the existence of medicine disposal facilities, indicating a low level of awareness. Furthermore, only 8% of the respondents found it inconvenient to reach the facility. To address this issue, the MRP needs to be strengthened and should involve the government and private healthcare facilities. The involvement of more community pharmacies in this MRP should be encouraged due to the widespread availability of community pharmacies. These findings showed that 84% of the respondents were unaware of the pharmaceutical disposal facilities around their area. Awareness is needed to inform them that the unused drugs can be returned to participating community pharmacists around their area. The government can provide incentives, support, and guidelines to the community pharmacies to encourage them to provide a more flexible and convenient disposal option to the public. Pharmacists should collaborate with other relevant government agencies to effectively implement the MRP. Recently, there has been significant progress in Malaysia regarding the involvement of large chain community pharmacies and multinational manufacturers such as Caring Pharmacy, Alpro Pharmacy, and GlaxoSmithKline. They have placed disposal bins for unused pharmaceuticals throughout their countrywide pharmacy as part of their Environmental, Social, and Governance (ESG) policy.

The Ministry of Health and the Ministry of Natural Resources and Environmental Science collaborated to list the locations of these disposable bins on the MyMediSAFE website. This information should be included in the curriculum or community outreach programme so that student pharmacists can prepare to serve the community in the future.

Limitations

The respondents to the survey were limited to pharmacy students at Universiti Teknologi MARA (UiTM), with the majority of students in the group being Malay. Nonetheless, the responses were almost similar to the results from the general public reported by Leong *et al.* (2021). The low respondent rate is also an indicator of students showing no interest in this topic, although the situation is alarming and affects their health. To enhance the knowledge of future pharmacists on pharmaceutical disposal guidelines and MRP, it would be beneficial to increase student involvement in community projects that include graded participation and to integrate the proper handling of unused or expired pharmaceuticals into the curriculum.

Conclusion

In conclusion, the findings indicate that the availability and accessibility of disposal facilities play a major role in determining disposal practices among pharmacy students. On top of that, their knowledge and beliefs on the impact of improper disposal on tap water quality as well as their knowledge and awareness of proper disposal practices, also influence their disposal behavior. Therefore, further efforts are necessary to improve their knowledge of the proper disposal practices.

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Conflict of interest

The authors declare no conflict of interest.

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Ethics statement

This study was carried out with ethical approval (048/2023) by the Research Ethics Committee.

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