

## Original Research

# Exploring medication disposal practices and public awareness in Al Ain: A Cross-sectional study

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### Abstract

**Background:** Medicines are vital for treating different diseases and supporting overall health. However, once they are no longer needed, they should be disposed of properly as improper disposal of unused or expired medications can pose serious risks to both the environment and public health. **Aims:** To evaluate medication disposal practices among adult residents of Al Ain, UAE, and to explore the pharmacist's role in medication disposal. **Methods:** A cross-sectional survey was conducted using a structured, self-administered questionnaire. The questionnaire assessed demographics, disposal practices, awareness of disposal programs, and the role of pharmacists. A total of 362 residents aged 18 and above participated. Data were analyzed using SPSS version 30.0, with chi-square tests applied to examine associations between demographic variables and disposal behavior. **Results:** Although 92.5% of participants reported checking medication expiry dates, only 63.6% took precautions when disposing of medications. Notably, 38.1% disposed of medications in regular trash. Awareness of official disposal programs was low (78.2% unaware), but 93.4% expressed willingness to use a medication disposal box. A significant association was found between age and safe disposal practices ( $p < 0.05$ ). Most respondents (85.1%) trusted pharmacists for guidance, yet 62.4% had never received such advice. **Conclusion:** While general awareness of medication safety is promising, unsafe disposal practices persist. Enhancing public education, empowering pharmacists, and expanding access to disposal infrastructure are critical for improving safe medication disposal in the community.

**Keywords:** Al Ain, Environmental health, Medication disposal, Pharmacist role, public awareness, United Arab Emirates

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## INTRODUCTION

Medicines are crucial in treating a wide range of diseases and in supporting both physical and mental health<sup>1</sup>. However, when medicines are no longer needed, it's important to dispose them properly<sup>2</sup> because their environmental impact can lead to complex and long-term effects that may harm

humans, animals, and plants. Eco-pharmacovigilance (EPV) emphasizes detecting, evaluating, and preventing the adverse effects of pharmaceuticals, particularly when they enter the environment<sup>3</sup>. Improper disposal of household medical waste, such as unused, expired, or unwanted medications, carries several risks. These include accidental ingestion by toddlers and children that could be lethal; intentional misuse by teens causing serious side effects such as drug abuse and dependency; sharing of leftover medicines with other patients having similar symptoms, which can lead to inappropriate or unsafe treatment<sup>4</sup>.

In the Arabian Gulf countries, medical waste places a significant financial load on the healthcare system, making it challenging to maintain high-quality services<sup>5</sup>.

Pharmacists play an important and multidimensional role in ecopharmacovigilance (EPV) by linking healthcare, patients, and environmental safety. Their involvement includes education, waste management, sustainable prescribing, and policy advocacy to mitigate the environmental impact of pharmaceuticals<sup>6</sup>. Their professional leadership is important in turning eco-pharmacovigilance from a conceptual model into a routine practice<sup>7,8</sup>. In line with this, the International Pharmaceutical Federation (FIP) has called for pharmacy teams to promote practice-friendly pharmaceutical waste disposal systems and to educate the public on environmentally responsible medicines management as part of broader sustainability actions within pharmacy<sup>9</sup>. Beyond counselling, pharmacists operationalize EPV through pharmaceutical stewardship interventions that reduce the volume of unused medicines requiring disposal. These include medication review and deprescribing support, adherence interventions to avoid oversupply, inventory control to minimize



expiries, separation and safe handling of recalled/outdated stock, and facilitating or signposting take-back/collection schemes where available. Pharmacists reduce the volume of unused medicines requiring disposal via pharmaceutical stewardship interventions. This includes medication review, adherence interventions to avoid oversupply, inventory control to minimize expiries, separation and safe handling of recalled/outdated stock, and facilitating or signposting take-back/collection schemes where available<sup>9,10</sup>.

In an earlier study conducted in the United Arab Emirates (UAE), Almost 85% of households respondents reported that they throw expired medications in the regular trash, whereas only 3% used other methods such as flushing them in the toilet, burying them in the yard, or returning them to the pharmacy<sup>11</sup>. It has also been reported that although many individuals with diabetes in the UAE are aware of the hazards of improper sharps disposal and know how to dispose of them safely, approximately 50% still discard used sharps in regular household waste<sup>12</sup>.

Despite the importance of proper medication disposal, limited research has examined these practices in Al Ain. Therefore, this study aims to assess disposal practices among adult residents, explore the role of pharmacists, identify knowledge gaps, and recommend strategies to support safer disposal practices in the community.

## METHODS

### Study design, setting and ethical consideration

This study employs a cross-sectional survey design. A structured, self-administered questionnaire was used to gather quantitative data on participants' medication disposal practices in Al Ain. The study was approved by the Ethical Committee of Fatima College of Health Sciences (Reference No: FECE-1-24-25KAMIL).

Al Ain, located in the Emirate of Abu Dhabi, is the fourth-largest city in the United Arab Emirates (UAE) with a population of around 1,009,735 residents, representing 27% of the emirate's total population. (Statistics Centre Abu Dhabi, 2022)<sup>13</sup>.

### Participants and sample size

The study targeted Al Ain residents above 18 years. Participants were recruited through a convenience sampling method. Inclusion criteria were age (18 years and above), residence in Al Ain, and consent to participate in the study. The sample size was determined using an online sample size calculator (calculator.Net)<sup>14</sup>. With a total population of 1,009,735 people and with a 95% confidence level and a 5% margin of error, the minimum required sample size for this study was 385 adults. This sample size was deemed sufficient to ensure statistical reliability and representativeness.

### Data Collection Instrument

A well-designed standardized English and Arabic-based questionnaire was produced by the authors based on current literature<sup>15-17</sup>. The questionnaire was assessed by four researchers who indicated that it had appropriate content and face validity. To improve the clarity and ease of understanding of the questionnaire, a pilot study was conducted with a small sample (n=5) to assess the clarity, functionality, and appropriateness of the questionnaire for an online format. Feedback from this pilot study was analyzed and used to make any necessary adjustments to improve the overall usability and comprehensiveness of the survey. The final version of the questionnaire consisted of three sections and 14 questions. The first section assessed the demographic information using 3 items including age group, gender, and the highest level of education. The second section assessed medication disposal practices. The section was assessed using 8 multiple-choice questions. The third section assessed the Pharmacist role in medication disposal. This section consists of 3 questions made up of 2 multiple choice questions and one open ended question. The survey was administered through Google Forms, ensuring secure access and ease of participation. The survey link was distributed via email to Fatima College Al Ain campus students and staff and through social media platforms, including Facebook and WhatsApp groups of Al Ain residents. The data collection period spanned from December 2024 to January 2025.

### Data Analysis

Before data analysis, data cleaning was performed to ensure accuracy and appropriateness. The data were then analyzed using IBM Statistical Package for Social Sciences (SPSS) version 30.0 to identify patterns and relationships in the information and for quantitative data analysis. Prior to running the chi-square analyses, the assumptions of the test were assessed. Specifically, the expected cell counts were reviewed to confirm that most cells had an expected frequency of at least five. When sparse data were encountered, related response categories were merged to meet this requirement. After these adjustments, all chi-square analyses satisfied the necessary assumptions, allowing the results to be interpreted with confidence. The chi-square test was used to determine the association between specific factors (age group, gender, and the highest level of education) and medication disposal practices, and the pharmacist's role in medication disposal. Significance was determined at P-value < 0.05. In addition to p-values, effect sizes were calculated for statistically significant chi-square associations using Cramér's V to assess the strength of relationships between categorical variables. Effect sizes were interpreted according to conventional thresholds, with values of approximately 0.10 indicating small effects, 0.30 moderate effects, and 0.50 large effects.

## RESULTS

A total of 362 surveys were returned, producing a response rate of 94.3%.



| Table 1. Demographic characteristics of the participants |                       |
|----------------------------------------------------------|-----------------------|
| Characteristics                                          | Frequency (%), N= 362 |
| <b>Age (years)</b>                                       |                       |
| 18-24                                                    | 70 (19.3)             |
| 25-34                                                    | 52 (14.4)             |
| 35-44                                                    | 111 (30.7)            |
| 45-54                                                    | 92 (25.4)             |
| 55+                                                      | 37 (10.2)             |
| <b>Gender</b>                                            |                       |
| Female                                                   | 319 (88.1)            |
| Male                                                     | 43 (11.9)             |
| <b>Highest education level</b>                           |                       |
| Bachelor's degree                                        | 188 (51.9)            |
| Diploma or technical training                            | 34 (9.4)              |
| Doctorate                                                | 24 (6.6)              |
| High school                                              | 64 (17.7)             |
| Master's degree                                          | 52 (14.4)             |

### Demographic characteristics of enrolled participants

The demographic profile of participants in this study was diverse, including variations in age, gender, and education level. A total of 362 individuals participated in the study. Most respondents were between 35 and 44 years of age (30.7%). The sample was predominantly female (88.1%), with male participants representing 11.9% of the total. In terms of education, just over half of the participants (51.9%) held a bachelor's degree. The detailed demographic characteristics of participants are presented in Table 1.

### Medication Disposal Practices, and Pharmacist's Role

Participants' perspectives on medication disposal practices and the pharmacist's role are summarized in Table 2. Among the 362 respondents, 36.5% admitted to not taking any precautions when disposing of medications, while a combined 63.6% reported either always or sometimes taking such precautions. More than two-thirds (64.6%) believed that improper disposal of medications can be harmful. Most respondents (over 90%) regularly checked medication expiry dates. Regarding the safest medication disposal method, discarding medications in regular household trash without precautions was the most cited option (38.1%) among other options. Half of the respondents (51.9%) disagreed with the belief that expired drugs are safe and require no precautions for disposal. When asked about diabetes-related sharps disposal, only 34.0% of respondents reported using a biohazard container. Awareness of disposal programs or collection boxes in Al Ain was low, with 78.2% unaware. However, 93.4% expressed willingness to use such boxes if they were made available. Knowledge of the Department of Health's disposal guide was limited; 85.4% had never heard of it, and only 5.0% had used it. 62.4% had

never received advice from a pharmacist regarding medication disposal, although 85.1% stated they would trust pharmacists to provide such guidance. When asked for suggestions, only 130 participants gave suggestions. 17.6% recommended establishing accessible collection boxes, 14.3% called for public awareness campaigns.

### Association of age, gender and education level with medication disposal practices, and the pharmacist's role in medication disposal

Participants aged 55 and older were significantly more likely to report taking precautions when disposing of medications (54.1%) compared to younger age groups ( $p < 0.05$ ) and demonstrated a small effect size (Cramér's  $V = 0.137$ ), indicating a meaningful but not strong relationship. Participants aged from 45 to 54 years were more aware of the potential harm of improper medication disposal ( $p < 0.05$ ) and also demonstrated a small effect size (Cramér's  $V = 0.244$ ) (Table 3). Although checking medication expiry dates was common across all age groups, education levels, and genders, no statistically significant differences were observed ( $p > 0.05$ ).

When comparing education levels (Table 3), a significant difference was noted in perceptions of the safest method of disposal ( $p < 0.05$ ). Those with doctorate degrees were more likely to select "return to pharmacy" (50.0%) as the safest option, compared to lower education levels with small effect sizes (Cramér's  $V = 0.145$ ), indicating limited but relevant practical significance. However, no significant differences were found regarding whether participants took disposal precautions by education level ( $p > 0.05$ ).

Gender comparisons showed significant differences in medication disposal awareness and practices (Table 4). Males were more likely to recognize the potential harm of improper disposal (79.1% vs. 62.7% in females;  $p < 0.05$ ) with small effect sizes (Cramér's  $V = 0.137$ ) and to choose safer methods such as returning medications to pharmacies ( $p < 0.05$ ) with small effect sizes (Cramér's  $V = 0.244$ ). Additionally, awareness of the Department of Health's disposal guide was significantly higher among females ( $p < 0.05$ ) (Cramér's  $V = 0.147$ ), indicating a meaningful but not strong relationship.

## DISCUSSION

This study provides valuable information about how the study participants in Al Ain, UAE, understand and handle the disposal of medications. The findings show a generally promising level of awareness among participants but also point to the need for better public education, as some misconceptions and unsafe disposal practices still exist within the Al Ain community.

The finding revealed that around two-thirds of Al Ain residents (63.6%) either always or sometimes take precautions when disposing of medications; this level of compliance is not ideal, considering the potential environmental and public health

| <b>Table 2. Responses to Medication Disposal Practices and pharmacist role (n =362)</b>                                                          |                                                                              |                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------------|
| <b>Question / Statement</b>                                                                                                                      | <b>Options</b>                                                               | <b>Frequency (%)</b> |
| Do you take any precautions when disposing of medications?                                                                                       | Yes                                                                          | 115 (31.8)           |
|                                                                                                                                                  | Sometimes                                                                    | 115 (31.8)           |
|                                                                                                                                                  | No                                                                           | 132 (36.5)           |
| Do you think medications can be harmful if not disposed of properly?                                                                             | Yes                                                                          | 234 (64.6)           |
|                                                                                                                                                  | No                                                                           | 33 (9.1)             |
|                                                                                                                                                  | Not sure                                                                     | 95 (26.2)            |
| Do you check the expiry date of your medication before you use it?                                                                               | Yes                                                                          | 335 (92.5)           |
|                                                                                                                                                  | No                                                                           | 4 (1.1)              |
|                                                                                                                                                  | Sometimes                                                                    | 23 (6.4)             |
| What do you think is the safest way for disposing medication?                                                                                    | Throw in regular household trash without precautions                         | 138 (38.1)           |
|                                                                                                                                                  | Flush in toilet or sink                                                      | 39 (10.8)            |
|                                                                                                                                                  | Return to pharmacy                                                           | 85 (23.5)            |
|                                                                                                                                                  | Other                                                                        | 100 (27.6)           |
| Do you believe that an expired drug is safe and needs no precautions for disposal compared to an active drug?                                    | Yes                                                                          | 55 (15.2)            |
|                                                                                                                                                  | No                                                                           | 188 (51.9)           |
|                                                                                                                                                  | Not sure                                                                     | 119 (32.9)           |
| If diabetic, do you dispose of used sharps in a biohazard container?                                                                             | Yes                                                                          | 123 (34.0)           |
|                                                                                                                                                  | No                                                                           | 163 (45.0)           |
|                                                                                                                                                  | Sometimes                                                                    | 31 (8.6)             |
|                                                                                                                                                  | Not Answered                                                                 | 45 (12.4)            |
| Are you aware of any medication disposal programs or collection boxes available in Al Ain?                                                       | Yes, and I know where they are                                               | 33 (9.1)             |
|                                                                                                                                                  | Yes, but I don't know the location                                           | 46 (12.7)            |
|                                                                                                                                                  | No, I am not aware                                                           | 283 (78.2)           |
| Are you willing to dispose of expired medication in the collection boxes if made available?                                                      | Yes                                                                          | 338 (93.4)           |
|                                                                                                                                                  | No                                                                           | 5 (1.4)              |
|                                                                                                                                                  | Not sure                                                                     | 19 (5.2)             |
| Have you heard about the Department of Health's (DOH) guide for the safe disposal of unused medicines at home?                                   | No, I have not heard of it                                                   | 309 (85.4)           |
|                                                                                                                                                  | Yes, but I have not used it                                                  | 35 (9.7)             |
|                                                                                                                                                  | Yes, I am familiar with it and have used it                                  | 18 (5.0)             |
| Have you ever received advice from a pharmacist about how to properly dispose of unused or expired medications?                                  | Yes, regularly                                                               | 29 (8.0)             |
|                                                                                                                                                  | Yes, occasionally                                                            | 26 (7.2)             |
|                                                                                                                                                  | Rarely                                                                       | 42 (11.6)            |
|                                                                                                                                                  | Never                                                                        | 226 (62.4)           |
|                                                                                                                                                  | I do not visit a pharmacist for such advice                                  | 39 (10.8)            |
| Would you trust pharmacists to provide guidance or services for safe medication disposal?                                                        | Yes                                                                          | 308 (85.1)           |
|                                                                                                                                                  | No                                                                           | 14 (3.9)             |
|                                                                                                                                                  | Not sure                                                                     | 40 (11.0)            |
| Do you have any suggestions regarding medication disposal in your community (e.g., awareness campaigns, collection boxes, pharmacy involvement)? | awareness campaigns to educate the public about proper disposal methods      | 52 (14.3)            |
|                                                                                                                                                  | establishing collection boxes in accessible locations                        | 65 (17.6)            |
|                                                                                                                                                  | Pharmacies or pharmacists' involvement in the process of medication disposal | 13 (3.6)             |
|                                                                                                                                                  | No suggestion                                                                | 232 (64.1)           |

risks associated with improper medication waste disposal. The inconsistency in precautionary behavior suggests the presence of gaps in public awareness, as well as potentially limited access to proper disposal options such as medication take-back programs or designated collection points.

The finding that 64.6% of respondents recognized the potential harm associated with improper medication disposal indicates a moderate level of public awareness. This awareness is encouraging, as it suggests that most individuals are aware of the environmental and health risks of incorrect disposal methods. However, this also implies that over one-third of the population may lack sufficient understanding of these risks. This level of awareness aligns with findings from another study conducted in Ethiopia, which reported that approximately 46.9% of participants lacked awareness about the harmful effects of disposing of unused medicine in regular waste<sup>18</sup>. This gap of knowledge highlights the need for targeted educational interventions. Public health campaigns, pharmacist-led counselling, and the implementation of accessible medication return programs could enhance understanding and promote safer disposal practices because increasing public awareness is crucial not only for environmental protection but also for preventing accidental poisonings and reducing the risk of drug misuse<sup>19</sup>.

The high rate of expiry date checks in the surveyed respondents in Al Ain reflects a regional trend toward improved medication safety practices. This rate is notably higher than figures reported in similar studies. For example, a study conducted in Sharjah, UAE, found that 86.3% of participants checked the expiry date of their medication before use<sup>17</sup>. Another study in the UAE reported a similar figure of 82%<sup>15</sup>. In contrast, a study in Qassim, Saudi Arabia, showed that only 45% of participants consistently checked drug expiry dates before use<sup>16</sup>. The elevated awareness of the study participants in Al Ain residents observed in this study could reflect higher levels of public health education and positive cultural attitudes towards medication use.

The prevalence of using regular trash to discard medications (38.1%) indicates a significant gap in public understanding of proper medication waste management. This practice poses risks to both environmental safety and public health as it can lead to soil and water sources contamination<sup>20</sup>. The finding that 51.9% of respondents disagreed with the belief that expired medications are safe and require no special precautions for disposal indicates a moderate level of awareness regarding the potential risks associated with expired medications. This also implies that nearly half of the surveyed population might underestimate the dangers of incorrectly discarding expired medications.

The results showed that 78.2% of respondents in Al Ain were unaware of existing medication disposal programs or collection boxes, while 93.4% expressed willingness to use such facilities if available, indicating a strong potential for

Al Ain community engagement in proper medication disposal practices. A similar pattern was observed in another region in the UAE<sup>17</sup>. The Department of Health Abu Dhabi provides a publicly accessible guide on the safe disposal of unused medicines, available through its official website<sup>21</sup> which emphasizes on the importance of proper disposal practices, and it provides simple steps to dispose of unused medications at home. Despite the availability of this guide, awareness remains critically low. In this study, 85.4% of respondents indicated they had never heard of the guide. This gap reflects a significant communication and outreach shortage, and it indicates that there must be a stronger collaboration between health authorities and the community. Considering the high rate of willingness among respondents to engage in safe disposal practices (93.4%), improving visibility and accessibility of these official resources could substantially enhance proper medication disposal behaviors across the community.

Structured pharmacist-led counseling based on eco-pharmacovigilance can strengthen safe medication disposal by addressing environmental risks across the medication life cycle. By educating patients, discouraging improper disposal, and promoting take-back programs<sup>9</sup>, pharmacists can enhance environmental stewardship and medication safety, especially when supported by standardized counselling tools, visual prompts, and digital reminders integrated into routine practice<sup>22</sup>.

The finding that 62.4% of respondents had never received advice from a pharmacist regarding medication disposal, even though 85.1% said they would trust a pharmacist to guide them on this issue, underscores a significant gap between public expectations and current pharmacy practice. This disconnect is not unique to this study. A recent cross-sectional survey of pharmacists across the United Arab Emirates (UAE) revealed that while many pharmacists acknowledge their role in promoting safe medication disposal. However, several barriers hinder their active engagement. These barriers include a lack of public awareness (88.9%), time constraints due to workload (82.4%), and insufficient training (78.1%)<sup>23</sup>. The high level of public trust in pharmacists offers a valuable opportunity to bridge this gap because pharmacists are well-positioned to educate patients on proper medication disposal methods during routine interactions. Implementing structured training programs and developing national guidelines can empower pharmacists to fulfill this role effectively. Also, addressing these barriers can significantly improve medication disposal practices.

Pharmacist-led interventions are an effective and underused method to improve safe medication disposal. Pharmacists can significantly enhance patients' knowledge and practices, reduce improper storage and disposal, and increase participation in take-back programs by providing brief counselling during routine pharmacy interactions<sup>23</sup>. However, a study conducted in UAE showed that there are serious gaps in knowledge and practices among community pharmacists regarding medicine waste reduction<sup>24</sup>.

**Table 3.** Association of age and education level with knowledge of safe disposal of medications

| Question/ Statement                                                  | Options                                              | Age comparison             |                               |                   |                 |           | P value      | Cramér's V*  |
|----------------------------------------------------------------------|------------------------------------------------------|----------------------------|-------------------------------|-------------------|-----------------|-----------|--------------|--------------|
|                                                                      |                                                      | 18-24                      | 25-34                         | 35-44             | 45-54           | 55+       |              |              |
| Do you take any precautions when disposing of medications?           | Yes                                                  | 13 (18.6)                  | 15 (28.8)                     | 38 (34.2)         | 29 (31.5)       | 20 (54.1) | <b>0.001</b> | <b>0.137</b> |
|                                                                      | Sometimes                                            | 24 (34.3)                  | 10 (19.2)                     | 42 (37.8)         | 29 (31.5)       | 10 (27.0) |              |              |
|                                                                      | No                                                   | 33 (47.1)                  | 27 (51.9)                     | 31 (27.9)         | 34 (37.0)       | 7 (18.9)  |              |              |
| Do you think medications can be harmful if not disposed of properly? | Yes                                                  | 38 (54.3)                  | 34 (65.4)                     | 69 (62.2)         | 61 (66.3)       | 32 (62.2) | <b>0.02</b>  | <b>0.244</b> |
|                                                                      | No                                                   | 9 (12.9)                   | 8 (15.4)                      | 12 (10.8)         | 4 (4.3)         | 0         |              |              |
|                                                                      | Not sure                                             | 23 (32.9)                  | 10 (19.2)                     | 30 (27.0)         | 27 (29.3)       | 5 (13.5)  |              |              |
|                                                                      | No                                                   | 2 (2.9)                    | 2 (3.8)                       | 4 (3.6)           | 5 (5.4)         | 1 (2.7)   |              |              |
|                                                                      | Not sure                                             | 6 (8.6)                    | 4 (7.7)                       | 21 (18.9)         | 8 (8.7)         | 1 (2.7)   |              |              |
| Question / Statement                                                 | Options                                              | Education level comparison |                               |                   |                 |           | P value      | Cramér's V*  |
|                                                                      |                                                      | High school                | Diploma or technical training | Bachelor's degree | Master's degree | Doctorate |              |              |
| What do you think is the safest way for disposing medication?        | Throw in regular household trash without precautions | 24 (37.5)                  | 13 (38.2)                     | 79 (42.0)         | 16 (30.8)       | 6 (25.0)  | <b>0.01</b>  | <b>0.145</b> |
|                                                                      | Flush in toilet or sink                              | 4 (6.3)                    | 5 (14.7)                      | 15 (8.0)          | 13 (25.0)       | 2 (8.3)   |              |              |
|                                                                      | Return to pharmacy                                   | 18 (28.1)                  | 6 (17.6)                      | 40 (21.3)         | 9 (17.3)        | 12 (50.0) |              |              |
|                                                                      | Other                                                | 18 (28.1)                  | 10 (29.4)                     | 54 (28.7)         | 14 (26.9)       | 4 (16.7)  |              |              |
|                                                                      | No                                                   | 3 (4.7)                    | 1 (2.9)                       | 7 (3.7)           | 2 (3.8)         | 1 (4.2)   |              |              |
|                                                                      | Not sure                                             | 8 (12.5)                   | 6 (17.6)                      | 23 (12.2)         | 2 (3.8)         | 1 (4.2)   |              |              |

Cramér's V is reported for statistically significant associations to indicate effect size

A group of participants offered suggestions regarding medication disposal in Al Ain, with 17.6% recommending the establishment of accessible collection boxes and 14.3% suggesting public awareness campaigns. This reflects a proactive group within the community motivated to enhance medication disposal practices. The call for accessible collection boxes aligns with the U.S. Food and Drug Administration (FDA) guidelines for medication disposal, which include permanent collection sites and mail-back programs<sup>25</sup>. These programs effectively reduce the risk of medication misuse and environmental contamination. Similarly, the emphasis on public awareness campaigns is supported by evidence suggesting that educational initiatives significantly improve public knowledge and attitudes toward proper medication disposal<sup>18</sup>. Strengthening pharmacist involvement in medication disposal requires formal policy recognition within national practice frameworks. Evidence shows that regulatory support, reimbursement, and mandated participation in take-back programs improve sustainability and public uptake, and aligning community pharmacy practice with health and environmental policies can institutionalize pharmacist-led disposal counselling as a standard of care<sup>26</sup>.

The demographic analysis of medication disposal practices and the pharmacist's role in medication disposal showed

few significant differences based on age, gender, or education level, suggesting that while demographic factors may influence awareness, they do not solely dictate disposal practices<sup>27,28</sup>. Age was found to be a significant predictor of safe medication disposal behavior, with 54.1% of participants aged 55 years and older reporting that they take precautions when disposing of medications, compared to markedly lower rates among younger age groups ( $p < 0.05$ ). This finding may reflect higher health literacy and accumulated experience with medications among older adults. Consistent findings have been reported in a survey conducted in the United States, older adults perceive medication safety behaviors as more important and reasonable compared to younger adults<sup>28</sup>. Another study in Iraq found that age was significantly associated with awareness and attitudes toward safe medication disposal, with older participants more likely to be aware of the environmental impact of improper disposal<sup>29</sup>. Higher education levels were significantly linked to better perceptions of safe medication disposal ( $p < 0.05$ ). Half of the participants with doctorate degrees identified returning medications to a pharmacy as the safest method, much higher than those with less education. This may be due to increased exposure to information about pharmaceutical waste management and its consequences, which likely encourages more responsible disposal practices. These findings highlight the necessity for targeted educational interventions aimed at populations with lower educational attainment.

**Table 4.** Association of gender with knowledge of safe disposal of medications

| Question / Statement                                                                                           | Options                                              | Frequency (%) | Frequency (%) | P value      | Cramér's V*  |
|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------|---------------|---------------|--------------|--------------|
|                                                                                                                |                                                      | Male          | Female        |              |              |
| Do you think medications can be harmful if not disposed of properly?                                           | Yes                                                  | 34 (79.1)     | 200 (62.7)    | <b>0.038</b> | <b>0.137</b> |
|                                                                                                                | No                                                   | 0 (0.0)       | 33 (10.3)     |              |              |
|                                                                                                                | Not sure                                             | 9 (20.9)      | 86 (27.0)     |              |              |
|                                                                                                                | No                                                   | 0 (0.0)       | 4 (1.3)       |              |              |
|                                                                                                                | Sometimes                                            | 1 (2.3)       | 22 (6.9)      |              |              |
| What do you think is the safest way for disposing medication?                                                  | Throw in regular household trash without precautions | 3 (7.0)       | 135 (42.3)    | <b>0.001</b> | <b>0.244</b> |
|                                                                                                                | Flush in toilet or sink                              | 6 (14.0)      | 33 (10.3)     |              |              |
|                                                                                                                | Return to pharmacy                                   | 18 (41.9)     | 67 (21.0)     |              |              |
|                                                                                                                | Other                                                | 16 (37.2)     | 84 (26.3)     |              |              |
|                                                                                                                | No                                                   | 26 (60.5)     | 162 (50.8)    |              |              |
|                                                                                                                | Not sure                                             | 11 (25.6)     | 108 (33.9)    |              |              |
|                                                                                                                | No                                                   | 0 (0.0)       | 5 (1.6)       |              |              |
| Have you heard about the Department of Health's (DOH) guide for the safe disposal of unused medicines at home? | Not sure                                             | 1 (2.3)       | 18 (5.6)      | <b>0.023</b> | <b>0.147</b> |
|                                                                                                                | No, I have not heard of it                           | 33 (76.7)     | 276 (86.5)    |              |              |
|                                                                                                                | Yes, but I have not used it                          | 9 (20.9)      | 26 (8.2)      |              |              |
|                                                                                                                | Yes, I am familiar with it and have used it          | 1 (2.3)       | 17 (5.3)      |              |              |
|                                                                                                                | No                                                   | 4 (9.3)       | 10 (3.1)      |              |              |
|                                                                                                                | Not sure                                             | 2 (4.7)       | 38 (11.9)     |              |              |

Cramér's V is reported for statistically significant associations to indicate effect size

## Recommendations

To improve medication disposal practices in Al Ain, several key strategies are recommended. First, enhancing public awareness through culturally sensitive and widely disseminated educational campaigns is essential. Second, empower pharmacists by providing structured training and clear national guidelines that define their role in advising patients on safe medication disposal. Given their accessibility and the public trust they command, pharmacists are well-positioned to influence public behavior. Third, improving the visibility and accessibility of official resources, such as the Department of Health's online guide. Lastly, establishing an accessible medication collection infrastructure such as permanent drop-off boxes to offer a practical and widely supported solution. Together, these measures can significantly enhance public engagement and support safer medication disposal behaviours across the Al Ain community.

## Study limitations

few limitations should be acknowledged in the interpretation of this study's findings. Since the survey was administered

online (via Google Forms), it may have introduced selection bias as participation was limited to individuals with internet access and familiarity with digital platforms. Consequently, older adults and residents with limited digital literacy or reduced engagement with online communication channels may be underrepresented. Future studies should consider mixed-method or in-person data collection approaches to ensure broader population representation and to enhance external validity. Another limitation of the study is that most of the participants were women (88.1%), which may have introduced some gender bias. As a result, this limitation could restrict the accurate representation of male perspectives and limit the generalizability of the findings. While the sample size was likely large enough for statistical analysis, using a bigger and more balanced sample could improve the robustness and external validity of the results. Also, because the survey was self-administered, participants may have overreported positive behaviors. This could mean that the results slightly overestimate the actual prevalence of these practices. Finally, the cross-sectional design captures behavior at a single point in time and does not account for seasonal or long-term trends in medication disposal practices.



## CONCLUSION

This study highlights important insights into medication disposal practices among the surveyed residents of Al Ain, UAE. While the findings reveal a generally encouraging level of awareness, mainly regarding expiry date checks, there remain substantial deficiencies in appropriate disposal behaviors. A notable concern is the routine disposal of unused or expired medications via household waste and the limited awareness of official disposal resources. The high degree of public trust in pharmacists, coupled with a demonstrated willingness among respondents to engage in proper disposal practices, presents great opportunities for interventions, such as pharmacist-led counselling, well-designed public awareness campaigns, and enhanced access to permanent disposal facilities. These measures can support responsible pharmaceutical waste management and promote both environmental sustainability and public health.

## AUTHOR'S CONTRIBUTIONS

Noon Abubakr Abdelrahman Kamil: Supervision, Methodology, Software, Writing- Reviewing and Editing. Shahbaa Salem Saeed Sulaiman Alshebli: Data curation, Writing- Original draft preparation, Investigation. Hind Abdulla Khamis Mohammed Al Haddadi: Data curation, Writing- Original draft preparation, Investigation. Abdiraheem Yusuf Ali: Writing- Original draft preparation, Investigation. Monika Sachdeva: Writing- Original draft preparation, Investigation. Memona Abuzar: Writing- Original draft preparation, Investigation. Sara Alnuaimi: Writing- Original draft preparation, Investigation. Yassin Al Hariri: Writing- Original draft preparation, Investigation.

## CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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