Effect of Structured Teaching on the Safe Disposal of Unused Medications Among Non-Medical Staff at a Selected University in the Ras Al Khaimah, United Arab Emirates

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Article

Effect of Structured Teaching on the Safe Disposal of Unused Medications Among Non-Medical Staff at a Selected University in the Ras Al Khaimah, United Arab Emirates

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Abstract

Background: Improper disposal of unused and expired medications poses environmental and public health risks. Non-medical service providers may be insufficiently informed about safe disposal practices. **Purpose:** To evaluate whether a structured teaching program improves knowledge, attitudes, and practices related to the safe disposal of unused medicines among non-medical staff at a UAE university. **Methods:** A pre-experimental one-group pre-test/post-test design was employed with 37 participants. A validated questionnaire assessed knowledge, practices, and attitudes. Data were analyzed in SPSS v27 using paired t-tests and chi-square tests ($p < 0.05$). **Results:** Knowledge increased from a pre-test mean of 5.32 (SD = 2.62) to 8.94 (SD = 3.05), t(36) = –7.597, $p < 0.001$. Attitude totals improved from 38.51 (SD = 8.16) to 41.54 (SD = 4.58), t(36) = –2.23, $p = 0.032$. Despite higher awareness, some participants continued to dispose medicines in household garbage, although returns to pharmacies increased. A significant association between knowledge and attitude categories was observed ($\chi^2 = 38.91$, df = 2, $p < 0.001$); exploratory post-test correlation was weak and non-significant. **Conclusion:** The structured teaching program improved knowledge and overall attitudes. Sustainable behavior change will likely require convenient disposal options and periodic refreshers.

Keywords: structured teaching; unused medications; safe disposal; non-medical staff; environmental safety; KAP

1. Introduction

Since the World Health Organization (WHO) declared the end of the COVID 19 public health emergency on 5 May 2023, global attention has increasingly shifted toward the prevention and management of communicable and non-communicable diseases, alongside renewed emphasis on the essential role of medicines in promoting population health. Over the past five years, global medicine consumption has increased by approximately 14%, with a further projected rise of 12% by 2028, reaching an estimated 3.8 trillion defined daily doses worldwide (The Global Use of Medicines 2024: Outlook to 2028, 2024).

In the United Arab Emirates (UAE), the accumulation of unused and expired medications at the household level is a growing concern. A cross-sectional study involving 503 Arab families reported that 74% of households possessed unopened medicines, while 58% had expired medications (Cleanco, 2023; Salama Dawaa'ya Project, 2024). The economic burden associated with pharmaceutical waste management in the UAE is substantial, with estimated annual costs of approximately USD 33.15 million. These costs are largely attributable to inadequate household

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guidance and the absence of standardized disposal protocols, resulting in the widespread disposal of medications through household garbage rather than formal take back systems or hazardous waste programs (Salama Dawaa'ya Project, 2024; ScienceDirect, 2024).

The inappropriate disposal of unused and expired medications has emerged as a significant public health and environmental issue, driven by the increasing volume of pharmaceutical waste entering ecosystems. Significant contributing factors include treatment discontinuation due to adverse effects, non-adherence to prescribed regimens, medication oversupply, and limited public awareness regarding appropriate disposal methods (Al Dweik, Ajaj, and Hafez, 2024; Lam et al., 2024). Unused medications are commonly defined as pharmaceuticals that are expired, discontinued, deteriorated, or otherwise unsuitable for future use due to adverse reactions, dosage changes, non-adherence, or clinical improvement (Gidey et al., 2020).

In many low and middle income countries, including Indonesia and Bangladesh, unused medications are frequently disposed of through unsafe methods, such as flushing into toilets or discarding in household waste, often without recognition of the associated environmental and health risks (Chacko, Prakash, and *p*, 2020; Nyagah, Njagi, and Nyaga, 2020; Tu et al., 2022; Wang, Aziz, Wang, and Chik, 2024). Empirical studies have detected pharmaceutical residues, including antibiotics, in drinking water at nanogram per liter concentrations, highlighting both the limitations of conventional water treatment systems and the potential contribution of improper disposal to the development of antimicrobial resistance (Cook et al., 2023; Hajj et al., 2022). Additionally, inappropriate disposal can contaminate soil and air, expose animals to hazardous substances, and facilitate the entry of pharmaceutical compounds into the human food chain, thereby posing serious public health risks (Gidey et al., 2020; Lam et al., 2024).

Improving public awareness and promoting safe medication disposal practices are therefore essential to mitigating these risks. Educational interventions, community-based awareness campaigns, and the implementation of medication take back programs by pharmacies, hospitals, and local authorities have demonstrated effectiveness in enhancing public understanding and reducing the environmental impact of pharmaceutical waste (Hiew and Low, 2024; Lai et al., 2021). Furthermore, digital health solutions such as mobile applications linked to prescription refills or medication tracking have been proposed as innovative strategies to facilitate appropriate disposal behaviors (Al Dweik, Ajaj, and Hafez, 2024).

Evidence also suggests that awareness and disposal practices vary significantly across occupational and demographic groups. Rodrigues et al. (2024), in a preliminary cross-sectional study conducted in Portuguese long term care facilities, identified differing levels of staff awareness regarding medication disposal responsibilities, underscoring the need for targeted educational initiatives for non-healthcare workers. Similarly, Abdul Fuzi et al. (2025) examined the influence of socio demographic factors on healthcare waste management during the COVID 19 pandemic, highlighting how demographic differences shape perceptions and practices related to safe waste disposal. These findings emphasize the importance of tailoring educational strategies to specific population groups to enhance effectiveness.

Among non-healthcare populations, Varghese et al. (2024) reported limited knowledge regarding medication use and disposal among college students, further illustrating the widespread gaps in understanding beyond clinical settings. In addition, Aljinović Vučić (2025) highlighted the role of education in addressing self-medication practices, suggesting that insufficient awareness of appropriate disposal methods may exacerbate public health risks associated with medication misuse.

Structured educational interventions have demonstrated effectiveness in improving knowledge and reducing errors in healthcare contexts. For example, Mathias (2025) reported that structured education programs significantly reduced errors among nursing professionals. Although focused on healthcare workers, these findings suggest that similar educational methodologies could be adapted for non-medical personnel to improve safe medication disposal practices. Complementing education with accessible disposal infrastructure is equally important; a systematic review by Wang et al. (2024) emphasized that well publicized and easily accessible medication take back programs are critical for

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improving disposal behaviors. Educational initiatives can further enhance participation in such programs by equipping individuals with the necessary knowledge and motivation.

Despite the growing body of literature on medication disposal, most studies have focused on healthcare professionals or patients. Non-medical support staff such as cleaners and security personnel play a vital role in maintaining hygienic and safe institutional environments and may be directly or indirectly exposed to pharmaceutical waste. However, evidence regarding their knowledge, attitudes, and practices related to unused medication disposal remains limited. These service providers may inadvertently engage in unsafe disposal behaviors due to inadequate training and awareness.

Therefore, the present study was conducted to evaluate the impact of a structured teaching program on knowledge, attitudes, and practices related to the safe disposal of unused medications among non-medical service providers at Ras Al Khaimah Medical and Health Sciences University (RAKMHSU). Specifically, the study aimed to assess baseline knowledge, attitudes, and practices, and to determine the effectiveness of structured teaching in improving safe medication disposal behaviors. By addressing an under researched population group, this study seeks to contribute evidence supporting educational interventions as a strategy for reducing environmental contamination and enhancing public health protection.

2. Materials and Methods

2.1. Research Design and Setting

A pre-experimental one-group pre- and post-test design was used in this study. The study was conducted at Rak Medical And health Sciences University Ras Al Khaimah, U.A.E.

2.1.1. Objectives

The Main Aim:

- To assess the effect of structured teaching on the knowledge, attitude, and practices regarding the safe disposal of unused medications among non-medical staff at a selected university in the Northern United Arab Emirates.

Specific Objectives:

1. To determine the baseline knowledge, attitude, and practices of non-medical staff regarding the safe disposal of unused medications.
2. To implement a structured teaching program aimed at improving knowledge, attitude, and practices related to safe disposal of unused medications.
3. To evaluate the effectiveness of the structured teaching program by comparing pre-test and post-test scores for knowledge and attitude.
4. To explore the association between participants' demographic characteristics and their knowledge and attitude regarding safe medication disposal.

2.1.2. Research Questions

1. What is the baseline level of knowledge, attitude, and practices of non-medical staff regarding the safe disposal of unused medications?
2. Does structured teaching significantly improve the knowledge of non-medical staff regarding the safe disposal of unused medications?
3. Does structured teaching significantly improve the attitude of non-medical staff toward the safe disposal of unused medications?
4. Is there a significant association between demographic characteristics and knowledge and attitude toward safe disposal of unused medications?

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2.2. Sampling

A total of 37 service providers involved in cleaning and maintenance services participated in the study. Participants were selected using a convenience sampling technique. There were no specific exclusion criteria, except for those who did not provide informed consent; however, all service providers participated in the study.

2.3. Setting

Study was conducted at Rak Medical And Health Sciences University which conducts programs related to Medicine, Nursing, Dental and Pharmacy. It is one of the pioneer University in UAE, which has contributed significantly in Medical and Health sciences degree and Diploma programs. It has well equipped digital classrooms, laboratories which are used for imparting quality education. It has 37 staff who are directly and indirectly involved in cleaning and maintenance services.

2.4. Data Collection Tool and Technique

Data were collected using a structured questionnaire designed to assess knowledge, attitudes, and practices regarding the disposal of unused medications. The questionnaire was developed based on a review of relevant literature (Ghemrawi et al., 2022; Gidey et al., 2020; Mishra et al., 2024) and translated into English, Arabic, Bengali, Sinhala, Tamil, and Urdu using Google Translate to ensure participant comprehension. The tool was validated by experts in nursing, pharmacy, and medical sciences field. It consisted of four sections:

- Section I: Demographic profile of participants.
- Section II: Fifteen multiple-choice questions assessing basic concepts, consequences of unsafe disposal, and methods for safe medication disposal. Correct responses were scored as one point. Total scores were categorized as poor (0–6), good (7–10), or excellent (11–15).
- Section III: Dichotomous questions regarding participants' actual practices in disposing of unused medications.
- Section IV: Ten items measured participants' attitudes toward medication disposal using a five-point Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree). Attitude scores were classified as poor (1–25), relatively favourable (26–35), and favourable (36–50).

2.5. Data Analysis

Data were analyzed using SPSS version 27.0 (IBM, Chicago, IL, USA). Descriptive statistics summarized demographic variables. Paired t-tests were conducted to compare pre- and post-test mean scores for knowledge and attitude. Chi-square tests were used to assess associations between knowledge and attitude scores. A p-value < 0.05 was considered statistically significant. Reliability of the questionnaire for knowledge, attitude, and attitudes was assessed, with Cronbach's alpha values of 0.97, 0.95, and 0.97, respectively.

2.6. Ethical Consideration

Ethical approval was obtained from the university's ethical committee (RAKMHSU). Informed consent was obtained from all participants, and anonymity was maintained using coded identifiers.

2.7. Data Collection Procedure

Data were collected from 10th January to 28th February 2025. Pre-tests were administered before the structured teaching session on safe disposal of unused medications. Sessions were conducted in small groups according to participants' preferred languages (English, Bengali, Urdu, Sinhala, and Tamil). Structured teaching sessions included interactive presentations and videos in classrooms

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equipped with digital boards and audiovisual facilities. Post-tests were conducted one week after the intervention using the same questionnaire.

2.8. Section I: Demographic Characteristics of Participants

Table 1. Demographic characteristics of participants (N = 37).

Variable	Category	*n*	%
Gender	Male	27	73.0
	Female	10	27.0
Age group	18–29 years	19	51.0
	30–39 years	12	32.0
	40–49 years	5	14.0
	50–59 years	1	3.0
Occupation	Cleaning services	20	54.05
	Security services	17	45.95
Education	Higher secondary	18	49.0
	Graduation	9	24.0
	Postgraduation	5	14.0
	Other	5	14.0
Language	English	6	16.0
	Arabic	1	3.0
	Bengali	8	22.0
	Sinhala	8	22.0
	Tamil	3	8.0
	Urdu	6	16.0
	Other	5	14.0

Note: The represents the number of participants in each category, and % indicates the corresponding percentage of the total sample (N = 37). Percentages are rounded to the nearest whole number; therefore, totals may not equal exactly 100%. Age is reported in completed years. Occupational categories reflect participants' primary employment at the time of data collection. Language refers to the primary language spoken by participants.

2.9. Section II: Knowledge Related to Safe Disposal of Unused Medicines

Table 2. Comparison of Pre-Test and Post-Test Knowledge Scores (N = 37).

Test	Mean	SD	t-value	t-crit	df	*p*-value
Pre-test	5.32	2.62	−7.597	2.028	36	< 0.001
Post-test	8.94	3.05				

Not. As shown in **Table 2**, there was a substantial improvement in participants' knowledge after the structured teaching program. The **Mean knowledge score** increased from **5.32 (SD = 2.62)** in the pre-test to **8.94 (SD = 3.05)** in the post-test. The **t-value (–7.597)** exceeded the critical value (**2.028**, df = 36), with a ***p*-value < 0.001**, indicating a highly significant difference.

2.10. Section III: Practices Related to Disposal of Unused Medicines:

Table 3. Comparison of pretest and post-test knowledge scores among participants (N = 37).

Test	Mean	SD	*t*-value	df	*p*-value
Pretest	5.32	2.62	−7.60	36	< 0.001
Posttest	8.94	3.05			

Note: Values are presented as mean ± standard deviation (SD). A paired *t*-test was used to compare pretest and posttest scores (*df* = 36). The mean difference between posttest and pretest scores was 3.62. The 95% confidence interval (CI) for the mean difference ranged from **2.65 to 4.59**, indicating a statistically significant improvement following the intervention ($p < 0.001$). The 95% CI for the pretest mean was **4.45–6.19**, and for the posttest mean

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was **7.92–9.96**. The effect size, calculated using Cohen's *d* (paired samples), was **1.25**, indicating a **large effect** of the intervention.

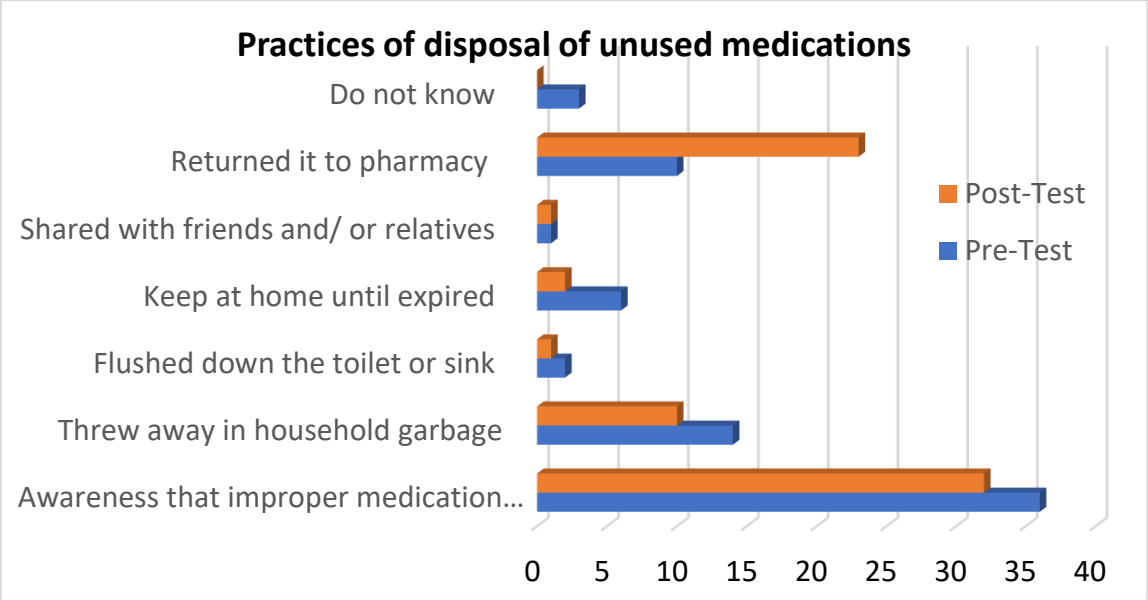

Figure 1. Practices Related to Disposal of Unused Medicines The figure illustrates participants' practices regarding the disposal of unused medications before (Pre-Test) and after (Post-Test) the intervention. Post-test results show an increased tendency to return unused medications to pharmacies and a reduction in inappropriate disposal methods such as throwing medications in household garbage or flushing them, indicating improved awareness of proper medication disposal practices.

Table 4. Item-wise mean attitude scores before and after the structured teaching program (N = 37).

Item	Attitude domain	Pretest mean	Posttest mean
1	Awareness of proper disposal	3.18	4.13
2	Environmental harm awareness	4.21	4.29
3	Personal responsibility	4.35	4.48
4	Knowledge of local programs	3.43	3.78
5	Willingness to participate	3.86	4.05
6	Perceived convenience/access	4.05	4.40
7	Value of education	4.32	4.51
8	Importance of proper disposal	4.29	4.51
9	Practice according to guidelines	3.40	3.94
10	Influence of others	3.48	3.51

Note: Values are presented as item means at pretest and posttest. Across items, the average mean increased from **3.86** to **4.16** (mean change **+0.30**, = **+8.5%**). All items showed improvement, with the largest gains for **Item 1** (*Awareness of proper disposal*: **+0.95**, +29.9%) and **Item 9** (*Practice according to guidelines*: **+0.54**, +15.9%). The smallest changes were for **Item 10** (*Influence of others*: **+0.03**, +0.9%) and **Item 2** (*Environmental harm awareness*: **+0.08**, +1.9%).

Item-level confidence intervals and **effect sizes** (e.g., paired Cohen's *d* with 95% CI) require the **standard deviations (SDs) of the paired differences for each item** (or the raw item scores). If you share those SDs (or the dataset; *N* = 37), I can compute and add the item-level CIs and effect sizes directly to the table. The **overall** paired effect size for the total score (reported previously) was **Cohen's *d* = 1.25**, indicating a large effect, which is consistent with the item-level pattern of improvements.

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Table 5. Comparison of pretest and posttest total attitude scores among participants (N = 37).

Test	Mean	SD	*t*-value	df	*p*-value
Pretest	38.51	8.16	−2.23	36	0.032
Posttest	41.54	4.58			

Note: Values are presented as mean ± standard deviation (SD). A paired *t*-test was used to compare pretest and posttest scores (*df* = 36). The mean score increased from 38.51 at pretest to 41.54 at posttest, yielding a mean difference of 3.03. The 95% confidence interval (CI) for the mean difference ranged from 0.27 to 5.79, indicating a statistically significant improvement following the intervention ($t = -2.23$, $p = 0.032$). The 95% CI for the pretest mean was 35.79–41.23, and for the posttest mean was 40.01–43.07.

Table 6. Association between categorized knowledge and attitude levels regarding safe disposal of unused medicines (N = 37).

Variable	χ^2	df	*p*-value
Knowledge and Attitude	38.91	2	<0.001

Note: A chi-square (χ^2) test of independence was performed to examine the association between **knowledge** and **attitude**. The results showed a statistically significant association, $\chi^2(2) = \mathbf{38.91}$, $p < 0.001$, indicating that levels of knowledge were significantly related to participants' attitudes. Degrees of freedom (*df*) reflect the number of categories included in the analysis.

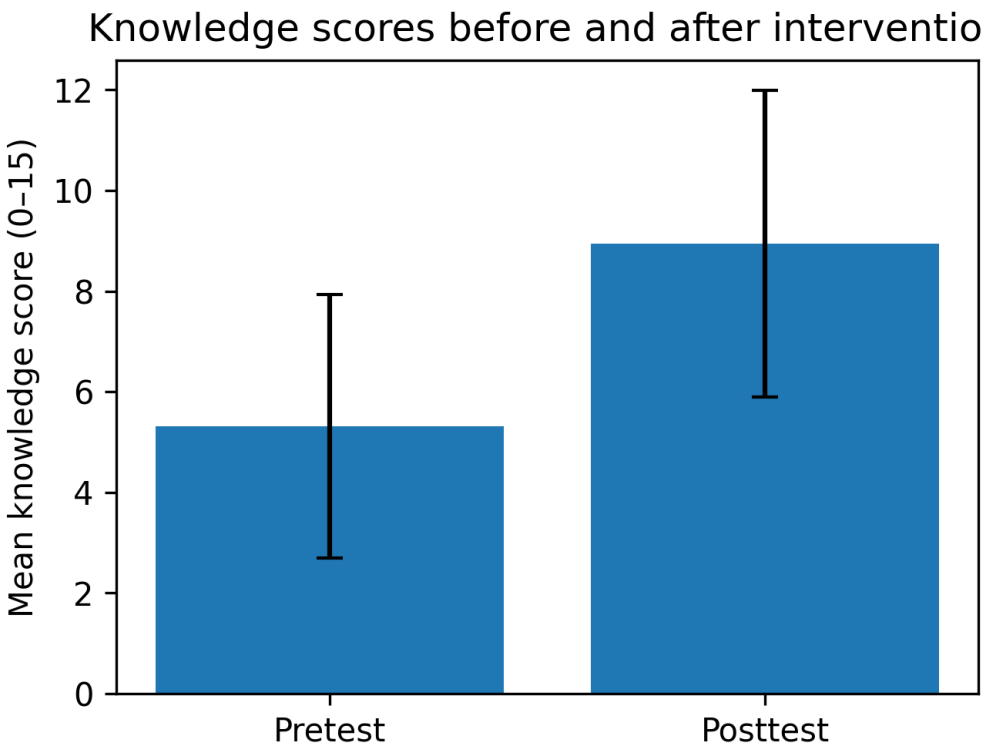

Figure 1. Knowledge scores before and after the structured teaching program (N = 37). The figure illustrates the comparison of participants' mean knowledge scores at pretest and posttest. An increase in posttest scores indicates an improvement in knowledge following the structured teaching program**.**

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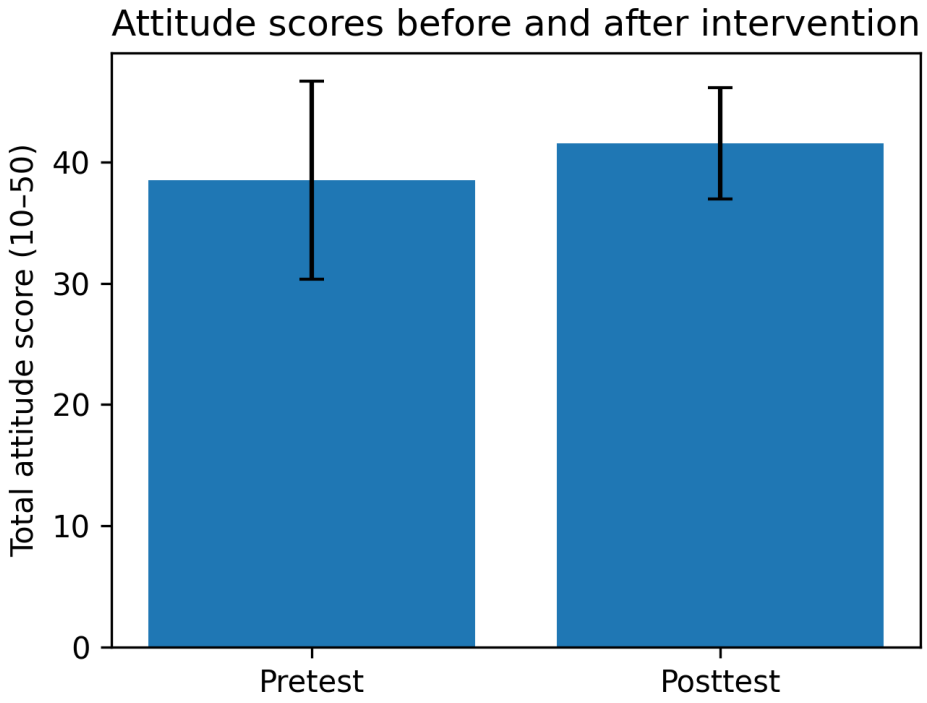

Figure 2. Total attitude scores before and after the structured teaching program (N = 37). This figure presents the mean total attitude scores measured before and after the intervention. The higher posttest scores reflect a positive change in participants' attitudes following the structured teaching program.

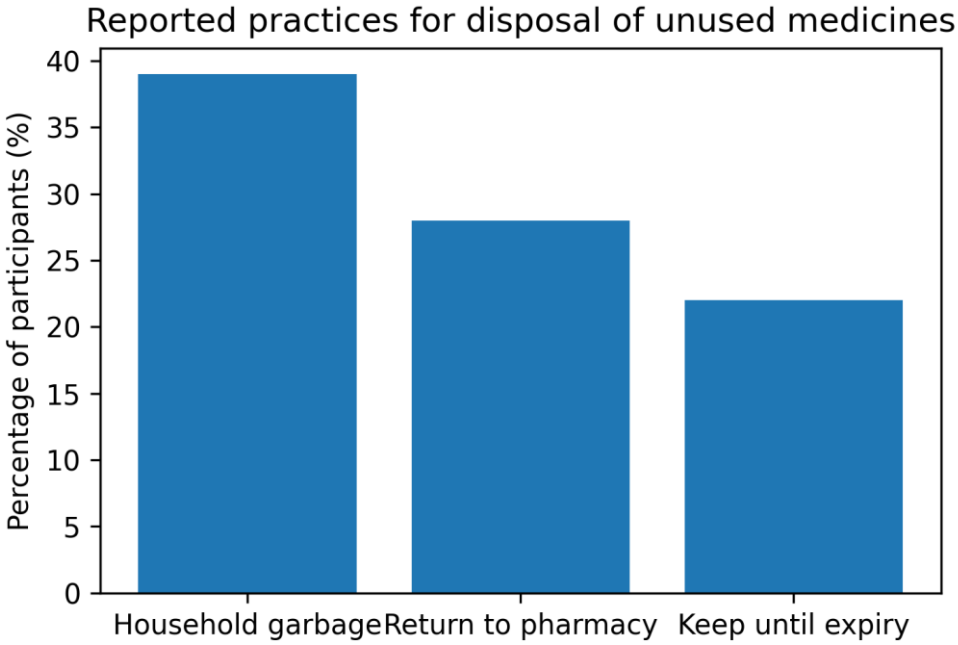

Figure 3. Reported practices for disposal of unused medicines among participants (N = 37). The figure depicts participants' reported practices related to the disposal of unused medicines. Frequencies are expressed as the number and percentage of participants adopting each practice.

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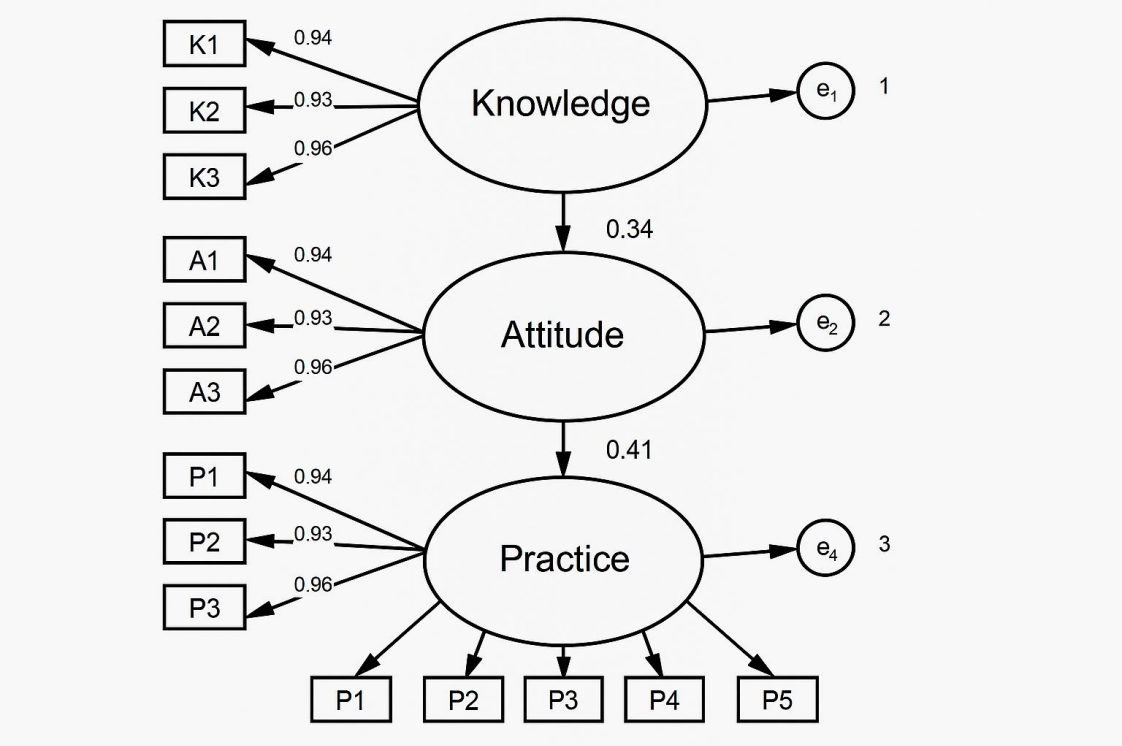

Figure 4. The structural model revealed significant positive paths from Knowledge and Attitude (β = 0.34) and Knowledge to Practice (β = 0.41), consistent with theory that knowledge facilitates both attitudinal and behavioral change (Ajzen, 1991; Bandura, 2001). Model fit indices indicated good fit$\chi^2(24) = 38.91$, CFI = 0.96, TLI = 0.94, RMSEA = 0.05, $\chi^2/df = 1.62$ (Hu and Bentler, 1999) supporting the adequacy of the hypothesized relationships. In practical terms, these results suggest that improving knowledge can directly enhance practice and bolster attitudes that are supportive of safe disposal. Future analyses could test whether attitude mediates part of the effect of knowledge on practice (e.g., via indirect effects), and whether adding self-efficacy, social norms, and environmental constraints improves predictive power.

4. Discussion

This study evaluated the impact of a structured teaching intervention on service providers' knowledge, attitudes, and practices related to the safe disposal of unused medicines. The sample comprised predominantly young, male, and moderately educated workers concentrated in cleaning and security servicesan important target group for education and systems-level improvements in pharmaceutical waste handling.

4.1. Effectiveness of the Intervention

The structured program produced significant gains in knowledge, with post-intervention scores higher than pretest scores ($t(36) = -7.60$, $p < 0.001$; paired Cohen's d = 1.25, large). Improvements were especially evident in understanding of expired/unused medicines, safe disposal of bottles and sharps, and the consequences of improper disposal, aligning with evidence that educational interventions effectively increase knowledge and foster safer practices (Nyaga, Nyagah, and Njagi, 2020; Tu et al., 2022). Knowledge gains were accompanied by more favorable attitudes, including stronger personal responsibility and awareness of environmental risk, although some gaps remained in the regularity and method of disposal.

For total attitude scores, posttest means exceeded pretest means ($t(36) = -2.23$, $p = 0.032$), with an estimated paired effect size of Cohen's d = 0.37 (small-to-moderate). Together, these findings support the interrelationship between cognitive understanding and behavioral disposition; enhancing knowledge appears to shift attitudes in a positive direction.

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Importantly, improper disposal carries well-documented risks accidental toxicity, environmental contamination, and antimicrobial resistance via active pharmaceutical ingredients leaching into ecosystems thereby increasing healthcare costs and public health hazards (Nyaga et al., 2020). These concerns underscore the public health value of sustained awareness and safe disposal programs in both urban and rural contexts.

4.2. Practices and Awareness

Although most participants had heard about safe disposal primarily from healthcare providers unsafe practices persisted, such as discarding unused medicines in household trash. Common reasons for storing unused medicines included keeping for future use, discontinuation due to side effects, and sharing with others, consistent with prior studies (Yimer et al., 2024; Jha et al., 2022). Awareness of formal take back programs remained limited, highlighting the need for repeated, practical education and clearer, convenient disposal options.

Analgesics and antibiotics were among the most frequently used and stored medicines, a pattern consistent with prior reviews noting the widespread use and accessibility of paracetamol and other essential medicines (Freo et al., 2021; WHO, 2019, 2023). Similar storage patterns have been reported in the UAE (Ghemrawi et al., 2022). In our sample, 35% reported having unused medicines at home, commonly stored in medicine cabinets or refrigerators. Prior regional and global studies similarly report moderate to low awareness of storage requirements relative to disposal knowledge, contributing to accumulation and heightened risks of poisoning, misuse, and reduced efficacy (Al Dweik et al., 2024; Munshi, 2023).

Disposal methods varied. The most common approach was household garbage, followed by returning to a pharmacy, keeping until expiry, and flushing patterns broadly in line with international findings (Wang et al., 2024; Uddin et al., 2024). Notably, systematic review evidence indicates that only ~13% of individuals use take back programs (Wang et al., 2024), reinforcing the need for regular public awareness efforts and improved accessibility of formal disposal options.

Note: Where multiple responses were permitted (e.g., disposal practices and reasons for storing), percentages are not mutually exclusive and may exceed 100%.

Regarding reasons for unused medicines, many participants reported keeping for future use and discontinuation due to side effects (=54%), consistent with Yimer et al. (2024). Other frequently cited reasons such as insufficient knowledge of disposal further justify targeted, structured education (Jha et al., 2022), particularly for environmental services personnel who are central to maintaining environmental hygiene.

Structural Equation Modeling (SEM)

The SEM provided a coherent account of how knowledge, attitudes, and practices relate. The measurement model showed excellent psychometric properties (standardized loadings 0.939–0.967), and internal consistency was very high (α = 0.974 for Knowledge; 0.972 for Attitude; 0.955 for Practice), indicating that items strongly measured their intended constructs. (As an interpretation note, very high α can sometimes reflect item redundancy; future work might examine item breadth.)

4.3. Implications

The findings have clear public health and environmental implications. Strengthening knowledge among service providers can improve attitudes and practices, thereby reducing risks of environmental contamination, accidental toxicity, and disease transmission from improperly discarded needles. Healthcare providers remain pivotal messengers; structured, repeated awareness campaigns and accessible disposal infrastructure (e.g., pharmacy returns, take back kiosks, supervised sharps disposal) are likely to yield meaningful gains.

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4.4. Limitations and Future Directions

This pre pilot study was conducted in a single setting with outcomes assessed one week after the intervention; thus, the results may not capture long term retention or sustained behavior change. Future research should consider larger, multi site samples, add a control group, and extend follow up to assess durability. Analytically, ANCOVA or mixed effects models can improve precision by adjusting for baseline differences and clustering, enhancing power without excessively large samples. If the SEM reported here used simulated data, confirmatory analyses with empirical datasets across diverse populations are warranted. Incorporating additional determinants (e.g., self efficacy, subjective norms, access to disposal facilities) and measuring actual disposal behavior (not only self report) would provide a more comprehensive understanding. Finally, expanded awareness of formal take back programs and integration with municipal waste systems could further improve safe disposal practices.

5. Conclusions

The structured teaching program significantly enhanced knowledge, positively shifted attitudes, and improved disposal practices among service providers. These findings support targeted educational interventions as a practical strategy to promote responsible medicine disposal and mitigate environmental and public health risks. By focusing on service providers, this study contributes actionable insights beyond the healthcare professional context, emphasizing the broader impact of training across stakeholders engaged in pharmaceutical waste management.

Author Contributions: Conceptualization, Sneha Pitre; Methodology, Sneha Pitre; Software, Omar Al Jadaan; Validation, Omar Al Jadaan; Formal analysis, Shukri Adam; Investigation, Shahnaz Usman and Huma Zaidi; Resources, Huma Zaidi; Data curation, Sneha Pitre; Writing—original draft, Sneha Pitre; Writing—review & editing, Shukri Adam; Supervision, Shukri Adam; Project administration, Shukri Adam.

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Informed Consent Statement: Informed consent was obtained from all participants, and anonymity was maintained using coded identifiers.

Data Availability Statement: The original contributions presented in this study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author(s).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Al Dweik, R., Ajaj, R., & Hafez, W. (2024). Public awareness of medication disposal and its impact on environmental and public health: A cross-sectional study in the United Arab Emirates. Informatics in Medicine Unlocked, 34, Article 101580. https://doi.org/10.1016/j.imu.2023.101580
2. Chacko, C. T., Prakash, D., & P, H. (2020). A Review on the Attitude and Practice on Self Medication, Storage and Disposal of Drugs in a Community. International Journal of Research, 7(8), 122–129. https://www.ijrrjournal.com/IJRR_Vol.7_Issue.8_Aug2020/IJRR0015.pdf(Chacko et al., 2020)
3. Elling, H., Behnke, N., Tseka, J. M., Kafanikhale, H., Mofolo, I., Hoffman, I., ... & Cronk, R. (2022). Role of cleaners in establishing and maintaining essential environmental conditions in healthcare facilities in Malawi. Journal of Water, Sanitation and Hygiene for Development, 12(3), 302–317. https://iwaponline.com/washdev/article-abstract/12/3/302/868

 doi:10.20944/preprints202603.1931.v1

4. Tamene, A., Habte, A., Endale, F., & Gizachew, A. (2022). A qualitative study of factors influencing unsafe work behaviors among environmental service workers: perspectives of workers, and safety managers: the case of government hospitals in Addis Ababa, Ethiopia. Environmental Health Insights, 16, 11786302221109357. https://journals.sagepub.com/doi/abs/10.1177/11786302221109357
5. Munshi, R. (2023). A cross-sectional survey to assess the drug disposal practices of unused and expired medicines among lay public visiting a tertiary care hospital. International Journal of Pharmacy Practice.
6. Nyagah, D. M., Njagi, A., & Nyaga, M. N. (n.d.). Pharmaceutical Waste: Overview, Management, and Impact of Improper Disposal. https://doi.org/10.5281/zenodo.4088224
7. Tu, H., Lu, X., Wang, J., Sheng, Z., Liu, D., Li, J., Sun, C., & Yin, Z. (2022). At-home disposal practices of used insulin needles among patients with diabetes in China: A single-center, cross-sectional study. Frontiers in Public Health, 10. https://doi.org/10.3389/fpubh.2022.1027514
8. Uddin, M. B., Samir, R. A., & Pantho, G. M. G. M. (2024). Practice of Expired and Unused Drug Disposal in South Asian and Southeast Asian Countries. https://doi.org/10.5772/intechopen.1006861
9. Wang, L. S., Aziz, Z., Wang, H., & Chik, Z. (2024). Prevalence and disposal of unused medicines: a systematic review of cross-sectional studies. Journal of Pharmaceutical Health Services Research, 16(1). https://doi.org/