



Original Research Article

KNOWLEDGE AND DISPOSAL PRACTICES OF UNUSED AND EXPIRED MEDICATIONS AMONG UNIVERSITY/COLLEGE STUDENTS AND FACULTY MEMBERS

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Abstract: **Background** The proper disposal of medications is a growing public health concern that has gained significant recognition globally. Inadequate awareness about appropriate disposal methods for unused medicines can lead to serious consequences. This study was conducted among university/college students and faculty members with the objective of assessing knowledge, attitudes, and practices related to the safe disposal of unused and expired medications. **Methods** A comparative study should be conducted. Data were collected through an online questionnaire. Participants included individuals of different genders, background, provided they met with conditions: they had to be at least 18 years old. **Results** A total of 574 participants took part in the study, with females comprising slightly higher proportion (52%) than males (48%). Statistically significant difference ($p < 0.005$) were observed in knowledge areas regarding the disposal of unused or expired medications, which were linked to participants' educational levels. A large majority (93%) acknowledged that improper disposal of medications negatively impacts the environment. A large proportion of participants (between 60% to 73%) demonstrated positive attitudes toward the proper disposal of unused and expired medications. These findings underscore the critical need to enhance community-based disposal strategies, such as returning expired medications to community pharmacies and increasing public education efforts through healthcare workers. **Conclusion** Although public awareness regarding the dangers and environmental risks of expired medications is on the rise, there remains a significant gap in knowledge about proper disposal techniques and safe management of unused prescriptions.

Keywords: Knowledge, Attitude, Unused Medicines, Drugs Disposal

INTRODUCTION

Pharmaceuticals play a vital role in disease treatment, prevention, and management. The proliferation of pharmaceutical sciences and healthcare has enhanced medication accessibility and utilization substantially. Nevertheless, the improper disposal of unused and expired pharmaceuticals has become a significant global issue, particularly in less developed nations [1].

The management of unused and expired medicinal

products presents considerable challenges due to potential adverse effects on environmental integrity and public health. Deficient awareness regarding appropriate disposal protocols may result in environmental contamination, unintentional overdosing, and prescription medication misuse. Self-medication practices often involve utilizing remnant medications from previous therapeutic regimens or substances obtained from acquaintances, frequently leading to suboptimal storage conditions, consumption of expired products, and potential

household disposal of these substances [2]. Various contributing factors to medication accumulation in households include medication non-adherence, utilization of OTC preparations, premature therapy discontinuation, adverse effects, prescription inaccuracies, perceived recovery, dosage modifications, non-compliance, and medication expiration [3].

WHO indicates that inappropriate prescription or dispensing practices result in substantial quantities of expired or unused medications being discarded. This creates significant environmental concerns due to improper disposal methodologies [4]. The consequences of inappropriate medication disposal encompass environmental degradation, pediatric poisoning incidents, detrimental effects on fauna, and antimicrobial resistance development [5]. Disposing of expired household medications in waste receptacles or sewage systems may generate environmental hazards with public health implications, as certain medicinal compounds contain potentially harmful constituents that may accumulate environmentally [6]. When discarded with municipal waste, the pharmacologically active components in medications may harm both environmental systems and human health through atmospheric release during incineration or soil penetration via water-mediated processes [7].

Inappropriate disposal practices, including discarding pharmaceuticals in domestic waste or sewage, can contaminate environmental soil and aquatic ecosystems. Research has documented pharmaceutical residues in subsurface water, riverine systems, and potable water supplies, which exacerbates antimicrobial resistance development and disrupts ecological balance [8]. Furthermore, improperly stored or discarded medications pose significant hazards through unintentional consumption, inappropriate use, or toxic exposure among vulnerable populations such as children, seniors, and domestic animals [9].

The use of drugs has gone up a lot in the last few years because more people can get health care, more people have chronic diseases, and more people are self-medicating [10-12]. This practice has caused a lot of unneeded and expired drugs to build up in homes, which is bad for both public health and the environment[13-15]. Surveys in India routinely reveal that 60–80% of households retain surplus medications, predominantly antibiotics, analgesics, and antipyretics, frequently due to non-adherence, premature cessation, dosage modifications, or apprehension of future disease [16-18].

The wrong way to get rid of drugs is becoming a bigger problem around the world. Many people throw away unwanted medications in the garbage,

burn them, or flush them down the toilet without knowing what will happen [19,20]. Such procedures permit pharmacologically active chemicals to pollute soil, groundwater, and surface water, with residues frequently identified in rivers and even treated drinking water [21-23]. Standard sewage treatment plants are not made to completely get rid of pharmaceutical residues, which means that persistent substances, including antibiotics, hormones, and painkillers, stay in the environment [24,25]. These pollutants cause antibiotic resistance, endocrine disturbance in aquatic life, and ecological imbalance [26-28]

The situation in India is exacerbated by the lack of comprehensive medication return programs or accessible guidelines for proper pharmaceutical disposal. Research among Indian households indicates that most individuals either discard medications in household waste receptacles or retain them indefinitely, unaware of the environmental and health implications [29].

While developed nations have implemented structured pharmaceutical waste management systems through pharmacy networks and governmental initiatives, such programs remain inadequate or non-existent across many developing countries. India's regulatory framework regarding pharmaceutical waste management continues to develop gradually, and public understanding about appropriate handling of expired or surplus medications remains insufficient. Consequently, the majority of individuals including those with higher educational attainment continue to employ unsafe disposal methods [29]. Even medical and pharmacy students demonstrate knowledge deficiencies regarding proper medication disposal practices despite their specialized education [30].

University students and faculty represent a potentially influential demographic in addressing this issue, as they typically possess higher educational qualifications and presumed health literacy. Particularly, students in healthcare disciplines should theoretically demonstrate superior knowledge regarding pharmaceutical safety and waste management. However, contemporary research reveals a gap between theoretical knowledge and practical application among these populations [31]. Bhosale and Patel's research (2020) found that numerous medical students, despite understanding the detrimental effects of improper disposal, continued to discard pharmaceuticals in household waste [32].

The FDA recommends several approaches for disposing of unused or expired medications:

a) Utilizing Drug take-back locations and programs promptly.

b) Flushing certain hazardous medications (those on the FDA flush list) down the toilet, while following specific instructions for disposing of non-flush list medications in household waste (Figure 2.2).

c) Combining medications with unappealing substances such as soil, cat litter, or used coffee grounds, then sealing in a plastic container before appropriate disposal in designated receptacles.

Unused medications present several hazards:

a) RISK: when consumed by individuals for whom they were not prescribed.

b) HAM: when accidentally ingested by children or pets.

c) DANGER: potentially fatal outcomes when not used according to directions [33-34].

MATERIAL AND METHODS

STATEMENT OF ETHICS: -

The university approved the research proposal. The study was voluntary among all the respondents. Any procedures have to be followed by the due guidelines and regulations.

STUDY DESIGN AND SAMPLE SIZE: -

The sample size has been determined with the help of Raosoft online software calculator. A margin of error of 5% and confidence level of 95% was kept in this set. In future there should be a comparative study on the same. A questionnaire will be used to collect the data, which will be administered on willing participants devoid of the incentives. The research will take place in 3-4 months.

INCLUSIONCRITERIA: -

Students holding diplomas, bachelor degree, masters and doctoral programs. Students had no less than 18 years of age. The Dean, Head of Department, and teachers should be also involved into this study.

EXCLUSION CRITERIA: -

The age of the participants was not less than 18.

QUESTIONNAIRE: -

It contained questions and questions were grouped into four sections. First part of the study descriptive phase data (socio-demographic) includes a total of 9 questions, i.e, age, gender, level of education, marital status, storage location within house, number of expired medicines stored at household, reason of keeping unused/expired medicines at home, have you received information regarding how to dispose the unused/expired medicines at home. The three others were made up of a diverse chain of conceptual questions that measured knowledge (seven questions), attitude (five questions), and practice (four questions) of people on the subject of drug disposal. The questions were borrowed in a number of researches [32,33,35,36]; moreover, it was also subsequently changed to fit the exact purposes of the current study.

DATA COLLECTION AND STATISTICAL ANALYSIS: -

Information was gathered through a questionnaire. I designed an online survey using Google Forms to collect responses while informing participants that their involvement was voluntary, their answers would be kept anonymous and confidential, and the data would be utilized solely for academic purposes. There are no correct or incorrect responses; participants are encouraged to reply based on their personal experiences. Completing the questionnaire is expected to take roughly 10-15 minutes. The data will be analyzed with the help of SPSS software and Excel. Descriptive statistics will be applied to all variables included in the research. Continuous data will be represented as means $\pm$ standard deviation (SD), while categorical variables will be shown as frequencies and percentages. Independent variables and the T-test will be employed in the analysis. A p-value lower than the established threshold of 0.05 will be deemed statistically significant.

RESULTS

The study encompassed 574 subjects, with a slightly higher female representation (52%) compared to male (48%). Educational attainment predominantly featured graduate degrees (69%), with smaller proportions holding postgraduate qualifications (17%), diplomas (11%), and doctoral degrees (1%). An overwhelming majority of participants identified as single (96%), with married individuals constituting just 4%. Regarding medication disposal awareness, 58% of respondents reported having received proper disposal information, while 42% had not. Medicine cabinets emerged as the predominant storage location (49%), followed by bedrooms (11%), refrigerators (9%), and living rooms (8%), with 17% of participants uncertain about where medications were stored. Age demographics revealed a substantial concentration in the 18-24 year category (90%), with minimal representation across older age brackets. Expired medication inventory averaged 4.11 items per participant (SD=3.98). Physician-directed medication changes were commonly reported as justification for keeping expired pharmaceuticals (Table 1).

A large majority (93%) acknowledged that improper disposal of medications negatively impacts the environment. Similarly, 63% agreed that medications disposed of in sinks or bathrooms can reach internal water systems, indicating good environmental awareness. However, when asked about disposal practices, 48% believed it is acceptable to throw sold medications like tablets and capsules into the garbage.

Additionally, 62% agreed that storing leftover medicines at home could lead to self-medication. Regarding educational outreach, 57% of participants reported being informed about safe disposal practices, while 66% stated that they read medicine disposal instructions regularly (Table 2).

TABLE 1

PARTICIPANTS' DESCRIPTIVE STATISTICS

PARAMETER	SUBCATEGORIES		N	%
Gender	Female		275	48%
	Male		299	52%
Education	Degree		397	69%
	Postgraduation		95	17%
	PhD		5	1%
	Diploma		63	11%
	Others (teachers, Dean, HOD)		14	2%
Marital status	Single		553	96%
	Married		21	4%
Have you receive information about How to dispose unused medications?	Yes		331	58%
	No		243	42%
Storage location at household	Locker		35	6%
	Refrigerator		64	11%
	Bedroom		52	9%
	Living room		46	*%
	Medicine cabinet		279	49%
	I don't know		98	17%
Age of respondent	18-24 years		519	90%
	25-31 years		43	7%
	32-38 years		4	1%
	More than 39 years		8	1%
Number of expired medications	Minimum	Maximum	Mean	Std. Deviation
	0	25	4.11	3.98

Table 2

The count of accurate and inaccurate responses to the knowledge queries.

KNOWLEDGE ITEMS	Yes (N) %	NO (N) %	I DON'T KNOW (N) %
Inappropriate discarding of unutilized and outdated medications negatively impacts the environment.	532 93%	37 6%	5 1%
Medicinal substances can infiltrate internal water systems when discarded via bathroom facilities or sinks.	360 63%	200 35%	14 2%
The optimal method for disposing of solid medicinal forms such as tablets and capsules is through the waste bin.	277 48%	281 49%	16 3%
Maintaining surplus medications at one's residence may encourage self-administration of medicines.	355 62%	212 37%	7 1%
Have you received information regarding the secure & appropriate method for discarding expired and unused medicinal products?	325 57%	247 43%	2 0%
Do you examine medication disposal guidelines?	376 66%	189 33%	9 2%
Are you familiar with any drug back system?	211 37%	345 60%	198 3%

A substantial majority of respondents (ranging from 60% to 73%) exhibited favorable perspectives regarding appropriate disposal of unused and expired medicinal products. Notably, 67% of participants (33% agree, 34% strongly agree) endorsed healthcare practitioners' involvement in offering guidance on safe disposal techniques. Likewise, 68% (31% agree, 37% strongly agree) advocated for educational initiatives to inform the public about correct disposal methodologies. Moreover, 71% of respondents (32% agree, 39% strongly agree) supported the implementation of public awareness campaigns concerning the detrimental impacts of inappropriate medicine disposal. Additionally, 68% (29% agree, 39% strongly agree) recognized children's heightened susceptibility to risks associated with unused or expired pharmaceuticals. These results highlight the significant importance of strengthening community-oriented disposal mechanisms, including the return of expired medications to local pharmacies and expanding public education through healthcare personnel (Table 3).

TABLE 3

The participants' attitudes toward unused/expired medication disposal were Examined

ATTITUDE S ITEMS	STRON GLY DISAG REE	DISAG REE	NEUTR AL	AGREE	STRONG LY AGREE	MEA N	STD. DEVI ATIO N
	COUNT	COUNT	COUNT	COUNT	COUNT		
	%	%	%	%	%		
The implem entati on of mandatory drug take- back programs for unused and expired medications should be considered.	75	65	88	154	191	3.56	1.389
	13%	11%	15%	27%	33%		
Medical practitioners and healthcare providers should offer guidance regarding appropriate disposal methods for unused and expired household medications.	55	53	77	192	196	3.73	1.282
	10%	9%	13%	33%	34%		
Educational initiatives concerning proper disposal techniques for unused and	49	48	88	177	211	3.79	1.259
	9%	8%	15%	31%	37%		

expired medications should be established.							
A public awareness initiative regarding the detrimental effects of inappropriate medicine disposal methods is deemed necessary.	60 10%	42 7%	74 13%	173 30%	224 39%	3.80	1.311
Children exhibit heightened vulnerability to risks associated with unused and expired household pharmaceuticals	55 10%	45 8%	81 14%	169 29%	223 39%	3.80	1.293

TABLE 4

The participants' behaviors regarding the disposal of unused or expired medications.

PRACTICE ITEMS	SUBCATEGORIES	N	%
Do you have any medications at home that are no longer being used?	Yes	193	34%
	No	380	66%
How frequently do you verify the expiration date of your medications?	Never	39	7%
	Rarely	45	8%
	Sometimes	73	13%
	Often	57	10%
	Always	359	63%
I get rid of my medications when their color and flavor change.	Yes	119	21%
	No	454	79%
How do you get rid of your expired medication?	Flush it down	47	8%
	Sink	34	6%
	Household trash can	293	51%
	Others methods	199	35%

Despite participants generally demonstrating favorable attitudes toward safe disposal of unused or expired medications, their actual disposal behaviors revealed troubling patterns. According to the findings, 66% of respondents reported not having unused medications at home, while 34% confirmed storing them. A substantial portion (63%) indicated they consistently verify expiration dates, though 21% reported discarding medications only upon noticing changes in color or taste. Concerningly, 51%

of participants disposed of expired medications in household waste, whereas merely 6% utilized sinks, and 35% employed other unspecified methods. These results demonstrate a considerable discrepancy between awareness and practice, emphasizing the necessity for enhanced community-based disposal systems and education regarding proper disposal techniques (Table 4).

A notable disparity was evident in medication disposal knowledge between genders. Female participants demonstrated higher awareness (41.2%) compared to males (37.7%) regarding environmental harm from improper medication disposal. Additionally, 27.6% of females versus 25.8% of males recognized that sink or bathroom disposal can contaminate internal water sources. Concerning disposal techniques, approximately 21.2% of females and 19.9% of males considered it acceptable to discard solid medications in garbage receptacles. While females exhibited marginally superior environmental and water safety consciousness, male participants showed greater familiarity with instructional materials and drug take-back initiatives. The findings indicated that 27.4% of females and 25.2% of males acknowledged that keeping unused medications at home could result in self-medication. When inquired about whether they had ever received advice on the proper disposal of medications, 22.8% of females and 25.4% of males indicated they had.

Regarding their actions, 26.9% of females and 28.9% of males mentioned they checked the disposal guidelines for medications. Finally, awareness of drug take-back programs was slightly greater among males (16.9%) compared to females (14.4%). All observed differences were statistically significant, with a P-Value of less than 0.001, suggesting that gender significantly influences knowledge and behavior concerning medication disposal. This highlights the necessity for targeted educational initiatives that address gender-specific deficiencies, aiming to increase men's awareness of environmental issues and to provide women with more information on proper disposal options like take-back programs. Public health initiatives, educational curricula, and counseling from healthcare providers could be enhanced to tackle these differences and promote safer disposal practices across different demographics (Table 5)

A Chi-square test indicated significant results (P-Value <0.05).

A Chi-Square test was performed to evaluate the association between age and knowledge regarding the disposal of unused or expired medications. The results indicated that out of all the knowledge items evaluated, only two demonstrated a statistically significant correlation with age ($P < 0.005$). The knowledge item “It is best to dispose solid medications such as tablets and capsules into garbage can” had a significant association with age ($P = 0.0004$), where younger participants (especially 18-24 years) demonstrated greater awareness compared to other age groups. Similarly, a significant association ($P = 0.0034$) was found for the item “Do you know about any drug take-back system?”, indicating age-related differences in awareness, with limited knowledge observed particularly among participants over 32 years of age. For the remaining knowledge items such as awareness of environmental effects of improper disposal, the risk of contamination of internal water sources, and knowledge about reading disposal instructions- no significant association was observed with age ($P > 0.05$), suggesting consistent levels of understanding across all age groups. The findings suggest that age plays a significant role in determining awareness about specific aspects of medication disposal, particularly the correct disposal of solid dosage forms and knowledge about take-back systems. Younger participants showed higher awareness in these areas. However, for general knowledge items, such as environmental harm or storing excess medicine, no substantial age-related difference was found. This highlights the need for targeted educational efforts, especially for older populations, to improve knowledge about medication disposal practices. Awareness programs and pharmacist-led counselling may help bridge the gap, especially in less-informed age groups. Strengthening public knowledge through campaigns and community-based initiatives is essential for promoting safe and environmentally sound medication disposal behaviors (Table 6).

TABLE 5

Differences in knowledge regarding medication disposal were noted between male and female participants.

KNOWLEDGE ITEMS	SUB-CATEGORIE	YES	NO	I DONO'T KNOW	P-VALUE
Inappropriate discarding of unused and outdated medications negatively impacts the environment	FEMALE COUNT %	278 41.2%	18 2.7%	3 0.4%	<0.001
	MALE COUNT, %	254 37.7%	19 2.8%	2 0.3%	
Medicinal substances can infiltrate internal water systems when discarded via bathroom facilities or sinks.	FEMALE COUNT %	186 27.6%	104 15.4%	9 1.3%	<0.001
	MALE COUNT, %	174 25.8%	96 14.2%	5 0.7%	
The optimal method for disposing of solid medicinal forms such as tablets and capsules is through the waste bin.	FEMALE COUNT %	143 21.2%	145 21.5%	11 1.6%	<0.001
	MALE COUNT, %	134 19.9%	136 20.2%	5 0.7%	
Maintaining surplus medications at one's residence may encourage self-administration of medicines.	FEMALE COUNT %	185 27.4%	110 16.3%	4 0.6%	<0.001
	MALE COUNT, %	170 25.2%	102 15.5%	3 0.4%	
Have you received information regarding the secure & appropriate method for discarding expired and unused medicinal products?	FEMALE COUNT %	154 22.8%	143 21.2%	2 0.3%	<0.001
	MALE COUNT, %	171 25.4%	104 15.4%	0 0.0%	
Do you examine medication disposal guidelines?	FEMALE COUNT %	181 26.9%	111 15.4%	7 1.0%	<0.001
	MALE COUNT, %	195 28.9%	78 11.6%	2 0.3%	
Are you familiar with any drug back system?	FEMALE COUNT %	97 14.4%	190 28.2%	12 1.8%	<0.001
	MALE COUNT, %	114 16.9%	155 23.0%	6 0.9%	

TABLE 6

The relationship between age and awareness of how to dispose of unused or expired medications

KNOWLEDGE ITEMS	AGE (YEARS)	YES COUNT, %	NO COUNT, %	I DON'T KNOW COUNT, %	P-VALUE
Inappropriate discarding of unutilized and outdated medications negatively impacts the environment	18-24	483 93%	32 6%	4 1%	0.6606
	25-31	37 86%	5 12%	1 2%	
	32-38	4 100%	0 0%	0 0%	
	More than 39	8 100%	0 0%	0 0%	
Medicinal substances can infiltrate internal water systems when discarded via bathroom facilities or sinks.	18-24	324, 62%	182 35%	13 3%	0.5510
	25-31	25 58%	17 40%	1 2%	
	32-38	4 100%	0 0%	0 0%	
	More than 39	7 88%	1 13%	0 0%	
The optimal method for disposing of solid medicinal forms such as tablets and capsules is through the waste bin.	18-24	251 48%	252 49%	16 3%	0.0707
	25-31	25 58%	18 42%	0 0%	
	32-38	0 0%	4 100%	0 0%	
	More than 39	1 13%	7 88%	0 0%	
Maintaining surplus medications at one's residence may encourage self-administration of medicines.	18-24	320 62%	192 37%	7 1%	0.7394
	25-31	25 58%	18 42%	0 0%	
	32-38	3 75%	1 25%	0 0%	
	More than 39	7 88%	1 13%	0 0%	
Have you received information regarding the secure & appropriate method for discarding expired and unused medicinal products?	18-24	291 56%	226 44%	2 0%	0.7494
	25-31	25 58%	18 42%	0 0%	
	32-38	4 100%	0 0%	0 0%	
	More than 39	5 63%	3 38%	0 0%	
Do you examine medication disposal guidelines?	18-24	333 64%	178 34%	8 2%	0.4458
	25-31	33 77%	9 21%	1 2%	
	32-38	4 100%	0 0%	0 0%	
	More than 39	6 75%	2 25%	0 0%	
Are you familiar with any drug back system?	18-24	178 34%	323 62%	18 3%	

	25-31	26 60%	17 40%	0 0%	0.003 4
	32-38	4 100%	0 0%	0 0%	
	More than 39	3 38%	5 63%	0 0%	

A Chi-square test indicated significant results (P-Value <0.05).

An independent t-test was performed to evaluate differences in attitudes toward safe medication disposal based on gender. The findings indicated statistically significant variations ($p < 0.005$) in all attitude items when comparing male and female participants. Regarding drug take-back programs, female participants reported a notably more favorable attitude (Mean= 3.73, SD= 1.301) compared to males (Mean= 3.38, SD= 1.458), with a p-value of 0.003. In terms of the role of healthcare professionals, females (Mean= 3.90, SD= 1.185) demonstrated stronger agreement than males (Mean= 3.560, SD= 1.359) about the importance of healthcare professionals providing guidance on safe disposal, $p = 0.001$. When it came to the need for awareness programs, female respondents (Mean= 3.91, SD= 1.186) displayed greater support compared to males (Mean= 3.66, SD= 1.323), $p = 0.016$. Concerning public awareness of the harmful effects of improper disposal, females (Mean= 3.95, SD= 1.232) endorsed the necessity for public awareness campaigns more strongly than males (Mean= 3.65, SD= 1.378), $p = 0.009$. In relation to children's vulnerability to medication risks, females (Mean= 3.95, SD= 1.231) were more inclined to agree that children face higher risks unused or expired household medications than males (Mean= 3.64, SD= 1.341), $p = 0.005$. The research showed notable gender-based differences in attitudes toward the safe disposal of unused and expired medications, with female participants consistently exhibiting more favorable attitudes across all assessed items. They showed stronger agreement than men regarding the significance of drug take-back programs, the advisory role of healthcare professionals, and the necessity of public awareness efforts. Additionally, females recognized the risks associated with improper disposal, particularly regarding children's vulnerabilities. These results imply that women may be more aware of the health and environmental consequences of medication disposal, underscoring the need for targeted awareness initiatives, especially aimed at male populations (Table 7).

TABLE 7

The variance in the participant's attitude regarding medication disposal based on gender.

ATTITUDES ITEMS	GENDER	N	MEAN	STD. DEVIATION	P- VALUE
The implementation of mandatory drug take-back programs for unused and expired medications should be considered.	Female	298	3.73	1.301	0.003
	Male	275	3.38	1.458	
Medical practitioners and healthcare providers should offer guidance regarding appropriate disposal methods for unused and expired household medications.	Female	298	3.90	1.185	0.001
	Male	275	3.56	1.359	
Educational initiatives concerning proper disposal techniques for unused and expired medications should be established.	Female	298	3.91	1.186	0.016
	Male	275	3.66	1.323	
A public awareness initiative regarding the detrimental effects of inappropriate medicine disposal methods is deemed necessary.	Female	298	3.95	1.232	0.009
	Male	275	3.65	1.378	

Children exhibit heightened vulnerability to risks associated with unused and expired household pharmaceuticals	Female	298	3.95	1.231	0.005
	Male	275	3.64	1.341	

TABLE 8

The association between education level and the knowledge about disposing unused/expired medication.

KNOWLEDGE ITEMS		DEGREE	POST-GRADUATION	PHD	DIPL OMA	OTHER	P-VALUE
Inappropriate discarding of unutilized and outdated medications negatively impacts the environment	COORECT COUNT, %	371 55.0%	84 12.5%	4 0.6%	59 8.8%	13 1.9%	<0.001
	INCORRECT COUNT, %	22 3.3%	9 1.3%	1 0.1%	4 0.6%	1 0.1%	
Medicinal substances can infiltrate internal water systems when discarded via bathroom facilities or sinks.	COORECT COUNT, %	245 36.4%	71 10.5%	3 0.4%	31 4.6%	9 1.3%	<0.001
	INCORRECT COUNT, %	140 20.8%	23 3.3%	2 0.3%	32 4.6%	5 0.7%	
The optimal method for disposing of solid medicinal forms such as tablets and capsules is through the waste bin.	COORECT COUNT, %	195 28.9%	42 6.2%	3 0.4%	31 4.6%	6 0.9%	<0.001
	INCORRECT COUNT, %	190 28.2%	48 7.1%	2 0.3%	32 4.7%	8 1.2%	
Maintaining surplus medications at one's residence may	COORECT COUNT, %	241 35.8%	58 8.6%	2 0.3%	43 6.4%	10 1.5%	<0.001
	INCORRECT COUNT, %	150	35	3	20	4	

encourage self-administration of medicines.	%	22.3%	5.2%	0.4%	3.0%	0.6%	
Have you received information regarding the secure & appropriate method for discarding expired and unused medicinal products?	COORECT COUNT, %	205 30.45	55 8.2%	3 0.4%	52 7.7%	10 1.5%	<0.001
	INCORRECT COUNT, %	189 28.0%	40 5.9%	2 0.3%	11 1.6%	4 0.6%	
Do you examine medication disposal guidelines?	COORECT COUNT, %	247 36.6%	61 9.1%	4 0.6%	53 7.9%	11 1.6%	<0.001
	INCORRECT COUNT, %	142 21.1%	32 4.7%	1 0.1%	10 1.5%	3 0.4%	
Are you familiar with any drug back system?	COORECT COUNT, %	124 18.45	39 5.8%	5 0.7%	34 5.0%	9 1.3%	<0.001
	INCORRECT COUNT, %	261 38.4%	50 7.4%	0 0.0%	29 4.3%	5 0.7%	

Significant (P-Value <0.05) according to chi square test.

The Independent T-test indicated a statistically significant outcome (P-Value <0.05).

The results revealed a strong correlation between the level of education and participants' understanding of the safe disposal of unused and expired medications ($p < 0.001$). Individuals with a degree-level education consistently exhibited higher levels of accurate knowledge across all assessed items. For example, 55% of those holding a degree correctly recognized that improper disposal can harm the environment, while only 12.5% of postgraduate individuals and less than 1% of PhD graduates were aware of this issue. Furthermore, 36.4% of degree holders acknowledged the danger of water contamination due to medicines being disposed of in sinks or bathrooms, which was significantly higher than the rates among other educational levels. Similar patterns were noted regarding knowledge of appropriate disposal methods, including reading instructions, recognizing risks associated with self-medication, and being familiar with drug take-back initiatives. Notably, those with higher educational credentials did not always exhibit superior awareness, suggesting that formal education alone may not guarantee sufficient knowledge. These findings highlight the necessity for focused public health education initiatives targeting various educational backgrounds to improve safe medication disposal practices (Table 8).

DISCUSSION

The increasing accessibility and usage of pharmaceuticals has resulted in the build-up and inappropriate disposal of unused and expired medications in homes, posing problems for the

environment and public health. Implementing policies and raising public awareness of proper medication disposal techniques can help to mitigate this issue. Assessing the public's knowledge, attitudes, and practices regarding the disposal of

unused and expired medications was the primary goal of this study. With an emphasis on gender, educational attainment, and other sociodemographic characteristics, our current study sought to evaluate participants' knowledge, attitudes, and practices regarding the safe disposal of unused and expired medications. The results showed that while most participants showed awareness of the negative consequences of inappropriate medication disposal, there are still notable discrepancies between knowledge and practice. In particular, 63% of respondents agreed that disposal through sinks or bathrooms can contaminate internal water sources, and 93% agreed that improper disposal has a negative impact on the environment. These results are consistent with research from other countries, where participants also expressed a high level of awareness of the effects on the environment [37]. Nonetheless, over half of the participants (51%) stated that they disposed of their expired medications in the trash, which is a practice that may be harmful to the environment and public health. This inappropriate disposal technique is in line with research from Malaysia and the US, where household waste is still frequently disposed of this way because people are unaware of other options [38,39]. The startling finding that only 37% of participants knew about drug take-back programs suggests that there is a lack of infrastructure and public education to promote safe disposal. Similar shortcomings have been noted in comparable studies, underscoring the pressing need for accessible disposal programs and focused awareness campaigns [40]. Significant gender differences in attitudes and knowledge were also found in the current study. Compared to men, female participants showed greater awareness and more positive attitudes regarding the proper disposal of medications; this trend was also observed in studies conducted in Saudi Arabia and Lebanon [41,42]. This discrepancy may be partially explained by women's increased participation in healthcare choices and domestic duties [42]. Additionally, one important factor influencing knowledge and practice was found to be educational attainment. Postgraduate and doctorate degree holders demonstrated superior environmental knowledge, impacts and appropriate disposal methods, whereas individuals with less education demonstrated greater prevalences of misunderstandings and inappropriate disposal. This result supports earlier studies' findings that responsible medication disposal practices are positively connected with higher educational attainment [43,44]. Household storage practices continue to be a concern in addition to knowledge gaps. The risk of self-medication and accidental ingestion is increased because nearly half of the respondents (49%) kept their medications in easily accessible places, like medicine cabinets. The link between inappropriate storage and a rise in self-

medication, especially among vulnerable populations like children, has also been emphasized in earlier research [45]. Notwithstanding the gaps found, most respondents had favorable opinions about seeking advice from medical professionals regarding safe disposal. This illustrates how healthcare professionals can help close the knowledge-practice gap, as advised by international health organizations like the World Health Organization (WHO) [46]. Overall, the study emphasizes how urgently comprehensive public education campaigns, the implementation of policies to improve drug take-back programs, and the active participation of medical professionals in promoting safe disposal practices are needed [47].

CONCLUSION

The current study reveals notable discrepancies in the study population's knowledge, attitudes, and actual practices around the disposal of unused and expired medications. Even though a significant number of participants showed that they were aware of the negative consequences of inappropriate medication disposal, especially the impact on the environment, this awareness does not always translate into appropriate disposal practices.

With little knowledge of appropriate alternatives like drug take-back programs, a sizable portion of respondents acknowledged throwing expired medications in the trash. This illustrates the pressing need for focused awareness campaigns to encourage appropriate disposal practices and lower the risks of environmental contamination.

The study also showed that attitudes and behaviors are significantly influenced by gender and educational attainment. Participants who were female and had more education demonstrated greater awareness and more favorable attitudes regarding proper disposal. Additionally, it is still common to keep medications in easily accessible areas of the home, which raises the possibility of self-medication, inadvertent ingestion, and possible abuse.

Overall, the results highlight how critical it is to improve medication disposal and public education, increase access to take-back programs, and motivate medical staff to actively participate in patient education. Promoting safe disposal methods, protecting the environment, and reducing the risks associated with leftover or expired medications in homes all depend on addressing these issues.

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