



Contents lists available at ScienceDirect

Saudi Pharmaceutical Journal

journal homepage: www.sciencedirect.com



Original article

Knowledge and practices concerning the storage and disposal of home medications among people in the eastern region of Saudi Arabia: A cross-sectional study

EL Walid EL Hassan, Alanoud Ahmed Al Taisan, Amal Khaleel Abualhommos*^{*}

Pharmacy Practice Department, Clinical Pharmacy College, King Faisal University, Alhasa, Saudi Arabia

ARTICLE INFO

Article history:

Received 18 August 2021

Accepted 27 December 2021

Available online 31 December 2021

Keywords:

Attitude

Disposal

Knowledge

Medications

Saudi Arabia

Storage

ABSTRACT

Background: Medications are widely used and stored in people's homes throughout the year. Inappropriate storage of home medications is a worldwide problem and may affect the effectiveness and stability of medications, which impacts the activity and capability of these medications to treat diseases. This study aimed to assess the awareness of the public in the eastern region of Saudi Arabia concerning the appropriate storage of used medications and the proper disposal of unwanted medications. **Method:** A cross-sectional survey was conducted in the eastern region of Saudi Arabia between February and June 2018. The study questionnaire tool was constructed based on several previous studies regarding medication storage, recycling, and the correct and safe disposal of expired, unwanted, or unused medication.

Results: A total of 820 responses was collected. The results showed that 91.0% of the respondents keep their medications in the original container, and only 4.5% of them write the expiry date on the new containers. While 47.1% of the respondents read the storage instructions written in the medication leaflet, only 16.2% of the respondents ask the pharmacist about the storage instructions. A majority of the respondents (84.4%) check the expiry date of medications before use, and 70.1% of them periodically check the expiry date of stored medications. Age, gender, and education level were important factors that affected medication storage practices.

Conclusion: This work underpinned the lack of awareness among the public regarding the appropriate way to store home medications and the proper way to dispose of unwanted and expired medications.

© 2022 The Authors. Published by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Medications are pharmaceutical preparations that are widely used and stored in people's homes worldwide throughout the year (Abou-Auda, 2003, Bound and Voulvoulis, 2005, Kusturica et al., 2012). Inappropriate storage of home medications is a global problem and may affect the effectiveness and stability of medications, which impacts the activity and capability of these medications to treat diseases (Abou-Auda, 2003, Abahussain et al., 2012). Simi-

larly, improper disposal of unwanted medications, including unused, expired, spilt, or contaminated medications may lead to poisoning if taken by adults or children intentionally or by accident (Kiyangi and Lauwo, 1993, Beirens et al., 2006, Franklin and Rodgers, 2008, Abahussain et al., 2012), and will also affect the environment (Kozak et al., 2016, U.S Food and Drug Administration, 2020). On the other hand, storing and disposing of medications appropriately and safely maintains the efficacy and stability of medications, and protects the environment and people from getting poisoned (Persson et al., 2009, U.S Food and Drug Administration, 2020). Home storage of medications is a public concern all over the world that arises due to improper utilisation of medications and/or non-adherence to treatment, which ultimately affects population health, the environment, and the utilisation of healthcare services (Crane et al., 2006, Mackridge and Marriott, 2007, Hussain et al., 2019, Paudel et al., 2019). Medicine utilisation patterns have changed over the past few years, which has subsequently led to greater volumes being purchased and, ulti-

* Corresponding author.

E-mail address: aabualhommos@kfu.edu.sa (A.K. Abualhommos).

Peer review under responsibility of King Saud University.



mately, a larger volume of unused or leftover medications in homes (De Bolle et al., 2008). According to the World Health Organization (WHO), more than 50% of medicines are inappropriately prescribed and dispensed, which leads to unnecessary storage (World Health Organization, 2011).

A recent study in Jordan reported that around 58.0% of the study participants had unused, leftover, or expired medications in their homes (Naser et al., 2021). Previous studies from Saudi Arabia revealed that the mean number of medications in each house is eight, and the percentage of expired or unused medication is 25.8% (Abou-Auda, 2003, Al Ruwaili et al., 2014). Clear instructions for the appropriate storage of medications are usually retrieved from the leaflet attached to each prescribed and over-the-counter medication to maintain their efficacy and stability. Although some countries, like the United States, have published official instructions to guide the public on the appropriate way to dispose of unwanted or expired home medications, there are still no clear standards for the disposal of home medications from an official institution in Saudi Arabia (U.S Food and Drug Administration, 2020). Also, there are no clear instructions in Saudi Arabia or the law concerning the use of child-resistant packaging for medications (Alruwaili et al., 2013). Therefore, this study aimed to assess the awareness of the public in the eastern region of Saudi Arabia of the appropriate storage of used medications and the proper disposal of unwanted medications.

2. Material and methods

2.1. Study design and population

A cross-sectional study was conducted between February and June 2018 among the public in the eastern region of Saudi Arabia. The study questionnaire tool was constructed based on several previous studies regarding medication storage, recycling, and the correct and safe disposal of expired, unwanted, or unused medication (Pankajkumar et al., 2016, Bataduwaarachchi et al., 2018, Quadra et al., 2019, Naser et al., 2021). The questionnaire had two sections, with a total of 16 questions: the first part included basic demographic information such as gender, age, and level of education, whether the participants have children below six years old in the house, and city of residency. The second part consisted of 13 questions to assess participants' knowledge about the storage of medication, practices regarding the place of storage, and methods of handling stored medications at home. Additionally, the questionnaire included questions on the way/place in which medications are stored at home, whether the original containers of the medications are changed or not, and whether the expiry date is written on the new container. There were further questions on the common classes of medications that are stored at home, and on whether the participants ask pharmacists or read the attached leaflet for the proper way to store the medications. Some questions asked participants whether they check the expiry date of the stored medications before use and periodically, and whether they are aware of the types of pharmaceutical preparations or dosage forms that should be refrigerated. Participants were asked how they carry medications when travelling. They were also asked how they dispose of both expired medications and unused, unexpired medications. Inclusion criteria were for participants to be more than 18 years old and have unused leftover, or expired medications in their homes.

2.2. Sampling strategy

A convenient sample of participants who met the inclusion criteria was invited to participate in the study through social media

platforms (Twitter and WhatsApp). All participants participated voluntarily in the study and were thus considered exempt from written informed consent. The study aims and objectives were clearly explained at the beginning of the survey. In addition, the participants were informed that participation in the study was voluntary. The respondents were assured about the confidentiality of their responses, and they were informed that the study aimed to assess their knowledge and practices concerning the storage and disposal of home medications.

2.3. Instrument development

Reliability and validity tests were carried out with 15 participants. Based on the results of this pilot study, the questions were modified to ensure simplicity and ease of understanding. Experienced pharmacists checked the questionnaire design and verified the content validity of the questions.

2.4. Instrument translation

As arabic is the official language and the most commonly used language among the general population in Saudi Arabia, we translated the questionnaire items adapted from previous literature using the forward backward translation technique. The forward translation was completed by expert in linguistics who is fluent in Arabic. The translation process focused on the conceptual translation rather than the literal (word-forword) translation. Based on the WHO recommendation [16], the translated draft was revised and assessed to guarantee that it is satisfactory for them and reflected the same concepts covered by the originally adapted items. This step was followed by backward translation, which involved the backward translation of the produced Arabic version into the English language. This was undertaken by a bilingual clinical pharmacist who had no prior knowledge of the objectives of the study or of the original questionnaire. Finally, the back-translated draft of the questionnaire was compared to the items in the original English language version to assess if they were conceptually equivalent.

2.5. Sample size

Using a confidence interval of 95%, a standard deviation of 0.5, and a margin of error of 5%, the minimum required sample size was 385 participants.

2.6. Ethical consideration

Ethical approval was obtained for this study from the Research Ethics Committee of Pharmacy

Practice at the Clinical Pharmacy College at King Faisal University (KFU-REC/2016-11-10).

2.7. Statistical analysis

Descriptive analysis was reported as a mean (\pm standard deviation [SD]). Categorical variables were reported as frequency (percentage). A Chi-square test was used to assess the difference in practices regarding the storage and disposal of home medications between different demographic groups. Binary logistic regression was used to identify predictors of medication storage and disposal practices. The statistical analyses were carried out using Statistical Package for Social Science (SPSS) software (version 27).

3. Results

3.1. Participants' characteristics

A total of 820 individuals participated in this study. About 74% of the respondents were female. Around half of the study respondents (45.5%) were aged 21–30 years. Approximately 67.0% of the participants had a bachelor's degree. Around half of the study respondents (47.7%) reported that they have children below six years old in the house. For further details about respondents' demographics, refer to [Table 1](#).

3.2. Knowledge and practices regarding the storage of medication

[Table 2](#) shows the respondents' medication storage practices. The vast majority (91.0%) of the study participants reported that they keep medications in the original container. Around 84.0% of the respondents reported that they check the expiry date before using the medications. Around 70.0% of the respondents reported that they check the expiry date of stored medications periodically. Only 47.1% of the study participants reported that they read the storage instructions of medications written on the leaflet, and 16.2% reported that they ask the pharmacist about the storage instructions. A very small proportion (4.5%) of the study participants reported that they write the expiry date on the new container, [Table 2](#).

[Table 3](#) shows participants' medication storage knowledge and practices. The most commonly reported places in which participants store medications were the cabinet (56.7%) and the refrigerator (79.0%). The most commonly reported class of medication stored at home was painkillers and antipyretics (97.8%). When the participants were asked about medications that should be

Table 1
Participants' demographic characteristics.

Item		Frequency (No.)	Percentage (%)
Gender	Female	603	73.5
	Male	217	26.5
Age groups	18–20 years	201	24.5
	21–30 years	373	45.5
	31–40 years	141	17.2
	40 years and more	105	12.8
Education level	Elementary school level	6	0.7
	Intermediate school level	33	4.0
	High school level	177	21.6
	Bachelor degree level	553	67.4
	Post-graduate level	42	5.1
	Diploma	9	1.1
Having children below 6 years old in the house	Yes	391	47.7
	No	429	52.3
Living city in the eastern region of Saudi Arabia	Al-Hasa	330	40.2
	Dammam	188	22.9
	Khobar	117	14.3
	Al-Jubail	55	6.7
	Dhahran	44	5.4
	Al-Qatif	32	3.9
	Hafr Albatin	12	1.7
	Ras Tanura	9	1.1
	Al-Khafji	8	1.0
	Abqaiq	4	0.5
	Villages and migrates	19	2.3

No: Frequency.

Table 2
Participants' medication storage practices.

Item	Frequency (No.)	Percentage (% answered yes)
Keeping medication in original container	746	91.0
Checking the expiration date before using the medications	692	84.4
Checking the expiration date of stored medications periodically	575	70.1
Reading the storing instructions of medications written on the leaflet	386	47.1
Asking the pharmacist about the storing instructions	133	16.2
Writing the expiration date on the new container	37	4.5

No: Frequency.

stored in the refrigerator, the most commonly reported dosage form was suppository (66.2%). Regarding how they carry medications when travelling, around half of the study participants (50.7%) reported that they carry medications in their handbags. When the participants were asked about how they dispose of unused and expired medications, 72.6% and 97.3% reported that they throw them in the garbage, respectively.

[Table 4](#) shows the gender-based differences in medication storage practices. There was a statistically significant difference between males and females in terms of the following practices: keeping medication in the original container, writing the expiry date on the new container if the medication is moved from the original one, reading the storage instructions of medications written on the leaflet, asking the pharmacist about the storage instructions when buying new medications, and checking the expiry date before using the medications ($p < 0.001$), [Table 4](#).

[Table 5](#) shows the age-based differences in medication storage practices. There was a statistically significant difference between participants from different age groups in terms of the following practices: writing the expiry date on the new container if the medication is moved from the original one, reading the storage instructions of medications written on the leaflet, asking the pharmacist about the storage instructions when buying new medications, checking the expiry date before using the medications, and periodically checking the expiry date of stored medications, [Table 5](#). [Table 6](#) shows the differences in medication storage practices based on education level. There was a statistically significant difference between participants from different education levels in terms of all medication storage practices.

3.3. Predictors of medication storage and disposal practices

Participants who hold diploma were less likely to keep medication in original container (OR: 0.26 (95 %CI: 0.07–0.99)). Participants who aged 40 years and above were more likely to write the expiration date on the new container if changing the original one (OR: 3.56 (95 %CI: 1.73–7.33)). Male participants and those who are aged 21–30 years were less likely to read the storing instructions of medications written on the leaflet (OR: 0.57 (95 %CI: 0.41–0.78)) and (OR: 0.69 (95 %CI: 0.53–0.91)), respectively. On the other hand, participants who are aged 31–40 years were more likely to read the storing instructions of medications written on the leaflet (OR: 1.78 (9 %CI: 1.23–2.57)). Participants who are aged 21–30 years were less likely to ask the pharmacist about the storing instructions when buying new medications (OR: 0.48 (95 %CI: 0.32–0.71)). However, participants who are aged 31–40 years and 41 years and above were more likely to (OR: 1.86 (1.20–2.89)) and (OR: 3.70 (95 %CI: 2.35–5.82)), respectively. Male and those with high school-level education were less likely to

Table 3
Participants' knowledge and practices regarding the storage of medications.

Item	Frequency (No.)	Percentage (%)	
Store medications in §	Cabinet	464	56.7
	No box	249	30.4
	Open box	184	22.5
	Bag	64	7.8
	Locked box	49	6.0
Place for storing medications §	Others	47	5.7
	Refrigerator	648	79.0
	Bed room	326	39.8
	Kitchen	242	29.5
	living room	109	13.3
Common classes of medications in the house §	Car	11	1.3
	Others	30	3.7
	Pain killers + antipyretics	801	97.8
	Cough syrups	446	54.5
	Vitamins and supplements	355	43.3
	Antibiotics	326	39.8
	Antacids	246	30.0
	Antidiabetic agents	191	23.3
	Antihypertensive	171	20.9
	Anti-hyperlipidemics	101	12.3
Medications that should be store in the refrigerator §	Others	33	4.0
	Suppositories	542	66.2
	Insulin	504	61.0
	Syrups	490	59.8
	Eye drops	439	53.6
	Injectable medications	415	50.7
	Ear drops	328	40.0
	Ointments	229	28.0
	Antibiotics tab + caps	217	26.5
	Hormones	193	23.6
	Creams	187	22.8
	Iron and folic acid tablets	126	15.4
	Vitamins tablets	119	14.5
	Others	22	1.3
	The way of carrying the medications in case of traveling	In handbag	416
With luggage		130	15.9
In a bag inside the airplane cabin		115	14.0
I do not carry medications during travel		114	13.9
Buy new medications from designated country		45	5.5
The way of disposing unused medications §	Throw it in the garbage	595	72.6
	Store it for future use	331	40.4
	Give it to a friend or relative	107	13.0
	Return it to the pharmacy	42	5.1
The way of disposing the expired medications	Throw it in the garbage	798	97.3
	Throw it in the toilet	53	6.5
	Return it to the pharmacy	28	3.4
	Burn it	6	0.7
	Buried in the soil	3	0.4

§ Participants could choose more than one answer, No: Frequency.

check the expiration date before use the medications (OR: 0.66 (95 %CI: 0.44–1.00)) and (OR: 0.62 (95 %CI: 0.40–0.95)), respectively. On the other hand, participants who are aged 31–40 years, 41 years and above, and those with post-graduate level of education were more likely to check the expiration date before use the medications (OR: 4.93 (95 %CI: 2.13–11.43)), (OR: 22.46 (95 %CI:

3.11–162.48)), (OR: 8.00 (95 %CI: 1.09–58.68)), respectively. Male participants were less likely to check the expiration date of stored medications periodically (OR: 0.43 (95 %CI: 0.31–0.59)). Those who are aged 31–40 years, 41 years and above were more likely to check the expiration date of stored medications periodically (OR: 3.43 (95 %CI: 2.04–5.77)) and (OR: 2.09 (95 %CI: 1.24–3.52)), respectively, [Table 7](#).

4. Discussion

This study explored the awareness of the public in the eastern region of Saudi Arabia on the appropriate storage of used medications and the proper disposal of unwanted medications. The key findings of the study are: 1) the majority of the study participants reported that they keep medications in the original container and check the expiry date before using the medications; 2) around half the study participants (47.1%) read the storage instructions of medications written on the leaflet; 3) a small proportion write the expiry date on the new container or ask the pharmacist about the appropriate storage instructions; 4) painkillers and antipyretics were the most commonly reported class of medications stored at home, in suppository dosage form, and 5) the majority of the participants dispose of unused and expired medications in the garbage.

Incorrect storage of home medications and incorrect disposal of unwanted medications are a big concern in Saudi Arabia. Even though there are clear instructions for the appropriate storage of medication in the leaflets attached to each type of prescribed and over-the-counter medication, there are no clear instructions guiding the disposal of unwanted or expired medications ([Alruwaili et al., 2013](#)). The majority of the study participants reported that they keep medications in the original container and check the expiry date before using the medications. Similar findings were reported among nursing and pharmacy university students in Saudi Arabia were more than half of the study participants reported that they check the expiry date of medications ([Bashatah and Wajid, 2020](#)).

The expiry date reflects the period for which the medication remains stable and, consequently, preserves its purity, quality and strength. Checking the expiry date of medications before use is important as expired medications could lead to multiple potential harmful effects on patient health, which include yielding toxic compounds and unintended side effects.

Around half the study participants (47.1%) read the storage instructions of medications written on the leaflet. Proper storage of unused medications is vital to maintain the medications' quality and guarantees their safety and efficacy. In our study, a small proportion of the participants reported that they write the expiry date on the new container or ask the pharmacist about the appropriate storage instructions. As mentioned before, writing the expiry date on the new container if the medication has been moved from the original container is important to identify the period at which the medication remains stable, safe and effective.

Unfortunately, only a small proportion of the participants reported that they ask the pharmacist about appropriate storage instructions. This practice should be enhanced and patients should ask pharmacists about the appropriate storage instructions for their medications before and after their use. Pharmacists have a major role in enhancing medication safety, from medication preparation and dispensing, to usage, storage, and disposal ([Agency for Healthcare Research and Quality, 2019](#)). Besides, unfortunately, previous studies in Saudi Arabia reported that even healthcare providers including pharmacists themselves do not provide instructions to the patients about the proper disposal of medications ([Al-Shareef et al., 2016](#), [AlAzmi et al., 2017](#)).

Table 4
Participants' medication storage practices stratified by gender.

			Frequency (No.)	Percentage (%)	P-value
Keeping medication in original container	Females	Yes	543	90.0	<0.000
		No	60	10.0	
	Males	Yes	203	93.5	
		No	14	6.5	
Writing the expiration date on the new container if changing the original one	Females	Yes	31	5.1	<0.000
		No	572	94.9	
	Males	Yes	6	2.7	
		No	211	97.3	
Reading the storing instructions of medications written on the leaflet	Females	Yes	306	50.7	<0.000
		No	297	49.3	
	Males	Yes	80	36.8	
		No	137	63.2	
Asking the pharmacist about the storing instructions when buying new medications	Females	Yes	96	15.9	<0.000
		No	507	84.1	
	Males	Yes	37	17.0	
		No	180	83.0	
Checking the expiration date before use the medications	Females	Yes	518	85.9	<0.000
		No	85	14.1	
	Males	Yes	174	80.1	
		No	43	19.9	
Checking the expiration date of stored medications periodically	Females	Yes	453	75.1	0.051
		No	150	24.9	
	Males	Yes	122	56.2	
		No	95	43.8	

No: Frequency

Table 5
Participants' medication storage practices stratified by age group.

		18–20 years		21–30 years		31–40 years		Above 40 years		p-value
		Frequency (No.)	Percentage (%)	Frequency (No.)	Percentage (%)	Frequency (No.)	Percentage (%)	Frequency (No.)	Percentage (%)	
Keeping medication in original container	Yes	177	88	341	91.4	134	95	94	89.5	0.020
	No	24	12	32	8.6	7	5	11	10	
Writing the expiration date on the new container if changing the original one	Yes	4	1.9	15	4	6	4.2	12	11.4	0.009
	No	197	98.1	358	96	135	95.8	93	88.6	
Reading the storing instructions of medications written on the leaflet	Yes	89	44.2	157	42	83	58.8	57	54.2	0.022
	No	112	55.8	216	58	58	41.2	48	45.8	
Asking the pharmacist about the storing instructions when buying new medications	Yes	20	9.9	41	10.9	34	24.1	38	36.1	0.015
	No	181	90.1	332	89.1	107	75.9	67	63.9	
Checking the expiration date before use the medications	Yes	144	71.6	309	82.8	135	95.7	104	99	0.017
	No	57	28.4	64	17.2	6	4.3	1	1	
Checking the expiration date of stored medications periodically	Yes	110	54.7	256	68.6	123	87.2	86	81.9	0.02
	No	91	45.3	117	31.4	18	12.8	19	18.1	

No: Frequency.

In our study, painkillers and antipyretics were the most commonly reported class of medications stored at home in suppository dosage form. In a previous study in Jordan, different dosage forms were reported, were 74.8% of the participants reported that tablets and capsules followed by eye/ear drops with 24.5% (Naser et al., 2021). Additionally, different types of unused/expired medications were reported including cold, cough and flu medications (70.9%), antibiotics (45.1%), and vitamins and supplements (35.6%). This might be due to the differences in the demographic characteristics of the study participants including the family type (having children or not), family size, and type of existed comorbidities among the study participants.

A recent systematic review has explored factors associated with medicine storage and reported that family size and having children aged below six years old are important factors that increase the probability of having stored and wasted medications (Jafarzadeh et al., 2021). This is especially true of the Middle East community as, to cut costs, a large proportion of the community practice self-medication and do not refer to healthcare professionals (Khalifeh et al., 2017).

The majority of the participants dispose of unused and expired medications in the garbage. This confirms the findings of previous studies, which reported that 70%–97% of medications are disposed of in the garbage (Al-Shareef et al., 2016, Banwat et al., 2016, Ristić et al., 2016, AlAzmi et al., 2017, Naser et al., 2021). This harmful practice among the Saudi population should be stopped and other medication disposal methods should be promoted by healthcare professionals and social media, such as dropping off the medicine at a drug take-back site or location (U.S Food and Drug Administration, 2020). Disposing of unused and expired medications in the garbage has multiple negative impacts on the environment and, ultimately, on the community. A previous study that was conducted in Jordan has reported that many vegetable farms in the Jordan Valley are irrigated by water resources that are contaminated by pharmaceutical residues (Zemann et al., 2014).

In our study, medication storage practices differed significantly by age, gender and education level. This was confirmed by a recent systematic review, which reported that being elderly, female, and having a higher education level were factors that improve practices associated with proper medication storage (Jafarzadeh et al., 2021).

Table 6
Participants' medication storage practices stratified by education level.

	Elementary school		Intermediate school		High school		Bachelor		Post-graduate		Diploma		p-value
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	
Keeping medication in original container	Yes 6	100	27	81.8	159	89.8	507	91.6	40	95.2	7	77.7	0.003
Writing the expiration date on the new container if changing the original one	No 0	0	6	18.2	18	10.2	46	8.4	2	4.8	2	22.3	
Reading the storing instructions of medications written on the leaflet	Yes 6	100	32	97	166	93.8	529	95.7	41	97.7	9	100	0.001
Asking the pharmacist about the storing instructions when buying new medications	Yes 5	83.3	11	33.3	82	46.3	261	47.1	25	59.5	2	22.2	0.004
Checking the expiration date before use the medications	No 1	16.7	22	66.7	95	53.7	292	52.9	17	40.5	7	77.8	
Checking the expiration date of stored medications periodically	Yes 2	33.3	6	18.1	28	15.8	93	16.8	4	9.5	0	0	0.003
	No 4	66.7	27	81.9	149	84.2	460	83.2	38	90.5	9	100	
	Yes 5	83.3	28	84.8	140	79	470	84.9	41	97.6	8	88.8	0.003
	No 1	16.7	5	15.2	37	21	83	15.1	1	2.4	1	11.2	
	Yes 3	50	21	63.6	114	64.4	398	71.9	33	78.5	6	66.6	0.004
	No 3	50	12	36.4	63	35.6	155	28.1	9	21.5	3	33.4	

Besides, a previous study that was conducted in Saudi Arabia and reported that there were no significant associations between demographic characteristics and differentiation between the disposal of prescription and non-prescription medications (Al-Shareef et al., 2016), our study found that low education level (having diploma), younger age (21–30 years), and male gender were important demographic variables that are associated with improper medication storage/disposal practices. However, this Saudi study confirmed our findings concerning having higher responsibility for finding an appropriate means of disposing of medication among older population and females compared to others (Al-Shareef et al., 2016). This could be attributed to the fact that these demographic groups have better medication storage practices due to gender-related physiopathology, interaction with the healthcare system, lifestyle, and other biological differences (for example, pregnancy) (Jafarzadeh et al., 2021).

Half of the respondents carry their medications in their handbags when travelling, which is the correct way to avoid heat, moisture, and to avoid altering the active ingredients when buying new medications from the another country.

There are several reasons excess amounts of medication are stored in homes, increasing the need for appropriate storage methods. These include over-prescription by physicians, over-purchasing (by the patients for self-medication practices), and non-adherence to treatment. Working on these three dimensions by promoting the rationale for prescribing among healthcare professionals, increasing patients' education, clarifying the importance of buying only the prescribed amount of medications, and increasing patients' adherence to their therapy will decrease the number of unused medications in homes and decrease the probability of negative impacts on the patients themselves, the community, and the environment.

5. Implication for practice

Based on our findings, we suggest that decision-makers establish a law to be implemented by the official institutions in Saudi Arabia that allows for the restoration of medications to private and government pharmacies. Guided by clear roles and standards, the pharmacies would then separate the unused medications from the unwanted or expired medications, and transfer the unwanted or expired medications to an institution that will use official and scientifically proven disposal methods. Besides, clear and official instructions on the appropriate way to store medications and the right way to dispose of unwanted or expired home medications should be made available to the public through campaigns, advertisements, and gatherings.

6. Strengths and limitations of the study

This study is among the first few to assess the awareness of the public in the eastern region of Saudi Arabia on the appropriate storage of used medications and the proper disposal of unwanted medications. We explored awareness of the appropriate storage of used medications and the proper disposal of unwanted medications from all classes of medications and did not restrict our study population to specific patient groups, which increases the generalisability of our findings. On the other hand, we were not able to estimate the response rate for our questionnaire study, which might lead to nonresponse bias, as we could not demonstrate how well the sample drawn from the population of interest, therefore, the findings should be interpreted carefully. Furthermore, the study design itself, a cross-sectional survey design, limited our ability to identify causality between study variables.

Table 7
Predictors of different medication storage practices.

Item		Odds ratio of keeping medication in original container (95 %CI)	Odds ratio of writing the expiration date on the new container if changing the original one (95 %CI)	Odds ratio of reading the storing instructions of medications written on the leaflet (95 %CI)	Odds ratio of asking the pharmacist about the storing instructions when buying new medications (95 %CI)	Odds ratio of checking the expiration date before use the medications (95 %CI)	Odds ratio of checking the expiration date of stored medications periodically (95 %CI)
Gender	Female (Reference category)	1.00	1.00	1.00	1.00	1.00	1.00
Age groups	Male	1.60 (0.88–2.93)	0.53 (0.22–1.28)	0.57 (0.41–0.78)***	1.09 (0.72–1.65)	0.66 (0.44–1.00)*	0.43 (0.31–0.59)***
	18–20 years (Reference category)	1.00	1.00	1.00	1.00	1.00	1.00
	21–30 years	1.11 (0.68–1.79)	0.81 (0.41–1.58)	0.69 (0.53–0.91)**	0.48 (0.32–0.71)***	0.81 (0.55–1.18)	0.88 (0.65–1.19)
	31–40 years	2.10 (0.94–4.67)	0.93 (0.38–2.27)	1.78 (1.23–2.57)**	1.86 (1.20–2.89)**	4.93 (2.13–11.43)***	3.43 (2.04–5.77)***
Education level	40 years and more	0.83 (0.42–1.62)	3.56 (1.73–7.33)**	1.39 (0.92–2.10)	3.70 (2.35–5.82)***	22.46 (3.11–162.48)**	2.09 (1.24–3.52)**
	Elementary school level (Reference category)	1.00	1.00	1.00	1.00	1.00	1.00
	Intermediate school level	0.43 (0.17–1.07)	0.65 (0.09–4.91)	0.55 (0.26–1.15)	1.15 (0.47–2.85)	1.04 (0.39–2.74)	0.74 (0.36–1.52)
	High school level	0.84 (0.48–1.46)	1.59 (0.77–3.27)	0.95 (0.68–1.32)	0.97 (0.62–1.53)	0.62 (0.40–0.95)*	0.71 (0.50–1.01)
	Bachelor degree level	1.45 (0.89–2.36)	0.90 (0.45–1.79)	1.01 (0.76–1.36)	1.16 (0.78–1.74)	1.13 (0.76–1.68)	1.32 (0.96–1.80)
	Post-graduate level	2.04 (0.48–8.62)	0.50 (0.07–3.76)	1.70 (0.90–3.20)	0.53 (0.19–1.51)	8.00 (1.09–58.68)*	1.60 (0.75–3.39)
Having children below 6 years old in the house	Diploma	0.26 (0.07–0.99)*	–	0.64 (0.19–2.20)	–	1.86 (0.24–14.67)	1.14 (0.30–4.33)
	No (Reference category)	1.00	1.00	1.00	1.00	1.00	1.00
	Yes	0.72 (0.41–1.25)	1.40 (0.67–2.94)	0.78 (0.56–1.08)	1.20 (0.78–1.85)	1.05 (0.67–1.64)	1.10 (0.77–1.57)

*p < 0.05; ** p < 0.01; *** p < 0.001.

7. Conclusion

This work highlights the lack of proper public awareness regarding the handling of medications, particularly storage and disposal practices in the eastern region of Saudi Arabia. We also suggest that further educational interventions should be directed to the public to promote safe and appropriate handling to maintain the effectiveness of prescribed medications. In this research, we found that the public in Saudi Arabia needs to be made aware of the appropriate way to store medications and the correct way to dispose of unwanted and expired medications.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

This study was supported by the Deanship of Scientific Research (DSR, Grant no. AN00366), King Faisal University, AlAhsa, Saudi Arabia.

References

- Abahussain, E., Waheedi, M., Koshy, S., 2012. Practice, awareness and opinion of pharmacists toward disposal of unwanted medications in Kuwait. *Saudi Pharm J.* 20 (3), 195–201.
- Abou-Auda, H.S., 2003. An economic assessment of the extent of medication use and wastage among families in Saudi Arabia and Arabian Gulf countries. *Clin. Ther.* 25 (4), 1276–1292.
- Agency for Healthcare Research and Quality. 2019. The Pharmacist's Role in Medication Safety. Retrieved June 17, 2021, from <https://psnet.ahrq.gov/primer/pharmacists-role-medication-safety>.
- Al-Shareef, F., El-Asrar, S.A., Al-Bakr, L., Al-Amro, M., Alqahtani, F., Aleanizy, F., Al-Rashood, S., 2016. Investigating the disposal of expired and unused medication in Riyadh, Saudi Arabia: a cross-sectional study. *Int. J. Clin. Pharm.* 38 (4), 822–828.
- Al Ruwaili, N., Al Balushi, A., Alharf, A., Alshaharani, H., Eldali, A., 2014. Do parents in Saudi Arabia store medications safely? *Int. J. Pediatr. Adolescent Med.* 1 (1), 21–25. <https://doi.org/10.1016/j.ijpam.2014.09.003>.
- AlAzmi, A., AlHamdan, H., Abualezz, R., Bahadig, F., Abonofal, N., Osman, M., 2017. Patients' Knowledge and Attitude toward the Disposal of Medications. *J. Pharm. (Cairo)*, 2017, 1–9.
- Alruwaili, N., Alomar, M., Sabei, I., Eldali, A., 2013. Safety of dispensing prescribed iron formulation in childresistant containers among pharmacies in Saudi Arabia: a cross-sectional survey. *Healthcare Low-resource Sett.* 1 (1), 6. <https://doi.org/10.4081/hls.2013.e6>.
- Banwat, S.B., Auta, A., Dayom, D.W., Buba, Z., 2016. Assessment of the storage and disposal of medicines in some homes in Jos north local government area of Plateau State, Nigeria. *Tropical J. Pharmaceut. Res.* 15 (5), 989. <https://doi.org/10.4314/tjpr.v15i5.13>.
- Bashatah, A., Wajid, S., 2020. Knowledge and Disposal Practice of Leftover and Expired Medicine: A Cross-Sectional Study from Nursing and Pharmacy Students' Perspectives. *Int. J. Environ. Res. Public Health.* 17 (6), 2068. <https://doi.org/10.3390/ijerph17062068>.
- Bataduwaarachchi, V.R., Thevarajah, R., Weeraratne, C., 2018. Medication waste disposal practices among patients attending selected out patient departments in a tertiary care institution: a cross sectional survey. *Int. J. Basic Clin. Pharmacol.* 7, 888. <https://doi.org/10.18203/2319-2003.ijbcp20181630>.
- Beirens, T.M.J., van Beeck, E.F., Dekker, R., Brug, J., Raat, H., 2006. Unsafe storage of poisons in homes with toddlers. *Accid Anal Prev.* 38 (4), 772–776.
- Bound, J.P., Voulvoulis, N., 2005. Household disposal of pharmaceuticals as a pathway for aquatic contamination in the United Kingdom. *Environ. Health Perspect.* 113 (12), 1705–1711.
- Crane, M., Watts, C., Boucard, T., 2006. Chronic aquatic environmental risks from exposure to human pharmaceuticals. *Sci. Total Environ.* 367 (1), 23–41.
- De Bolle, L., Mehuys, E., Adriaens, E., Remon, J.-P., Van Bortel, L., Christiaens, T., 2008. Home medication cabinets and self-medication: a source of potential health threats? *Ann. Pharmacother.* 42 (4), 572–579.
- Franklin, R., Rodgers, G., 2008. Unintentional child poisonings treated in United States hospital emergency departments: national estimates of incident cases, population-based poisoning rates, and product involvement. *Pediatrics* 122, 1244–1245.
- Hussain, R., Rashidian, A., Hafeez, A., 2019. A Survey On Household Storage Of Medicines In Punjab, Pakistan. *J. Ayub. Med. Coll. Abbottabad.* 31, 90–97.
- Jafarzadeh, A., Mahboub-Ahari, A., Najafi, M., Yousefi, M., Dalal, K., 2021. Medicine storage, wastage, and associated determinants among urban households: a systematic review and meta-analysis of household surveys. *BMC Public Health.* 21 (1). <https://doi.org/10.1186/s12889-021-11100-4>.
- Khalifeh, M.M., Moore, N.D., Salameh, P.R., 2017. Self-medication misuse in the Middle East: a systematic literature review. *Pharmacol. Res. Perspect.* 5 (4), e00323. <https://doi.org/10.1002/prp2.323>.
- Kiyingi, K., Lauwo, J., 1993. Drugs in the home: danger and waste. *World Health Forum.* 14, 381–384.
- Kozak, M.A., Melton, J.R., Gernant, S.A., Snyder, M.E., 2016. A needs assessment of unused and expired medication disposal practices: A study from the Medication Safety Research Network of Indiana. *Res. Social Adm. Pharm.* 12 (2), 336–340.
- Kusturica, M.P., Sabo, A., Tomic, Z., Horvat, O., Šolak, Z., 2012. Storage and disposal of unused medications: knowledge, behavior, and attitudes among Serbian people. *Int. J. Clin. Pharm.* 34 (4), 604–610.
- Mackridge, A.J., Marriott, J.F., 2007. Returned medicines: waste or a wasted opportunity? *J. Public Health (Oxf).* 29 (3), 258–262.
- Naser, A.Y., Amara, N., Dagash, A., Naddaf, A., 2021. Medications disposal and medications storage in Jordan: A cross-sectional study. *Int. J. Clin. Pract.* 75, 1–8.
- Pankajkumar, P.D., Chacko, S., Prakashkumar, B.S., 2016. Storage and Disposal of Medicines In Home Among Students. *J. Pharm. Res.* 10, 343–350.
- Paudel, E., Choi, E., Shrestha, N., 2019. Pharmaceutical waste management in private pharmacies of Kaski District, Nepal. *Int. J. Innovative Sci. Res. Technol.* 4, 2456–12165.
- Persson, M., Sabelström, E., Gunnarsson, B.o., 2009. Handling of unused prescription drugs—knowledge, behaviour and attitude among Swedish people. *Environ. Int.* 35 (5), 771–774.
- Quadra, G.R., Silva, P.S.A., Paranaíba, J.R., Josué, I.L.P., Souza, H., Costa, R., Fernandez, M., Vilas-Boas, J., Roland, F., 2019. Investigation of medicines consumption and disposal in Brazil: A study case in a developing country. *Sci. Total Environ.* 671, 505–509. <https://doi.org/10.1016/j.scitotenv.2019.03.334>.
- Ristić, G., Đorđević, A., Hristov, S., 2016. A regional model for household pharmaceutical waste management. *Proc. Inst. Civil Eng. - Waste Resource Manage.* 169 (4), 191–199.
- U.S Food and Drug Administration. 2020. Disposal of Unused Medicines: What You Should Know. Retrieved May 29, 2021, from <https://www.fda.gov/drugs/safe-disposal-medicines/disposal-unused-medicines-what-you-should-know>.
- U.S Food and Drug Administration. 2020. Drug Disposal: FDA's Flush List for Certain Medicines. Retrieved May 29, 2021, from <https://www.fda.gov/drugs/disposal-unused-medicines-what-you-should-know/drug-disposal-fdas-flush-list-certain-medicines>.
- World Health Organization, 2011. Promoting rational use of medicines, WHO Regional Office for South-East Asia.
- Zemann, M., Wolf, L., Pöschko, A., Schmidt, N., Sawarieh, A., Seder, N., Tiehm, A., Hötzel, H., Goldscheider, N., 2014. Sources and processes affecting the spatio-temporal distribution of pharmaceuticals and X-ray contrast media in the water resources of the Lower Jordan Valley, Jordan. *Sci. Total Environ.* 488–489, 100–114.