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ORIGINAL RESEARCH

Disposal Practices of Leftover Medicines Among University of Rwanda Undergraduate Students

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Background: University students typically use prescribed or non-prescribed medications, often resulting in the accumulation of leftover medications. Hence, understanding their disposal practices is crucial, as improper disposal contribute to significant public health and environmental risks.

Objective: This study intended to assess the disposal practices of leftover medications among undergraduate students at the University of Rwanda, as well as the factors influencing these practices.

Methods: The participants were randomly selected for this cross-sectional study. Data were collected using a self-administered questionnaire, and responses were entered into Microsoft Excel for cleaning. The cleaned data were imported into the Statistical Package for Social Sciences (SPSS) version 25.0 for analysis. Using SPSS, Inferential statistics, notably Pearson's chi-square test, was used to determine variables associated with the disposal practices, with a p-value <0.05 considered significant.

Results: Out of 378 students, 66.1% had leftover medications, with 21.2% keeping them for future use. Just 7.1% returned them to pharmacies, while 92.9% resorted to improper disposal practices, with the main methods being discarding them in the toilet (36.3%) and household rubbish (24.6%). Key reasons cited by 81.2% were that neither a drug take-back system was introduced on campus nor were disposal procedures communicated. Gender (x^2=9.735, p-value=0.046), level of study (x^2=8.331, p-value<001), and college (x^2=9.735, p-value=0.046),and lack of training (x^2=35.66, p-value<001), and lack of understanding about a drug take-back system (x^2=36.72, p-value<001) were significantly associated with improper disposal practices.

Conclusion: Leftover medications and improper disposal practices were prevalent, mostly caused by lack of awareness about proper disposal practices. This underscores the need to raise public awareness.

Keywords: unused medications, improper disposal, undergraduate, therapy

Background

Medications are an essential component of the healthcare system, serving a critical role in the diagnosis, treatment, prevention, and management of physiological and health conditions.[1–3] However, their overuse, underuse or misuse results in wastage of resources and spread of health hazards.[4] Despite that, more than half of medications are prescribed, dispensed or sold inappropriately, and half of patients fail to take them correctly.[4] This highlights that not all patients use medications as intended, often resulting in leftover medications. In the current study, leftover medications are defined as pharmaceuticals that were stopped to be consumed by the intended users at the time of data collection. This aligns with the World Health Organization (WHO)'s definition of pharmaceutical waste, which encompasses expired, unused, and contaminated drugs and vaccines.[5–7] The accumulation of leftover medications has grown due to increased global use, along with various initiatives aimed at improving medications availability and public access.[8] However, this rise in leftover medications poses risks to public health, including suicide, as well as to the environment by contaminating water supplies.[2,9–11]

Scholars found that prescriptions may accumulate leftover medications because patients are afraid to throw them away.[12,13] Moreover, self-medication, which poses a significant public health threat worldwide, has also been shown to be promoted by the accumulation of leftover medications among individuals and household.[10,11,14] Thus, the WHO

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recommends that any leftover medications should never be reused and must always be treated as pharmaceutical waste.[15–17] Otherwise, improper disposal practices of leftover medications, such as discarding them via garbage, sinks, or toilets, disrupt the ecosystem's balance.[13,18,19] Factors such as change of treatment, side effects, improvement of the patient's condition, patient non-adherence, poor prescribing, dispensing and manufacturers' promotional practices contribute to the accumulation of leftover medications.[1,9,17] Patients' uncertainty about the necessity of medications, along with the damage caused by improper storage, further contribute to the accumulation of leftover medications at the individual or household level.[1,9] Thus, reducing the environmental impact of pharmaceuticals is crucial to protect public health and ecology.[20]

However, in low- and middle-income countries (LMICs) where infrastructure and understanding are often limited, improper disposal practices of leftover medications still occur.[12,18,21–23] Common disposal method in Ethiopia and Uganda was found to be household garbage,[24–26] while in Nigeria it was discarding them in domestic dustbins.[27] Studies demonstrated some variables related to accumulating leftover medications.[12,13,22,28] In Ethiopia, higher household income and the use of non-prescription medications were associated with accumulating leftover medications, while in upper middle-income countries like Malaysia, it was correlated with age, and educational level.[26,29] The absence of drug take-back programs, insufficient policies, and lack of knowledge about safe disposal methods contribute to the improper disposal of leftover medications in LMICs.[19,22,30] Thus, public awareness is required to combat improper disposal to lower dangers and safeguard the environment.[2,19]

In Rwanda, a country that strives to become a leading destination for health tourism,[31] proper disposal practices are essential to protect both the environment and the public. This is particularly important as Rwanda stands among the cleanest cities in Africa.[32] Moreover, Rwanda Food and Drugs Authority, having achieved WHO Maturity level Three,[33] it is urged to ensure that policies regulating management of leftover medications are widely established, disseminated, understood, and acknowledged by the public. Regrettably, no studies have been conducted in Rwanda on disposal practices among Rwandans, including university students, despite their previously identified involvement in self-medication,[34] and their improved knowledge on seeking medical care.[35,36] To address this gap, particularly by focusing on one of the key populations that holds the future of the nation and can help educate the rest, this study aimed to assess the disposal practices of leftover medications among undergraduate students at the University of Rwanda, as well as factors influencing these practices.

In a densely populated country like Rwanda,[37,38] this study is important, aligning with two United Nations Sustainable Development Goals: SDG3 (Good Health and Well-Being), and SDG13 (Climate Action).[39] By shedding light on the issues of improper disposal practices that often lead to pharmaceutical pollution, this study supports SDG3 improving public health and aligns with SDG13 protecting the environment. The findings of this study will help address a key gap knowledge on disposal practices among Rwandan university students and provide insights to inform relevant authorities. The findings will also assist policymakers in designing initiatives to protect universities from the harmful effect of pharmaceutical pollution. By mitigating pharmaceutical pollution, this will not only improve students' health and academic goals but also enhance the university's international reputation in promoting a clean, healthy environment that supports students' mental and physical well-being.

Methods and Materials

Study Aim, Design and Setting

This study aimed to assess methods employed by undergraduate students at the University of Rwanda (UR) to dispose leftover medications and evaluated their level of awareness about proper disposal practices, as well as associated factors. Using a self-administered questionnaire, a descriptive cross-sectional study was conducted between November 1, 2022, and April 20, 2023. One of UR's campuses, notably, Huye campus was selected because it hosts a larger proportion of UR students compared to any other campuses.[40] UR is the only public university in Rwanda, with seven Colleges, among which, five—namely the College of Medicine and Health Sciences (CMHS), College of Science and Technology (CST), College of Veterinary Medicine and Animal Sciences (CAVM), College of Business and Economics (CBE) and College of Arts and Social Sciences (CASS)—have students pursuing their studies from Huye Campus. This underscores justification for its selection, given the wide range of student demographics and extensive academic representation. Huye campus is in the southern province of Rwanda, specifically in Huye district. This district is viewed as the country's centre of knowledge and culture, hosting numerous academic activities. In

addition to housing UR's largest campus, it is a home to the university's teaching hospital (CHUB), which hosts several healthcare students for their internships.

Study Population and Sample Size Calculation

The list of enrolled students for the 2022–2023 academic year, during which the study was conducted, was obtained from the University of Rwanda Students Union (URSU). With students from the first to the fifth academic years, the list indicated that there were 6723 registered students. From this number, the sample size was determined using Yamane's formula $nY = N/(1+(N*e^2))$[41], which considers the population size (N), desired margin of error (e = 0.05) at a 95% confidence interval, and sample size (nY). This resulted in a sample size of 378 students. To achieve this sample size, simple random sampling was used. The inclusion criteria to participate in this study were students had to be enrolled in an undergraduate program, registered for the 2022–2023 academic year, attending class at Huye campus and demonstrate a will to participate. The exclusion criteria were the opposite of these conditions.

Data Collection Process, and Data Collection Instrument

The questionnaire was semi-structured, consisting of closed-ended questions, and was designed using Google form. It comprised three sections: sociodemographic information, such as college, gender, age, education level, marital status, and housing, an evaluation of students' knowledge and awareness regarding disposal protocols of leftover medications, and disposal methods of leftover medications. To guarantee comprehension by all students, the questionnaire was written in English, the language used for academic purposes. The questionnaire was designed for a single submission, ensuring each participant completed the survey once, thereby reducing the risk of response bias. To choose participant at random, a link to google form containing the description of the study, and an option for consenting to participate was shared with the students' representatives of each undergraduate department, who then distributed it to their fellow students via WhatsApp groups. To facilitate participants in demonstrating their willingness to participate, the google form was designed to categorize responses into two major categories: those who accepted to participate and those that did not. Once the calculated sample size was reached from the responses of participants who agreed to participate, the google form link was disabled to prevent further submissions. In addition to those who agreed to participate, ten students declined, citing reasons like lack of time, interest, compensation, and unwilling to disclose information.

Validity and Reliability of the Study Tool

Prior to data collection, data collection tool was pretested on seventeen university students from the Huye campus. Each sub-component was considered consistent if it achieved a Cronbach's Alpha greater than 0.6. During these piloting phase, two questions were revised for better understanding, and one removed. Thereafter, the data collection tool showed good internal consistency, with Cronbach's Alpha (α)=0.87.

Data Analysis

After being cleaned in Microsoft Excel, data were imported into the Statistical Package for the Social Sciences (SPSS) version 25.0 for statistical analysis. Descriptive statistics were computed for each variable, and results were presented in frequencies and percentages. To conduct inferential statistics, a Pearson's chi-square test was conducted to determine whether there was a significant relationship between students' characteristics and their practices for disposing leftover medications. The results were tabulated, and a p-value of less than 0.05 was employed as the benchmark for statistical significance. For the purpose of this study, disposal practices such as discarding leftover medications down the toilet, in the rubbish, down the sink, or anywhere around the campus were classified as improper disposal methods, whereas returning them to a pharmacy was considered a proper disposal practice.

Results

Socio-Demographic Characteristics of Respondents (n=378)

Of the 378 participants, 57.1% (n = 216) were male and 42.9% (n = 162) were female. Up to 71.7% (n = 271) resided on campus. Most of the participants were single, accounting for 98.1% (n = 371). CMHS and CBE exhibited the highest

representation with 48.9% (n = 185) and 18.8% (n = 71), respectively. The distribution of academic years was 19.3% (n = 73) in year one, 28.6% (n = 108) in year two, 31.2% (n = 118) in year three, 8.5% (n = 32) in year four, and 12.4% (n = 47) in year five. Most participants fell within the 20–25 age group, comprising 78% (n = 295) (Table 1).

Methods Used to Dispose Leftover Medications (n=378)

While only 7.1% (n=27) reported returning leftover medications to the pharmacies for proper disposal, the improper disposal practices stood at 92.9%, which were as follow: 36.3% (n=137) of participants disposed of their leftover medications by flushing

Table 1 Socio-Demographic Characteristics of Respondents (n=378)

Characteristic	Frequency (N)	Percentage (%)
College		
CMHS	185	48.9
CAVM	26	6.9
CBE	71	18.8
CASS	66	17.5
CST	30	7.9
Gender		
Male	216	57.1
Female	162	42.9
Age (in Years)		
15–20	17	4.5
20–25	295	78
25–35	66	17.5
Marital Status		
Single	371	98.1
Married	7	1.9
Year of study		
Year 1	73	19.3
Year 2	108	28.6
Year 3	118	31.2
Year 4	32	8.5
Year 5	47	12.4
Accommodation		
On campus	271	71.7
Off campus	107	28.3
TOTAL	378	100

Abbreviations: CMHS, College of Medicine and Health Sciences; CAVM, College of Agriculture and Veterinary Medicine; CBE, College of Business and Economics; CASS, College of Arts and Social Sciences; CST, College of Sciences and Technology.

them down the toilet, 24.6% (n=93) disposed of their leftover medications in household rubbish, 16.1% (n=61) disposed of their leftover medications anywhere in the campus, and 15.9% (n=60) discarded them in the sink within the university (Table 2).

Knowledge and Awareness About Leftover Medications (n=378)

The participants provided potential answers regarding their knowledge and awareness of the disposal practices of leftover medications. When asked whether they have any leftover medications in their hostels, 66.1% (n=250) reported having them, suggesting widespread use of leftover medications among undergraduate students. When medications are prescribed, mostly, 84.9% (n=321) collect them, indicating a high adherence to obtaining prescribed medications. Moreover, 56.6% (n=214) collect repeat medications, which could point to issues with adherence. Only 52.4% (n=198) reported they finish consuming all prescribed medications, leaving 47.6% (n=180) who do not, indicating the risk of incomplete medication usage and presence of leftover medications. Additionally, 37.3% (n=141) decided by themselves not to use some of the prescribed medications, suggesting some level of self-regulation or doubt about the necessity of certain medications. Moreover, 38.1% (n=144) discard therapy, reflecting the level of leftover medications among students. Most respondents, 81.2% (n=308) indicated the absence of clear procedures for disposing leftover medications. While only 32% (n=121) were aware of the effects of improper disposal, which could indicate gaps in education on environmental and health impacts, only 14.8% (n=56) had received training on medical waste management, pointing to a need for improved educational programs (Table 3).

Table 2 The Methods of Disposing Leftover Medications by Undergraduate Students (n=378)

Methods of Disposing Leftover Medications	Frequency	Percentages (%)
Down the toilet	137	36.3
Within household rubbish	93	24.6
Anywhere in the campus	61	16.1
Down the sink	60	15.9
Return to pharmacy	27	7.1
Total	**378**	**100**

Table 3 Knowledge and Awareness of Undergraduate Students About Leftover Medication Disposal Practice (n = 378)

Variable	Category	Frequency	%
When you get a prescription from a doctor, do you collect all prescribed medications?	Yes	321	84.9
	No	57	15.1
Do you decide that you do not need some prescribed medication?	Yes	141	37.3
	No	237	62.7
Do you collect repeat prescription medication?	Yes	214	56.6
	No	164	43.4
Do you discard any therapy?	Yes	144	38.1
	No	234	61.9
Do you use all dispensed medication?	Yes	198	52.4
	No	180	47.6

(*Continued*)

Table 3 (Continued).

Variable	Category	Frequency	%
Do you have leftover medication in your hostel at present?	Yes	250	66.1
	No	128	33.9
Do you know about medical waste management?	Yes	142	37.7
	No	236	62.3
Do you know about the drug take-back system?	Yes	90	23.8
	No	288	76.2
Have you ever followed the drug take-back system?	Yes	115	30.4
	No	263	69.6
Are you aware of the effects of improper disposal?	Yes	121	32
	No	257	68
Do you get any training about medical waste management on campus?	Yes	56	14.8
	No	322	85.2
Are there clear procedures to handle leftover medication?	Yes	70	18.5
	No	308	81.5
Is there a drug take-back system?	Yes	71	18.8
	No	307	81.2
Is the leftover medication disposal practice correct in your campus?	Yes	71	18.8
	No	307	81.2

Reasons for Keeping Leftover Medications (n=378)

In this study, respondents cited various reasons for not using prescribed medications. The most common reason cited for retaining leftover mediations was for potential self-medication in the future, 21.2% (n=80). This was followed by 14.8% (n=56) who stopped using medications once their medical conditions improved, 12.2% (n=46) switched to another treatment, 10.6% (n=40) experienced side effects from the medications, 8.2% (n=31) reported an oversupply of medications by healthcare providers, 7.9% (n=30) were unsure how to dispose of medications, 6.9% (n=26) wanted to maintain a stock in case of shortage, 5.3% (n=20) lacked an understanding why their medications was prescribed, 5.4% (n=20) had medications that had passed their expiry date, 3.7% (n=14) intended to give the medication away, and 3.8% (n=15) lacked clarity in how medications should be used (Table 4).

Association Between Characteristics of Respondent and Medication Disposal Practices

Chi-square analysis revealed several factors that were significantly associated with medication disposal practices at the University of Rwanda. Specifically, year of study (X^2 = 8.331, p<001), collection of repeated prescribed medications (x^2 = 3.175, p<001), discarding therapy (X^2 = 28.35, p=0.043), using prescribed medications (X^2 = 32.92, p<001), knowledge about medical waste management (X^2 = 281.3, p=0.02), knowledge about drug take back system (X^2 = 36.72, p<001), awareness about effects of improper leftover medication disposal (X^2 = 280.2, p<001), and training about medical waste management (X^2 = 35.66, p<001), were found to be statistically significantly associated with leftover medication disposal practices at the university of Rwanda (Table 5)

Table 4 Reasons for Keeping Leftover Medications (N=378)

Variable	Frequency	Percentage
Not know how to dispose of them	30	7.9
To give them away	14	3.7
To keep a stock in case of shortage	26	6.9
To keep them for future self-medication	80	21.2
Change to another treatment	46	12.2
Excess quantity supplied	31	8.2
Medical condition improved	56	14.8
Passed expiry date	20	5.4
Side effects of medication	40	10.6
Unclear instructions	15	3.8
Unsure why medication was prescribed	20	5.3

Table 5 Association Between Characteristics of Respondents and Improper Disposal Practices

Variables	Improper Disposal of Leftover Medicines						
College of Participants	**Flushed Down the Toilet**	**Disposed of in the Sink**	**Thrown Away in Household Trash**	**Anywhere in Campus**	**Total**	**x^2**	**p-value**
CMHS	137 (36.2%)	48 (12.7%)	0	0	185 (48.9%)	9.735	0.046*
CAVM	0	12 (3.2%)	14 (3.7%)	0	26 (6.9)		
CASS	0	0	66 (17.5%)	0	66 (17.5%)		
CBE	0	0	13 (3.4%)	31 (8.2%)	44 (11.6%)		
CST	0	0	0	30 (7.9%)	30 (7.9%)		
Gender							
Male	73 (19.30%)	27 (7.10%)	56 (14.80%)	4 0(10.60%)	196 (51.8%)	9.735	0.046*
Female	64 (16.90%)	33 (8.70%)	37 (9.80%)	21 (5.60%)	155 (41%)		
Age in Years							
15–20	7 (1.90%)	1 (0.30%)	4 (1.10%)	2 (0.50%)	14 (3.8%)	8.668	0.735
20–25	106 (28.00%)	55 (14.60%)	77 (20.40%)	49 (13.00%)	287 (76%)		
25–35	24 (6.40%)	4 (1.10%)	12 (3.20%)	10 (2.60%)	50 (13.30%)		
Marital status							
Single	134 (35.40%)	60 (15.90%)	91 (24.10%)	59 (15.60%)	344 (91%)	2.457	0.704
Married	3 (0.80%)	0	2 (0.50%)	2 (0.50%)	7 (1.8%)		

(*Continued*)

Table 5 (Continued).

Variables	Improper Disposal of Leftover Medicines						
College of Participants	**Flushed Down the Toilet**	**Disposed of in the Sink**	**Thrown Away in Household Trash**	**Anywhere in Campus**	**Total**	**x^2**	**p-value**
Year of study of participant							
Year 1	73 (19.30%)	0	0	0	73 (19.3%)	8.331	<001**
Year 2	64 (16.90%)	44 (11.60%)	0	0	108 (28.6%)		
Year 3	0	16 (4.20%)	93 (24.60%)	0	109 (29%)		
Year 4	0	0	0	14 (3.70%)	14 (3.7%)		
Year 5	0	0	0	47 (12.40%)	47 (12.4%)		
Do you collect all prescribed medicines?							
Yes	117 (31.00%)	53 (14.00%)	81 (21.40%)	47 (12.40%)	298 (78.8%)	3.867	0.429
No	20 (5.30%)	7 (1.90%)	12 (3.20%)	14 (3.70%)	53 (14%)		
Do you collect repeated prescription medicines?							
Yes	0	33 (8.70%)	93 (24.60%)	61 (16.10%)	187 (49.5%)	3.175	<001**
No	137 (36.20%)	27 (7.10%)	0	0	164 (43.3%)		
Did you discard any therapy?							
Yes	0	0	56 (14.80%)	61 (16.10%)	117 (30.9%)	28.35	0.043*
No	137 (36.20%)	60 (15.90%)	37 (9.80%)	0	234 (61.9%)		
Did you use all dispensed medicines?							
Yes	0	17 (4.50%)	93 (24.60%)	61 (16.10%)	171 (45.2%)	32.92	<001**
No	137 (36.20%)	43 (11.40%)	0	0	180 (47.6%)		
Do you know about medical waste management?							
Yes	0	0	55 (14.60%)	60 (15.90%)	115 (30.4%)	281.3	0.02**
No	137 (36.30%)	60 (15.90%)	38 (10.10%)	0	235 (62.2%)		
Do you know about the drug take back system?							
Yes	0	0	2 (0.50%)	61 (16.10%)	63 (16.7%)	36.72	<001**
No	137 (36.20%)	60 (15.90%)	91 (24.10%)	0	288 (76.1%)		
Are you aware about the effects of improper disposal practice of leftover medicines?							
Yes	0	0	33 (8.70%)	61 (16.10%)	94 (24.9%)	280.2	<001**
No	137 (36.20%)	60 (15.90%)	60 (15.90%)	0	257 (68%)		

(*Continued*)

Table 5 (Continued).

Variables	Improper Disposal of Leftover Medicines						
College of Participants	**Flushed Down the Toilet**	**Disposed of in the Sink**	**Thrown Away in Household Trash**	**Anywhere in Campus**	**Total**	**x^2**	**p-value**
Did you get any training about medical waste management on campus?							
Yes	0	0	0	55 (14.60%)	55 (14.6%)	35.66	<001**
No	141 (37.30%)	61 (16.20%)	94 (25.10%)	0	296 (78.3%)		

Notes: x^2: Pearson Chi-square value; *: Statistical significance level at $p < 0.05$,**: Statistical significance level at p<001.

Discussion

This study highlighted the extent of leftover medications among undergraduate students at the University of Rwanda, their practices for disposing of these medications, their awareness of proper disposal methods, and the factors associated with their disposal practices. The results revealed that 66.1% of the students stored leftover medications. This is a high prevalence when compared to similar study in the region, where a study in Uganda found that 49.8% of participants kept unused medications.[25] Though countries have different economic status, the prevalence from the current study is low compared to similar studies conducted in Turkey and Malaysia, which found that 93.3% and 84%, respectively, kept unused medications.[42] However, our finding is close to studies conducted in Bangladesh and Baghdad which found that 65.5% and 66.3% of participants respectively kept leftover medications.[43,44] This comparison with countries across various income levels highlights the need for Rwanda to address the issue of leftover medications as it is a problem that affects the nations regardless of their economic status. Therefore, raising awareness about minimizing the accumulation of leftover medications, along with campaigns promoting rational medicine use is crucial among university students in Rwanda.

However, the current study raises concerns, as 21.2% of students reported keeping leftover medications for future use. This is like in Ethiopia, where 26% of people kept leftover medications for future use.[45] Excluding those who might be on chronic treatments, the current findings implicate that self-medication is still practiced, as previously identified at the University of Rwanda.[34] This raises significant concerns, as self-medication can lead to serious health issues including misdiagnosis, potential drug interactions, and increased complications, all of which may result in adverse drug reactions.[46,47] Education to prescribers and healthcare students, who are future prescribers, is crucial in addressing this issue, as self-medication is often promoted by inappropriate prescribing practices.[4,48] However, students-led awareness campaigns, especially those in healthcare programs, who have a better understanding of the issue, are highly encouraged, as attested by other studies.[49,50] This study found more other reasons for keeping medications, which included factors like medical condition improvement (14.9%) and changing to another treatment (12.3%). Similar factors for having leftover medications were observed in Ethiopia,[26,51] and Thailand.[52] All these factors are common behaviours exhibited by individuals included in self-medication practices, as highlighted in various studies,[53–55] necessitating measures.

Alarmingly, only 7.1% of students in the current study returned leftover medications to pharmacies, while the majority (92.9%) engaged in improper disposal methods, with the most common being flushing leftover medications down the toilet and discarding them in household rubbish. Compared to our current study, some studies have reported a lower percentage of people returning leftover medications. For instance, in Ethiopia, 0.1% of people returned unused medications to healthcare facilities.[26] A lower percentage of people in Zambia (4.42%)[56] and Thailand (2%)[57] also returned leftover medications. This suggests that although practices in Rwanda are also low, it could serve as a basis for proposing improvements. Rwanda can improve, as Malaysia reported a higher return rate (27%), despite income level differences between these two countries.[58] Regarding disposal methods, in Uganda, Ethiopia, Zambia and Nigeria, the most common disposal methods were also discarding medications in the household garbage, and flushing them down the

toilet.[25,45,57] Although outside Africa, the current findings also align with those from Saudi Arabia,[53] USA,[53] and the Netherlands,[12] which showed varying disposal practices like those in our study. These improper disposal practices are alarming as they pose a serious threat to the public health and environment.[2,9–11] Therefore, universities are encouraged to raise awareness about cleanliness including the importance of separating medications from other waste. They could also promote the in-campus collection of leftover medications at designated collection points. These could then be safely incinerated, preventing potential public health threat and environmental harm.

Our study revealed that respondents primarily disposed of leftover medications improperly due to lack of awareness in several areas. Specifically, insufficient knowledge about medical waste management, unaware of drug take-back initiatives, lack of understanding of the effects of improper disposal, and lack of training related to these topics. These results align with findings from other regions, particularly in Kenya, South Africa, Swaziland, and Mozambique, where incorrect disposal of leftover medication was attributed to insufficient knowledge, awareness, and the absence of effective strategies.[13,20,53,59–61] Related to our findings, in Nigeria, healthcare university students have reported a lack of training and awareness regarding safe disposal of medications. [60] Like our findings, majority of participants in Indonesia, Saudi-Arabia and Baghdad had not received training on how to dispose unused medications, thus they lacked awareness on proper disposal practices.[44,62,63] Contrary to our study, some studies revealed that participants had adequate knowledge regarding the disposal of unused pharmaceuticals,[30,56] and people were knowledgeable about managing leftovers.[64] This presents a significant challenge as the US Food and Drug Administration (FDA) recommends drug take-back programs for safe medication disposal.[59] Such programs promote proper disposal, reduce drug abuse and misuse, enhance public awareness, and ensure regulatory compliance through law enforcement agencies.[13] Hence, this indicates the need for further education in Rwanda.

Several factors were significantly associated with medication disposal practices in the current study. Colleges those students belonged to, their gender, and level of study were significantly associated with disposal practices. Same as our study, in Ethiopia and Uganda, year of study was associated with knowledge of disposal practices.[25,45] Education level was associated with awareness of proper disposal practices in Indonesia,[63] same as in Baghdad.[44] Though gender was not associated with disposal practices, level of education was found to have a similar influence, as reported in a study conducted in Thailand.[56] In Malaysia, people with higher education level were found to have a greater proportion of unused medications.[58] Similarly, in Gondar city, age was identified as a factor associated with having leftover medications.[10] Collection of repeated prescribed medications revealed that keeping leftover medications was significantly statistically associated with "self-discontinuation" after illness recovery, before the prescribed period.[43] Our study showed that lack of knowledge about leftover medication management among undergraduate students was statistically significantly associated with keeping unused medications at home. These results are in line with the findings of a study conducted in Bangladesh, where this issue was prominent among undergraduate students.[43] During our study, most of the students said that there was no drug take-back system at the campus; hence, this absence was statistically significantly associated with the presence of leftover medication among the students. This study conformed to the one conducted in Bangladesh, where 87.2% of the respondents confirmed the absence of drug take-back programs at their university, resulting in 34% threw leftover medications in the dustbin and 22% flushed them down the toilet.[43]

Conclusion

This study revealed a high prevalence of leftover medications among undergraduate students at the University of Rwanda, with various reasons for retaining them, including future use, improvement in their medical condition, transitioning to another treatment and reported side effects among many others. The majority were found to have poor knowledge about the proper disposal of leftover medications, leading to improper disposal practices like discarding them in the toilet, household rubbish, or indiscriminately around the campus. The reasons behind improper disposal practices included a lack of training, the absence of an established drug take-back system, and unclear procedures for proper medication disposal. Their disposal practices were associated with factors like age, and education level, highlighting the need for educational initiatives to promote proper medication disposal practices. Collaboration between the government, Ministry of Health policymakers, University of Rwanda, and its students is also essential to improve leftover medication disposal practices and mitigate the negative effects of improper disposal. Urgent action, including development and dissemination of policies for proper disposal, are also crucial. Strengthening the drug take-back system, establishing

collection points and promoting public awareness of the environmental and health impacts of improper disposal are also crucial steps to address this issue.

Study Strengths and Limitations

This study, being the first of this kind in Rwanda, offers several strengths. It serves as a foundational baseline for crafting relevant policies and provides a framework for designing future research initiatives. However, it presented various limitations such as insufficient literature on leftover medication disposal practices in Rwanda. Moreover, this study was conducted among undergraduate students from a public university, thus future studies should include private university students to address this limitation and provide a more comprehensive understanding. Another important limitation is that the study was unable to verify with participants or physically examine the leftover medications they reported having. Therefore, future studies should focus on collecting and quantifying these leftover medications.

Abbreviations

CASS, College of Arts and Social Sciences; CAVM, College of Agriculture and Veterinary Medicines; CBE, College of Business and Economics; CMHS, College of Medicine and Health Sciences; CST, College of Sciences and Technology; FDA, Food and Drug Authority; MOH, Ministry of Health; NGO, Non-Government Organization; OTC, Over-The-Counter; UR, University of Rwanda; WHO, World Health Organization.

Data Sharing Statement

All relevant data have been included in this manuscript. A dataset may be shared upon a reasonable request provided to the corresponding author.

Ethics Approval and Consent to Participate

The Ethical Clearance was requested and obtained from the Institutional Review Board, College of Medicine, and Health Sciences (IRB/CMHS) at the University of Rwanda with reference number CMHS/IRB/016/2023. The participants voluntarily gave their informed consent after being explained about the study's protocols, privacy policies, and data security measures. All procedures related to this study were conducted in accordance with the Helsinki Declaration of 1975.

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Author Contributions

All authors made a significant contribution to the work reported, whether in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas, took part in drafting, revising, or critically reviewing the article, gave final approval of the version to be published, agreed on the journal to which the article has been submitted, and agreed to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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