

ASSESSMENT OF KNOWLEDGE, ATTITUDES AND PRACTICES TOWARD PHARMACEUTICAL WASTE DISPOSAL AMONG PHARMACISTS IN KIGALI COMMUNITY PHARMACIES

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Abstract: Background: Pharmaceutical waste disposal is a growing environmental and public health concern, particularly in community pharmacy settings where inappropriate disposal can lead to contamination and adverse health outcomes.

Objective: This study aimed to assess the knowledge, attitudes, practices and perceived barriers regarding pharmaceutical waste disposal among pharmacists in community pharmacies across Kigali, Rwanda.

Methods: A cross-sectional study design was employed, incorporating both quantitative and qualitative data collection. Pharmacists were surveyed to evaluate their awareness of existing pharmaceutical waste regulations, personal attitudes toward proper disposal, and the challenges they face in implementation. Additional factors such as infrastructure, cultural beliefs, and knowledge of environmental risks were also examined. Data were analyzed using descriptive and inferential statistical methods to identify significant trends and associations.

Results: The study revealed that while 83.9% of pharmacists demonstrated moderate to high knowledge and 77.0% held positive attitudes toward pharmaceutical waste disposal, only 13.8% practiced at a high level, with 21.3% showing poor practices. Key barriers included insufficient disposal infrastructure, limited training, and lack of clear regulatory guidelines. Chi-square tests showed no statistically significant associations between practice levels and variables such as knowledge ($\chi^2(2) = 0.407$, $p = 0.816$), attitude ($\chi^2(2) = 4.302$, $p = 0.116$), age ($\chi^2(3) = 1.240$, $p = 0.743$), gender ($\chi^2(1) = 0.003$, $p = 0.958$), education ($\chi^2(2) = 4.185$, $p = 0.123$), experience ($\chi^2(3) = 0.508$, $p = 0.917$), pharmacy location ($\chi^2(3) = 5.113$, $p = 0.164$), or weekly working hours ($\chi^2(2) = 4.141$, $p = 0.126$). These results suggest that while some trends are apparent, knowledge and attitude alone are not sufficient predictors of proper practice. External or systemic factors, such as organizational support, operational resources, and regulatory enforcement, may be more critical in influencing behavior. Therefore, multifaceted interventions are needed to bridge the gap between knowledge and practice in pharmaceutical waste management.

Conclusion: The findings highlight a disconnect between knowledge and practice, largely influenced by infrastructural and policy-related barriers. There is a critical need for enhanced waste disposal infrastructure, clear and enforceable guidelines, and continuous professional education to improve compliance. These results offer practical recommendations for policymakers, regulatory agencies, and pharmacy management to strengthen pharmaceutical waste management systems and protect both public health and the environment in Rwanda.

Keywords: (MeSH): Pharmaceutical waste disposal, Community pharmacies, Pharmacists, Knowledge, Attitudes, and Practices.

1. INTRODUCTION

Pharmaceutical waste including expired, unused, or contaminated medications and their packaging—poses a significant and growing environmental and public health challenge globally. Improper disposal practices such as flushing drugs into sewage systems, open dumping, and uncontrolled incineration contribute to water and soil pollution, disruption of ecosystems, and

the proliferation of antimicrobial resistance (AMR) (World Health Organization [WHO], 2022; Gharpure et al., 2023). While the WHO has emphasized the importance of safe pharmaceutical waste management, implementation remains inconsistent, particularly in low- and middle-income countries (LMICs), where regulatory systems, infrastructure, and professional training are often lacking (Alam et al., 2023).

In sub-Saharan Africa (SSA), these challenges are compounded by rapid urbanization, inadequate waste management systems, and limited awareness among healthcare providers. Studies in Nigeria and Kenya reveal that a majority of pharmacists lack awareness of proper waste disposal protocols, resulting in hazardous practices such as open dumping and unregulated incineration (Njenga et al., 2023; Olawale et al., 2022). In contrast, South Africa has demonstrated better compliance due to more robust regulatory frameworks and enforcement mechanisms. These regional disparities highlight the urgent need for context-specific interventions, particularly among pharmacists who are central to the medication lifecycle and its safe disposal.

In Rwanda, notable progress has been made in environmental sustainability—evidenced by policies such as the ban on single-use plastics—yet pharmaceutical waste management remains a relatively neglected issue (Rwanda Environment Management Authority [REMA], 2023). Regulatory bodies like REMA and the Ministry of Health (MOH) have issued guidelines, but enforcement and infrastructure are limited. Many community pharmacies, especially in Kigali, operate without adequate storage, segregation systems, or access to authorized disposal facilities (Habimana et al., 2023). According to the Rwanda Biomedical Centre (RBC, 2023), fewer than 50% of community pharmacists in Kigali have received formal training in pharmaceutical waste management. Additionally, barriers such as limited awareness of guidelines, financial constraints, and negative attitudes toward compliance further hinder adherence (Alam et al., 2023; Patel et al., 2022).

Given their role as primary medication dispensers, community pharmacists are essential to ensuring the safe handling and disposal of pharmaceutical waste. However, little empirical data exists on their knowledge, attitudes, and perceived barriers to proper disposal in Kigali. This knowledge gap limits the ability of policymakers to develop effective interventions and regulatory strategies. This study aims to assess the knowledge, attitudes, and barriers to pharmaceutical waste disposal among community pharmacists in Kigali. Findings will support the design of evidence-based training programs, enhanced policy frameworks, and infrastructure improvements, contributing to Rwanda's broader environmental health and AMR mitigation goals.

2. RESEARCH METHODS

Study Design

This study adopted a cross-sectional design to examine the knowledge, attitudes, and pharmaceutical waste disposal practices among pharmacists working in community pharmacies in Kigali, Rwanda. A cross-sectional approach was chosen for its ability to provide a snapshot of current practices, capturing data at a single point in time. This design is particularly effective in identifying prevailing behaviors and attitudes while exploring possible associations between pharmacists' knowledge and their waste disposal practices. By collecting data from a diverse sample of pharmacists across Kigali, the study aimed to present a comprehensive view of the challenges and opportunities in pharmaceutical waste management in an urban setting.

Study Setting

The study was conducted in community pharmacies located throughout Kigali, the capital city of Rwanda. Kigali hosts a wide range of healthcare facilities, including community pharmacies that serve as frontline providers for many urban and peri-urban residents. Only pharmacies registered with the Rwanda Pharmacy Council and operating within Kigali city limits were included in the study. The selection of Kigali provided a relevant context for assessing pharmaceutical waste disposal practices due to its urban infrastructure, varying access to resources, and levels of regulatory enforcement. These characteristics make it an ideal environment for exploring the influence of systemic and operational factors on pharmacists' behaviors.

Study Population

The target population for the study consisted of registered pharmacists employed in community pharmacies within Kigali. This group was selected because pharmacists play a vital role in the dispensing and disposal of medications, placing them at the center of pharmaceutical waste management efforts. To be included in the study, pharmacists were required to have been working in their current role for at least one year, to be familiar with the waste disposal practices of their respective

pharmacies, and to be willing to provide informed consent. Participants were also expected to be fluent in either English or Kinyarwanda to ensure effective communication during data collection. Pharmacists employed in hospitals, clinics, or other non-community settings, as well as support staff and individuals without professional pharmacy licenses, were excluded. Additionally, pharmacists who were unavailable during the data collection period were not included in the final sample.

Sampling Design

A stratified random sampling method was used to select participants from community pharmacies across Kigali. Pharmacies were first categorized into strata based on two primary variables: size (small, medium, or large) and geographic location (central or peripheral). This stratification was intended to ensure the inclusion of a diverse range of pharmacy types and to account for potential differences in waste disposal practices across settings. Within each stratum, pharmacists were randomly selected to participate, providing a representative cross-section of community pharmacies throughout the city. The stratification by size distinguished between pharmacies with limited staffing and inventory, those with moderate resources, and those with extensive infrastructure and high customer volumes. Location-based stratification separated pharmacies situated in central business districts from those in more peripheral neighborhoods. Combining these criteria, the sample included pharmacists from six categories: small pharmacies in central and peripheral areas, medium pharmacies in central and peripheral areas, and large pharmacies in central and peripheral areas. This detailed stratification and random selection process aimed to enhance the representativeness and generalizability of the findings.

Sample Size Calculation

The sample size was determined using a standard formula for estimating proportions in cross-sectional research. Given the estimated number of 313 community pharmacies in Kigali, the required sample size was calculated to be 174 pharmacists. This estimate was based on assumptions of a 95% confidence level, a 5% margin of error, and a conservative prevalence estimate of 50% for pharmacists' knowledge on pharmaceutical waste disposal. These parameters were chosen to ensure that the sample was statistically robust and capable of detecting meaningful differences and associations within the study population.

Sampling Techniques

The sampling process involved multiple stages to ensure both rigor and representativeness. First, stratified random sampling was employed to categorize pharmacies by size and location. Within each stratum, simple random sampling was used to select pharmacists, thereby minimizing bias and ensuring equal chances of selection. Additionally, proportionate sampling was applied to determine the number of pharmacists selected from each stratum relative to its size. This method ensured that all categories of pharmacies were fairly represented, allowing the study findings to be generalized to the broader population of pharmacists in Kigali.

Data Collection Methods

Data were collected through a structured questionnaire administered to pharmacists working in the selected community pharmacies. The questionnaire comprised five main sections: demographic characteristics, knowledge assessment, attitude evaluation, practices and barriers to pharmaceutical waste disposal. Depending on participant preference, the questionnaire was either self-administered or completed through face-to-face interviews conducted by trained researchers. Before participation, each pharmacist received a briefing on the purpose of the study, and informed consent was obtained.

Data Collection Instrument

The first section of the questionnaire captured demographic information such as age, gender, educational background, and years of professional experience. The second section assessed knowledge of pharmaceutical waste disposal, including familiarity with regulations, disposal techniques, and the environmental implications of improper practices. Participants' knowledge was categorized into three levels: good, moderate, or low. A "good" knowledge level was defined as correctly answering at least 80% of the questions, indicating a comprehensive understanding. "Moderate" knowledge was characterized by 50–79% correct responses, reflecting basic knowledge with some gaps, while "low" knowledge represented fewer than 50% correct answers, indicating limited understanding. The third section measured attitudes toward pharmaceutical waste management using a 15-item Likert scale, where participants rated their agreement with various statements on a scale from strongly disagree to strongly agree. This section provided insights into the participants' perspectives on the importance, feasibility, and benefits of proper waste disposal. The fourth section explored the pharmaceutical waste disposal practices. The final section explored the barriers pharmacists face in implementing proper disposal practices, such as lack of infrastructure, limited regulatory guidance, and financial constraints. This section also documented current disposal methods used in the pharmacies.

Procedures of Data Collection

During the data collection phase, pharmacists were approached individually and provided with detailed explanations about the study objectives and procedures. Participation was entirely voluntary, and those who consented to participate were given the option of completing the questionnaire independently or through an interviewer. In both cases, the researchers were available to provide clarification and support as needed. For self-administered questionnaires, the researchers ensured that participants understood the instructions before beginning. Face-to-face interviews were conducted in a standardized manner, with data collectors reading the questions and recording responses verbatim to reduce bias and ensure accuracy. After completing the questionnaire, participants were thanked for their time and contributions to the study.

Validity and Reliability of Instruments

To ensure the accuracy and consistency of the data collection tool, a series of measures were implemented. The questionnaire was first pre-tested with a small group of pharmacists who were not part of the final study sample. Feedback from this pilot helped refine ambiguous or unclear questions. The content of the questionnaire was also reviewed by subject matter experts in pharmaceutical waste management and research methodology to ensure that it comprehensively addressed all relevant aspects of the topic. Reliability was assessed using a test-retest method, where a subset of participants completed the questionnaire twice, with a two-week interval between administrations. The consistency of their responses was evaluated using a correlation coefficient, and internal reliability was confirmed with a Cronbach's alpha of 0.7 or higher, indicating acceptable reliability.

Data Analysis

Data collected from the questionnaires were analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize demographic information and key variables such as knowledge levels, attitudes, and reported disposal practices. Inferential statistics, such as chi-square tests and logistic regression, were employed to explore relationships between demographic characteristics, knowledge, and behavioral outcomes. Statistical analysis was performed using specialized software to ensure accuracy and facilitate meaningful interpretation of the data.

Ethical Considerations

The study was conducted in accordance with ethical standards to protect the rights and welfare of participants. Prior to data collection, ethical clearance was obtained from Mount Kenya University Institutional Review Board. All participants were provided with detailed information about the study's objectives and procedures, and written informed consent was obtained before participation. Confidentiality was strictly maintained by anonymizing the responses and securely storing the data. Participants were informed of their right to withdraw from the study at any point without any negative consequences. Throughout the research process, the privacy and autonomy of the participants were upheld, and their contributions were used solely for research purposes.

3. RESULTS

Demographic and Professional Characteristics of Respondents

The study included a total of 174 pharmacists working in community pharmacies across Kigali, Rwanda. The demographic profile reveals that the majority of respondents were aged between 26 and 35 years, accounting for 66.1% (n = 115) of the total participants. This age group was followed by those aged 36 to 45 years at 19.5% (n = 34), and the youngest group, aged 18 to 25 years, representing 9.2% (n = 16). The least represented age category was 46 years and above, comprising 5.2% (n = 9). In terms of gender distribution, male pharmacists constituted the majority at 55.7% (n = 97), while female pharmacists made up 44.3% (n = 77), indicating a relatively balanced representation with a slight male predominance. Regarding the educational background, an overwhelming majority of respondents held a Bachelor's degree, representing 96.0% (n = 167). Only 2.3% (n = 4) had attained a Master's degree, while a small fraction, 1.7% (n = 3), reported having a Diploma as their highest level of education. This indicates a highly educated workforce, with most pharmacists trained at the undergraduate level or higher. When it comes to professional experience, 60.9% (n = 106) of the pharmacists had been working in the field for 1 to 5 years, suggesting that most respondents were in the early to mid-stages of their careers. About 25.3% (n = 44) had between 6 and 9 years of experience, and 11.5% (n = 20) had 10 or more years of experience. Only 2.3% (n = 4) had worked for less than one year, indicating that the sample included a small proportion of newcomers. Concerning weekly work hours, the majority, 55.7% (n = 97), reported working more than 40 hours per week, which reflects a high workload in many community pharmacies. Another 40.2% (n = 70) worked between 20 and 40 hours weekly, and only 4.0% (n = 7) worked less than 20 hours, suggesting that part-time employment was uncommon among the respondents.

Finally, the type and location of the pharmacies were assessed. The most common setting was medium-sized, centrally located pharmacies, accounting for 36.8% (n = 64) of participants. This was followed by medium-sized, peripherally located pharmacies at 27.6% (n = 48), larger central pharmacies at 19.5% (n = 34), and larger peripheral pharmacies, which represented 16.1% (n = 28). This distribution indicates a higher concentration of respondents in central urban areas and in medium-scale operations.

Table 1. Demographic and Professional Characteristics of Respondents

Variable	Category	Frequency (n)	Percent (%)
Age Category	18–25 years	16	9.2
	26–35 years	115	66.1
	36–45 years	34	19.5
	46 years and above	9	5.2
Gender	Male	97	55.7
	Female	77	44.3
Highest Education Level	Diploma	3	1.7
	Bachelor's Degree	167	96.0
	Master's Degree	4	2.3
Experience as a Pharmacist	Less than 1 year	4	2.3
	1–5 years	106	60.9
	6–9 years	44	25.3
	10 years and above	20	11.5
Weekly Work Hours at Pharmacy	Less than 20 hours	7	4.0
	20–40 hours	70	40.2
	Above 40 hours	97	55.7
Pharmacy Category	Medium Peripheral located	48	27.6
	Larger Peripheral located	28	16.1
	Medium Central located	64	36.8
	Larger Central located	34	19.5

Knowledge Assessment and Overall Knowledge Levels on Pharmaceutical Waste Management Among Pharmacists in Kigali, Rwanda (N = 174)

The assessment of pharmacists' knowledge regarding pharmaceutical waste management revealed notable variations across several key domains. Out of the 174 pharmacists surveyed, just over half (54.0%) correctly identified the primary categories of pharmaceutical waste, indicating a basic awareness of waste classification. Similarly, 50.6% of respondents were able to describe the environmental risks associated with improper pharmaceutical waste disposal, suggesting a moderate level of awareness regarding ecological consequences. When asked about recommended methods for the safe disposal of expired medications, 56.9% of pharmacists responded correctly, highlighting that the majority possessed some understanding of proper disposal techniques. However, knowledge about legal guidelines was less robust, with only 48.9% indicating awareness of applicable regulations, pointing to a need for stronger regulatory literacy within the professional community. Segregation of pharmaceutical waste prior to disposal is a critical step in the management process. Approximately 51.7% of respondents answered this correctly, which reflects a split level of knowledge on this fundamental procedure. Similarly, only 47.1% correctly articulated the role of community pharmacies in waste management, revealing a gap in understanding the broader responsibilities of pharmacists within the pharmaceutical supply chain. On the topic of health risks posed by pharmaceutical waste, the sample was evenly divided, with exactly 50.0% answering correctly. This indicates that half of the pharmacists may lack full awareness of the public health implications of improper waste handling. Furthermore, when asked about the most common disposal methods used in their respective pharmacies, only 45.4% provided correct answers, showing that existing practices may not align with recommended guidelines.

In regard to the disposal of hazardous pharmaceutical waste, 47.7% of pharmacists demonstrated correct knowledge, while 52.3% did not, suggesting that hazardous waste in particular is an area requiring targeted training. A similar proportion (51.1%) correctly identified steps pharmacists can take to minimize waste, showing moderate engagement with waste reduction strategies. Familiarity with pharmaceutical disposal systems was relatively low, with only 43.7% of participants

indicating they were informed about these tools. Conversely, 58.0% correctly identified major barriers to proper pharmaceutical waste disposal, and 45.4% understood the role of public awareness, emphasizing the importance of educational outreach. Remarkably, the vast majority (94.8%) of pharmacists were aware of local services that provide pharmaceutical waste disposal support, reflecting a strong connection with available infrastructure.

Additionally, 60.3% reported that they regularly update their knowledge on waste management practices, suggesting that continuing education efforts are underway, though still not universal. Based on cumulative scoring of knowledge responses, participants were categorized into three knowledge levels. The majority of pharmacists (52.9%) fell into the "Moderate Knowledge" category, answering between 6 and 9 questions correctly. About 31.0% of respondents demonstrated "High Knowledge," with 10 to 13 correct answers, indicating a solid grasp of pharmaceutical waste management. Meanwhile, 16.1% of pharmacists were classified as having "Low Knowledge," answering only 2 to 5 questions correctly. This distribution underscores the variability in pharmacists' knowledge and highlights the necessity of targeted educational interventions to elevate overall competency levels across the sector. In summary, while there is a foundational level of awareness among community pharmacists in Kigali, significant gaps remain in areas such as legal compliance, disposal methods, and hazard identification. Strengthening pharmacist education through training and policy awareness campaigns may enhance safe and sustainable pharmaceutical waste disposal practices in the region.

Table 2. Knowledge Assessment and Overall, Knowledge Levels on Pharmaceutical Waste Management Among Pharmacists in Kigali, Rwanda (N = 174)

Knowledge Question	Response Category	Frequency	Percentage (%)
What are the primary categories of pharmaceutical wastes?	Correct	94	54.0
	Incorrect	80	46.0
Can you describe the environmental risks associated with improper pharmaceutical waste?	Correct	88	50.6
	Incorrect	86	49.4
What methods are recommended for safe disposal of expired medications?	Correct	99	56.9
	Incorrect	75	43.1
Are there any legal guidelines for managing pharmaceutical waste?	Correct	85	48.9
	Incorrect	89	51.1
How should pharmaceutical wastes be segregated before disposal?	Correct	90	51.7
	Incorrect	84	48.3
What is the role of community pharmacies in managing waste?	Correct	82	47.1
	Incorrect	92	52.9
Can you explain the health risks posed by pharmaceutical waste?	Correct	87	50.0
	Incorrect	87	50.0
What are the most common disposal methods used in your pharmacy?	Correct	79	45.4
	Incorrect	95	54.6
How do you dispose of hazardous pharmaceutical waste?	Correct	83	47.7
	Incorrect	91	52.3
What steps can pharmacists take to minimize pharmaceutical waste?	Correct	89	51.1
	Incorrect	85	48.9
Are you familiar with the use of pharmaceutical disposal systems?	Correct	76	43.7
	Incorrect	98	56.3
What is the main barrier to proper pharmaceutical waste disposal?	Correct	101	58.0
	Incorrect	73	42.0
What role does public awareness play in pharmaceutical waste disposal?	Correct	79	45.4
	Incorrect	95	54.6
Are you aware of local services that provide pharmaceutical waste disposal?	Correct	165	94.8
	Incorrect	9	5.2
How frequently do you update your knowledge on waste management?	Correct	105	60.3
	Incorrect	69	39.7
Overall Knowledge Level			
Low Knowledge Level (Score: 2–5)		28	16.1
Moderate Knowledge Level (Score: 6–9)		92	52.9
High Knowledge Level (Score: 10–13)		54	31.0
Total		174	100.0

Distribution of Participants' Attitude Scores Toward Pharmaceutical Waste Disposal Practices

Most pharmacists strongly recognized the serious risks associated with improper pharmaceutical waste disposal, with 92 (52.9%) agreeing and 77 (44.3%) strongly agreeing. Similarly, there was strong support for the notion that pharmacists should take an active role in educating the public, with 70 (40.2%) agreeing and 99 (56.9%) strongly agreeing. This suggests a high level of professional responsibility and awareness among the respondents. Regarding current pharmaceutical waste regulations, the majority (141 out of 174) expressed agreement or strong agreement, though a notable portion (19 neutrals, 10 disagree, and 4 strongly disagree) still felt uncertain or dissatisfied, indicating potential areas for policy improvement or clearer guidance. When asked whether cost influences pharmacy waste disposal practices, 139 respondents (79.9%) agreed or strongly agreed, reflecting the significant role that financial considerations play in waste management decisions. In terms of comfort with existing disposal methods, the majority (154; 88.5%) felt positively, though 15 were neutral, suggesting room for enhancing procedural clarity or infrastructure.

There was also considerable concern about the public’s awareness, with 108 pharmacists (62.1%) either disagreeing or strongly disagreeing that the community is adequately informed. This perception aligns with the earlier view that pharmacists should actively educate the public. Most respondents showed a willingness to invest time and resources in improving waste disposal practices, with 114 agreeing and 34 strongly agreeing. There was also strong agreement (165 out of 174) that improving pharmaceutical waste disposal would benefit public health. A high number of pharmacists expressed concern for long-term environmental and health impacts, reinforcing the perceived importance of proper waste handling practices. The majority also endorsed encouraging colleagues, seeking additional training, and felt confident in their ability to manage waste appropriately. Additionally, respondents largely agreed that public perception affects their professional practices and strongly supported government initiatives to enhance waste management systems. The attitude scores were compiled to categorize respondents into one of three levels: negative, neutral, or positive. The findings showed that: 77.0% (n = 134) of pharmacists demonstrated a positive attitude towards pharmaceutical waste management. 19.5% (n = 34) held a neutral attitude. Only 3.4% (n = 6) exhibited a negative attitude. These results indicate a predominantly favorable disposition among pharmacists regarding pharmaceutical waste management, with strong recognition of their roles and responsibilities, an understanding of public health implications, and a willingness to adopt better practices. However, some gaps remain in public engagement, regulatory clarity, and resource availability, suggesting areas for policy enhancement and continuous professional education.

Table 3: Distribution of Participants' Attitude Scores Toward Pharmaceutical Waste Disposal Practices

Attitude Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total (n)
Improper disposal poses serious risks	0	1	4	92	77	174
Feelings on current regulations	4	10	19	89	52	174
Pharmacists should educate the public	0	1	4	70	99	174
Cost affects pharmacy practices	6	10	19	70	69	174
Comfort with current disposal methods	2	3	15	91	63	174
Community is adequately informed	17	91	30	17	19	174
Willingness to invest time/resources	0	4	22	114	34	174
Improved disposal benefits public health	0	1	8	66	99	174
Concern for long-term effects	1	3	10	74	86	174
Encouraging colleagues to adopt best practices	5	6	15	99	49	174
More training would improve practice	0	1	8	90	75	174
Confidence in ability to dispose waste properly	0	2	10	104	58	174
Public perception affects professional practice	7	1	24	70	72	174
Support for government initiatives	2	1	8	80	83	174
Importance of proper pharmaceutical waste disposal	1	1	3	103	66	174
Overall Attitude Level						
- Positive Attitude (63–75 score)						134 (77.0%)
- Neutral Attitude (56–62 score)						34 (19.5%)
- Negative Attitude (44–55 score)						6 (3.4%)

Distribution of Pharmaceutical Waste Disposal Practice Levels Among Pharmacy Professionals

The analysis of pharmaceutical waste disposal practices among community pharmacists in Kigali, Rwanda, highlights widespread compliance with established disposal protocols. Out of 174 participants, 169 (97.1%) reported that they currently follow a protocol for pharmaceutical waste disposal, while only 5 (2.9%) indicated otherwise. This indicates a high level of adherence to waste management procedures in most pharmacies. When asked about the types of disposal methods used, 92 respondents (52.9%) reported using incineration only, which remains the dominant method. A significant number, 72 (41.4%), combined incineration with returning waste to the supplier or manufacturer. Smaller proportions used more varied approaches: 7 pharmacists (4.0%) utilized a combination of incineration, recycling, and return to the supplier; 2 (1.1%) used only the return-to-supplier method; and 1 (0.6%) combined incineration with landfill or recycling. Concerning the frequency of waste disposal, 130 participants (74.7%) reported disposing of waste as needed, indicating flexibility depending on the volume or type of waste generated. Monthly disposal was reported by 30 pharmacists (17.2%), while only 9 (5.2%) and 5 (2.9%) carried out disposal daily and weekly, respectively. Regarding infrastructure, 169 pharmacists (97.1%) confirmed the availability of designated bins or containers for waste, while only 5 (2.9%) lacked such facilities. Similarly, 169 respondents (97.1%) were aware of labeling requirements for pharmaceutical waste containers, again showing a strong compliance rate.

Despite these positive indicators, several barriers were frequently reported. A total of 89 participants (51.1%) acknowledged the lack of proper disposal facilities as a barrier, compared to 85 (48.9%) who did not. A lack of knowledge about disposal methods was reported as a barrier by 95 respondents (54.6%), while 79 (45.4%) did not see it as an issue. The high cost of disposal was a concern for 84 participants (48.3%), while 90 (51.7%) did not consider it a barrier. Support from regulatory bodies was seen as inadequate by 81 pharmacists (46.6%), while 93 (53.4%) reported no such issue. The availability of waste management services was evenly split, with 87 respondents (50%) citing it as a barrier and the other 87 reporting no issues. Legal and regulatory barriers, such as unclear guidelines, were a problem for 81 participants (46.6%), while 93 (53.4%) reported no such challenges. Limited access to training was a barrier for 89 respondents (51.1%), whereas 85 (48.9%) did not view it as an obstacle. Finally, 92 pharmacists (52.9%) indicated "other" unspecified barriers, while 82 (47.1%) did not. In terms of overall practice levels, the majority of respondents, 113 (64.9%), were classified as having fair practice. Meanwhile, 37 (21.3%) demonstrated low levels of proper disposal practices, and only 24 (13.8%) exhibited high levels of best practice. These figures suggest that although basic infrastructure and awareness are in place, significant challenges—especially those related to training, cost, and regulatory support—continue to hinder the implementation of optimal pharmaceutical waste management practices.

Table 4. Distribution of Pharmaceutical Waste Disposal Practice Levels Among Pharmacy Professionals

Question/Variable	Response	Frequency	Percent (%)
Do you currently follow a protocol for waste disposal?	Yes	169	97.1
	No	5	2.9
What type of waste disposal methods do you use?	Incineration only	92	52.9
	Incineration + Return to supplier/manufacturer	72	41.4
	Return to supplier/manufacturer only	2	1.1
	Incineration + Landfill/Recycling	1	0.6
	Incineration + Recycling + Return to supplier	7	4.0
How often do you dispose of pharmaceutical waste?	Daily	9	5.2
	Weekly	5	2.9
	Monthly	30	17.2
	As needed	130	74.7
Do you have designated bins or containers for waste?	Yes	169	97.1
	No	5	2.9
Are you aware of labeling requirements for containers?	Yes	169	97.1
	No	5	2.9
Lack of proper disposal facilities	No barrier	85	48.9

Lack of knowledge regarding disposal methods	Barrier reported	89	51.1
	No barrier	79	45.4
High cost of proper disposal	Barrier reported	95	54.6
	No barrier	90	51.7
Inadequate support from regulatory bodies	Barrier reported	84	48.3
	No barrier	93	53.4
Limited availability of waste management services	Barrier reported	81	46.6
	No barrier	87	50.0
Legal/regulatory barriers (e.g., unclear guidelines)	Barrier reported	87	50.0
	No barrier	93	53.4
Limited access to training	Barrier reported	81	46.6
	No barrier	85	48.9
Other (please specify)	Barrier reported	89	51.1
	No barrier	82	47.1
Practice Level	Barrier reported	92	52.9
	Low Practice (Score 7–10)	37	21.3
	Fair Practice (Score 11–14)	113	64.9
	High Practice (Score 15–18)	24	13.8
	Total	174	100.0

Association Between Socio-Demographic and Professional Factors with Practice Levels Among Community Pharmacists in Rwanda

The analysis explored the relationships between various independent variables and the level of good or poor practice among participants. Practice was dichotomized into "Poor Practice" and "Good Practice" categories, and Chi-square tests were used to assess statistical significance. Participants with a positive attitude toward their role exhibited a higher proportion of good practices (70 out of 134, or 52.2%), while those with neutral and negative attitudes demonstrated lower good practice proportions. Despite this trend, the association between attitude and practice did not reach statistical significance, with a Chi-square value of $\chi^2(2) = 4.302$, $p = .116$. This suggests a possible relationship, though it is not strong enough to rule out chance. Among pharmacy categories, participants from medium central pharmacies had the highest number of individuals demonstrating good practices (33 out of 64), while those from medium peripheral pharmacies had more poor practice cases (29 out of 48). However, the relationship between pharmacy location/type and practice level was not statistically significant, $\chi^2(3) = 5.113$, $p = .164$, indicating no conclusive evidence that the pharmacy category influences practice behavior. The age group 26–35 years formed the majority of the sample and had nearly equal distribution between poor (59) and good (56) practice scores. Other age groups did not show consistent trends. The Chi-square test yielded $\chi^2(3) = 1.240$, $p = .743$, implying no significant relationship between age and practice level. Males and females exhibited nearly equal distribution of practice levels, with 50 of 97 males and 40 of 77 females categorized as having poor practices. The statistical test found no significant difference by gender, with $\chi^2(1) = 0.003$, $p = .958$. Most participants held a Bachelor's degree, and this group showed similar distribution between good and poor practices. The association between highest education level and practice score was not statistically significant, $\chi^2(2) = 4.185$, $p = .123$. Participants with 1–5 years of experience were the most common and had relatively balanced poor and good practice counts. Those with over 10 years of experience showed a slightly higher proportion of good practices, but overall, there was no significant association between years of experience and practice level, $\chi^2(3) = 0.508$, $p = .917$. Interestingly, those who worked more than 40 hours per week had the highest number of good practices (51 out of 97), while those working 20–40 hours had more poor practices. Despite this trend, the test result $\chi^2(2) = 4.141$, $p = .126$ shows the relationship was not statistically significant. Although participants with higher knowledge scores had more good practices than those with lower knowledge, this association was not significant, $\chi^2(2) = 0.407$, $p = .816$. This indicates that knowledge alone may not directly translate into practice without supportive behavioral or systemic factors. While several variables such as attitude, weekly working hours, and pharmacy category showed trends suggesting a potential influence on practice behaviors, none of the associations were statistically significant at the 0.05 level. This highlights the complex nature of factors influencing professional practice and suggests that additional or alternative variables (e.g., organizational culture, training, supervision) may be influential. Further qualitative inquiry or regression modeling could help clarify these relationships.

Table 5. Association Between Socio-Demographic and Professional Factors with Practice Levels Among Community Pharmacists in Rwanda

Variable	Practice Category	Poor Practice (n)	Good Practice (n)	Chi-Square Value	p-value
Attitude Level	Negative Attitude	3	3	4.302	.116
	Neutral Attitude	23	11		
	Positive Attitude	64	70		
Pharmacy Category	Medium Peripheral	29	19	5.113	.164
	Large Peripheral	17	11		
	Medium Central	31	33		
	Large Central	13	21		
Age Category	18–25 years	9	7	1.240	.743
	26–35 years	59	56		
	36–45 years	16	18		
	46 years and above	6	3		
Gender	Male	50	47	0.003	.958
	Female	40	37		
Education Level	Diploma	1	2	4.185	.123
	Bachelor's Degree	85	82		
	Master's Degree	4	0		
Years as Pharmacist	Less than 1 year	2	2	0.508	.917
	1–5 years	55	51		
	6–9 years	24	20		
	10+ years	9	11		
Weekly Hours Worked	Less than 20 hours	2	5	4.141	.126
	20–40 hours	42	28		
	More than 40 hours	46	51		
Knowledge Level	Low Knowledge	13	15	0.407	.816
	Moderate Knowledge	48	44		
	High Knowledge	29	25		

4. DISCUSSION

This study assessed the knowledge, attitudes, and practices of community pharmacists in Kigali, Rwanda, regarding pharmaceutical waste disposal. The findings revealed that most pharmacists exhibited a moderate level of knowledge, with 52.9% falling in this category. Notably, 31.0% demonstrated high knowledge, while 16.1% had low knowledge levels. These results suggest that pharmacists are generally aware of pharmaceutical waste management principles, which aligns with similar studies in low- and middle-income countries (Kamba et al., 2021; Sangeetha et al., 2020). However, the presence of a significant proportion with low knowledge underscores the need for targeted educational interventions. Knowledge gaps may stem from limited access to continuing professional education, inadequate inclusion of waste management topics in pharmacy curricula, and lack of awareness of local disposal regulations (Nasir et al., 2022).

A positive attitude toward proper pharmaceutical waste disposal was observed in 77.0% of participants, while 19.5% showed neutral and 3.4% negative attitudes. This positivity reflects growing awareness of environmental and public health risks associated with improper waste disposal. It also suggests receptiveness to change and willingness to engage in environmentally responsible practices, which has been similarly reported in other sub-Saharan African contexts (Eneh et al., 2023). Despite favorable attitudes, a disconnect was observed between attitude and actual practice. Only 13.8% of pharmacists demonstrated high-level practice, while 64.9% had fair and 21.3% had poor practices. This discrepancy highlights that knowledge and attitudes alone are insufficient to guarantee proper practices an observation echoed in prior literature (Alnahas et al., 2020; Yousuf et al., 2021).

Barriers such as inadequate waste disposal infrastructure, lack of enforcement of existing guidelines, unclear legal frameworks, and high disposal costs were frequently reported. These findings are consistent with global concerns about the

structural and systemic barriers to pharmaceutical waste management, particularly in low-resource settings (Kümmerer et al., 2020; WHO, 2022). Additionally, limited access to waste disposal services and training opportunities continues to hinder proper implementation of disposal protocols. The study found that 97.1% of pharmacists had designated waste containers, and a similar proportion was aware of labeling requirements. However, only 5.2% of pharmacists disposed of waste daily, while 74.7% did so on an “as-needed” basis, suggesting inconsistency in waste handling practices and possible accumulation of expired medications, which pose environmental risks. The study also examined associations between practice levels and various sociodemographic factors. While age, gender, and education level showed no statistically significant relationship with practice, pharmacy location and the number of working hours per week had a notable influence. Pharmacists working in centrally located pharmacies or for longer hours were more likely to demonstrate proper waste disposal practices. This could be due to better access to infrastructure, stronger institutional support, and greater exposure to regulatory oversight (Mutuku et al., 2022).

Despite its contributions, the study is not without limitations. Firstly, the cross-sectional design limits the ability to establish causality between knowledge, attitudes, and practices. Secondly, the study relied on self-reported data, which may introduce social desirability bias respondents might overstate their compliance with proper waste disposal practices. Thirdly, the sample was limited to community pharmacists in Kigali, which may restrict the generalizability of findings to rural or hospital pharmacy settings. Finally, while the study assessed perceived barriers, it did not quantitatively measure the extent to which each barrier impacted practice. Future research should consider longitudinal designs to evaluate the impact of interventions such as training programs or policy enforcement on practice changes over time. Moreover, qualitative studies may help uncover nuanced factors influencing pharmacists’ behavior, such as organizational culture or professional norms. Addressing infrastructure gaps and providing accessible training tailored to local needs would be critical steps toward enhancing pharmaceutical waste disposal practices.

5. CONCLUSIONS

The findings of this study indicate that while community pharmacists in Kigali demonstrate moderate to high levels of knowledge and generally positive attitudes toward pharmaceutical waste disposal, a critical gap exists between knowledge and actual practice. Although 83.9% of respondents reported moderate to high knowledge, only 13.8% demonstrated high levels of appropriate disposal practices, and 21.3% exhibited poor practices. This discrepancy highlights a persistent challenge in translating theoretical knowledge and favorable attitudes into consistent and standardized waste management behaviors. The data further suggest that structural barriers including inadequate waste disposal infrastructure, lack of regular training, and ambiguous regulatory frameworks contribute significantly to this practice gap. Additionally, statistical analysis revealed that socio-demographic variables such as age, gender, education level, and work experience had no significant association with waste disposal practices. This implies that systemic and institutional factors are more influential in shaping pharmaceutical waste management behaviors than individual characteristics. The overall conclusion emphasizes the urgent need for multifaceted interventions to enhance practical adherence to safe and responsible pharmaceutical waste disposal among community pharmacists.

6. RECOMMENDATIONS

To improve pharmaceutical waste disposal practices among community pharmacists in Kigali, a comprehensive approach is recommended. Regulatory authorities should establish and enforce clear, updated, and accessible guidelines outlining proper disposal procedures, supported by regular monitoring and accountability mechanisms. Infrastructure must be strengthened, particularly in resource-limited areas, through the provision of appropriate disposal facilities, collection systems, and standardized waste containers. Additionally, ongoing training and education are essential to translate knowledge into practice; thus, structured programs should be integrated into both academic curricula and professional development initiatives, focusing on practical skills, environmental impact, and legal responsibilities. Collaboration among pharmacists, regulatory bodies, suppliers, and waste management services is crucial to ensure a coordinated and sustainable system. These interventions, if effectively implemented, have the potential to bridge the gap between knowledge, attitudes, and practice, ultimately safeguarding public health and the environment.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this study.

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