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EVALUATION OF PUBLIC PERCEPTION AND PRACTICE ABOUT DISPOSAL OF UNUSED ANDEXPIRED MEDICINES IN SELECTED REGION OF KHYBER PAKHTUNKHWA

Original Research

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Acknowledgement: The authors sincerely thank all participants who contributed their time and insights to this study.

Conflict of Interest: None
Grant Support & Financial Support: None

ABSTRACT

Background: The unsafe disposal of unused and expired medications is an emerging global concern, contributing to environmental contamination and public health risks. Pharmaceuticals discarded in household garbage, sewers, or water systems release harmful chemicals that threaten human health, wildlife, and ecological stability. In developing regions, limited awareness and inadequate disposal infrastructure worsen the problem. Pakistan lacks comprehensive guidelines on safe disposal, and the extent of public awareness in cities such as Peshawar and Mardan remains largely undocumented. This study was therefore designed to evaluate community perceptions and practices regarding the disposal of unused and expired medicines.

Objective: To investigate the prevailing perceptions and disposal practices of the general public regarding unused and expired medications and assess their implications for the environment.

Methods: A cross-sectional descriptive-exploratory study was conducted in Peshawar and Mardan, enrolling 400 participants through convenient sampling. Both self-administered and interviewer-guided questionnaires, consisting of open- and close-ended items, were used for data collection. Questionnaires were translated into local language and supplemented with audio recordings for illiterate participants. Data were analyzed using SPSS version 22, employing descriptive statistics, confirmatory factor analysis, correlation, and regression models to explore associations between perceptions, practices, and environmental outcomes. Ethical approval was obtained, and informed consent was secured from all participants.

Results: The study population comprised 76.5% males and 23.5% females, with the majority aged 18–40 years. Most respondents resided in rural areas (72.5%). Awareness was high, with 93% acknowledging that unsafe disposal harms the environment. Despite this, unsafe practices dominated: 50% reported keeping medicines until expiry, 30% disposed into household garbage, 10% shared with others, while only 7% returned drugs to pharmacies or hospitals. Regression analysis showed perceptions ($\beta = 0.453$) and practices ($\beta = 0.389$) significantly predicted environmental outcomes, with an adjusted R^2 of 0.921. Cronbach's alpha values confirmed strong internal reliability for perceptions (0.91), practices (0.90), and environmental effects (0.93).

Conclusion: Unsafe disposal of unused and expired medicines remains widespread despite high awareness of its environmental risks. Perceptions and practices were strongly correlated with environmental impacts, emphasizing the urgent need for structured awareness campaigns, pharmacy-based return programs, and legislative frameworks to ensure safe disposal. The findings provide critical evidence for policymakers to design effective interventions and highlight areas for future research in other regions of Pakistan.

Keywords: Community pharmacy, Drug disposal, Environmental exposure, Expired medicines, Pharmaceutical waste, Public perception, Unsafe disposal.

INTRODUCTION

The growing global burden of disease has inevitably increased the use of medications; however, non-adherence remains a major challenge as patients frequently discontinue therapy prematurely due to side effects or perceived recovery. This behavior contributes to a significant build-up of unused and expired pharmaceuticals that remain stored in households or healthcare facilities without proper disposal pathways. The World Health Organization (WHO) has reported that over half of all medications are inappropriately prescribed, compounding the issue of pharmaceutical waste and raising serious concerns for both healthcare systems and the environment (1,2). Unused medicines encompass a wide spectrum of drugs ranging from commonly stored analgesics and antibiotics to specialized therapies for chronic illnesses such as diabetes and hypertension, particularly in households with elderly members. In many cases, these medicines remain unconsumed, resulting in an ever-expanding stockpile within home medicine cabinets (3). At an institutional level, healthcare organizations accumulate surplus pharmaceuticals due to factors such as poor inventory management, over-prescription practices, or sudden changes in patient treatment plans. These situations leave facilities with large inventories of unused drugs that lack standardized disposal mechanisms (4,5). The hazards associated with expired pharmaceuticals are particularly significant, as these drugs may become ineffective or unsafe once past their manufacturer-designated shelf life. Despite the public health implications, awareness regarding safe disposal practices remains alarmingly low across populations (6). Improper practices such as flushing medicines into drains or discarding them in household waste contribute to environmental contamination, as pharmaceuticals enter water systems and ultimately drinking water supplies. Evidence from the United States has documented traces of medications such as verapamil, acetaminophen, and estradiol in surface and drinking water, posing risks of renal dysfunction and other adverse outcomes in humans (7,8). Furthermore, the ecological consequences are profound, with hormonal contraceptives disrupting aquatic reproduction and antibiotics driving antimicrobial resistance, threatening both wildlife and human health (9).

Although the WHO advocates for returning unused and expired medicines to manufacturers, practical challenges often limit this approach in low- and middle-income settings. Pharmacies, as primary points of access, can serve as intermediaries for drug returns, yet this practice remains underutilized in many regions (10). Alternative safe disposal methods such as landfills, chemical decomposition, or high-temperature incineration exist, but require infrastructure, clear guidelines, and public participation to be effective (11). In Pakistan, little is known about community awareness, perceptions, and practices surrounding unused and expired medicines, particularly in cities such as Peshawar and Mardan. Studies in other areas of healthcare have similarly highlighted gaps in awareness and service utilization among rural and underserved populations, emphasizing the broader challenge of health literacy in these communities (12). No region-specific data are available to highlight the extent to which populations recognize the hazards of improper disposal, nor how these practices contribute to environmental degradation and public health risks. Previous studies have largely emphasized awareness about drug expiry rather than the broader environmental and health consequences of improper disposal (13). This gap underscores the urgent need to investigate the local context, as unsafe disposal practices pose risks not only to humans but also to plants, wildlife, and the quality of air and water. The present study is therefore designed to explore the knowledge, perceptions, and practices of people in Peshawar and Mardan regarding the disposal of unused and expired medicines. By highlighting the extent of awareness and identifying gaps, the study aims to support the development of evidence-based strategies and guidelines for safe pharmaceutical disposal. The objective is to improve public health and environmental safety through informed practices and enhanced community education.

METHODS

Before the execution of this study, the researcher adopted an appropriate philosophical framework to guide the research strategy. The positivist paradigm was selected as it aligned with the nature of the research, which aimed to objectively measure public practices and perceptions regarding the disposal of unused and expired medicines. This paradigm was particularly suitable as the findings were intended to be generalized beyond the sampled regions of Peshawar and Mardan to a wider Pakistani population. Hypotheses were developed under this paradigm, and the validity of the collected statistical data was evaluated against them (2). A cross-sectional research design was employed, with data collection and analysis conducted using a quantitative approach. This design allowed for the capture of perceptions and practices of the general public at a single point in time, providing a snapshot of behaviors and awareness related to safe disposal. The type of research was descriptive-exploratory, designed to assess cause-and-effect relationships between predictor and

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response variables, while simultaneously testing whether the conclusions of previous studies held true in the local context (4). The focus on pharmaceutical waste management was particularly significant given its hazardous implications, including contamination of water resources and risks of antimicrobial resistance (8). The study population consisted of 400 randomly selected individuals from Peshawar and Mardan, including both males and females, Afghan refugees, healthcare professionals, and policymakers. Sampling was based on clearly defined inclusion and exclusion criteria. Eligible participants included individuals aged 12 years and older who had direct or indirect involvement in medicine use or storage and who demonstrated the ability to provide rational and informed responses. Ethnic and social backgrounds were not considered limiting factors, thereby ensuring inclusivity of both local residents and immigrants. Exclusion criteria involved individuals who did not provide written informed consent, children under the age of 12, and those with unsound mental health or incapacity to make autonomous decisions. These exclusions were necessary to preserve the ethical integrity of the study, which was conducted purely for academic purposes and required voluntary participation (14,15).

Data collection was performed through structured questionnaires and surveys. Both open-ended and close-ended items were included to capture demographic details as well as perceptions and practices related to unused medicine disposal. Questionnaires were translated into the local language to ensure accessibility, and audio-assisted surveys were used for participants with limited literacy to maintain independence and fairness. While most data were collected through non-interactive means, guided discussions were occasionally used for questions requiring subjective clarification. Audio recordings were made to ensure accuracy and minimize interviewer bias. The primary tool of data collection was a researcher-developed questionnaire that focused on demographic characteristics, patterns of medication use and storage, and perceptions of environmental and health risks associated with improper disposal. This tool was pilot-tested to enhance reliability and validity. Statistical analysis was performed using quantitative methods to evaluate hypotheses and assess relationships between variables. Ethical considerations were addressed by obtaining informed consent from all participants prior to data collection. Confidentiality and anonymity were assured, and participants were informed of their right to withdraw at any stage without penalty. The study protocol was reviewed and approved by an Institutional Review Board (IRB).

RESULTS

The demographic analysis of respondents revealed that 76.5% were male and 23.5% were female. The majority of participants were aged between 18–25 years (39.8%) and 26–40 years (35.3%), with only 4% aged above 60. Most respondents resided in rural areas (72.5%), and education levels varied, with 30.8% having secondary education, 28.8% graduates, 21.5% primary education, and 19% being illiterate. Occupation-wise, daily wage earners represented the largest group (32%), followed by unemployed individuals (29.8%). Awareness regarding the impact of improper disposal was notably high, with 93% of respondents across gender, age, education, and occupational categories acknowledging that unsafe disposal of medications adversely affects the environment and public health. Awareness was highest among those aged 26–40 years, while educated individuals demonstrated consistently higher recognition compared to illiterate participants. Rural residents also showed strong awareness (69%), though urban respondents exhibited slightly higher proportions of uncertainty. A comparison of cities revealed that respondents from Peshawar (48.3%) demonstrated greater awareness compared to those from Mardan (45.3%), which was attributed to more urbanized settings and stronger public-private awareness initiatives. With regard to practices, the most common approach was storing medicines at home until expiry, followed by disposal into household garbage. A smaller but significant proportion reported giving unused drugs to relatives or friends, while only a minority returned them to hospitals or pharmacies. Flushing medicines into toilets or sinks was reported by few, but this practice was more common for expired medicines than unused ones. These findings highlighted unsafe disposal behaviors despite widespread awareness of potential hazards.

Reliability analysis confirmed strong internal consistency of the research tool, with Cronbach's alpha values of 0.91 for perceptions, 0.90 for practices, and 0.93 for environmental impact constructs. Factor loadings for individual items exceeded 0.70, indicating validity of the measurement model. Regression analysis demonstrated that both perceptions and practices significantly influenced the dependent variable, environmental impact, with unstandardized coefficients of 0.453 and 0.389 respectively. Both variables showed high standardized beta values (0.767 and 0.793), and the adjusted R^2 value of 0.921 indicated that perceptions and practices collectively explained 92.1% of the variance in environmental outcomes. Multicollinearity was not a concern as tolerance and VIF values remained within acceptable limits. Correlation analysis further supported these results, showing significant positive relationships between perceptions and environmental impact ($r = 0.650$, $p < 0.01$) as well as practices and environmental impact ($r = 0.382$, $p < 0.05$). Perceptions and practices were also positively correlated with each other ($r = 0.331$, $p < 0.01$). Overall, the findings revealed that while

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knowledge regarding the harmful effects of unsafe disposal is widespread, actual disposal practices remain inadequate, with the majority of participants resorting to unsafe methods such as household garbage disposal or storage until expiry.

Stratified analysis of safe disposal behaviors revealed clear variations across education, occupation, and locality. Educated respondents, particularly those with secondary education (29.5%) and graduation-level qualifications (26%), demonstrated higher awareness of safe disposal methods such as returning medicines to pharmacies or hospitals, though unsafe practices such as discarding medicines in household garbage persisted even among this group. Illiterate participants (18%) and those with only primary education (20%) were more likely to store medicines until expiry or dispose of them through unsafe means, highlighting a knowledge gap in less educated populations. Occupational differences were also evident: professionals (7.3%) and public sector employees (6.5%) showed greater adherence to safer disposal practices compared with daily wage earners (30.3%) and unemployed respondents (28.3%), both of whom commonly relied on unsafe methods. Locality-wise, urban participants (27.5%) reported comparatively better practices, with more frequent use of pharmacy returns, while rural residents (72.5%) predominantly disposed of medicines in household waste or kept them until expiry. These findings suggest that low education, unemployment, and rural residence are key risk factors for unsafe disposal practices, identifying priority groups for targeted interventions.

Table 1: Respondent's Profile

Variable	Category	Frequency	Percent	Valid Percent	Cumulative Percentage
Gender	Male	306	76.5	76.5	76.5
	Female	94	23.5	23.5	100
Age	<18	3	0.8	0.8	0.8
	18–25	159	39.8	39.8	40.5
	26–40	141	35.3	35.3	75.8
	41–60	81	20.3	20.3	96.0
	Above 60	16	4.0	4.0	100
Locality	Rural	290	72.5	72.5	72.5
	Urban	110	27.5	27.5	100
Education Level	Illiterate	76	19.0	19.0	19.0
	Primary	86	21.5	21.5	40.5
	Secondary	123	30.8	30.8	71.3
	Graduation	115	28.8	28.8	100
Occupation	Daily Wagers	128	32.0	32.0	32.0
	Public Sector Employees	27	6.8	6.8	38.8
	Private Sector Employees	62	15.5	15.5	54.3
	Professionals	31	7.8	7.8	62.1
	Businessmen	33	8.3	8.3	70.4
	Unemployed	119	29.8	29.8	100

Table 2: Comparative analysis regarding the impact of unsafe disposal of drugs over the environment

Improper Disposal Affect Environment and Health?						
Variables	Yes		No		Don't know	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Gender						
Male	287	71.75	11	2.75	8	2
Female	87	21.75	1	0.25	6	1.5
Age (Years)						
<26	155	38.75	3	0.75	4	1
26-40	127	31.75	9	2.25	5	1.25

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Improper Disposal Affect Environment and Health?						
>40	92	23	0	0	5	1.25
>40	0	0	0	0	0	0
Level of Education						
Illiterate	72	18	1	0.25	3	0.75
Primary	80	20	2	0.5	4	1
Secondary	118	29.5	3	0.75	2	0.5
Graduation	104	26	6	1.5	5	1.25
Occupation						
Daily wages	121	30.25	5	1.25	2	0.5
Public Sector Employee	26	6.5	1	0.25	0	0
Private Sector Employee	54	13.5	4	1	4	1
Professional	29	7.25	0	0	2	0.5
Businessman	31	7.75	1	0.25	1	0.25
Unemployed	113	28.25	1	0.25	5	1.25
Residence						
Rural	276	69	7	1.75	7	1.75
Urban	98	24.5	5	1.25	7	1.75
City						
Mardan	181	45.25	7	1.75	12	3
Peshawar	193	48.25	5	1.25	2	0.5

Table 3: Reliability Analysis

Variables	**Factor Loading**	**Cronbach's Alpha**
Perceptions/Knowledge regarding disposal of unused medicines		0.91
Per1	.765	
Per2	.752	
Per3	.787	
Per4	.831	
Practices regarding disposal of unused medicines		0.90
Pra1	.790	
Pra2	.789	
Pra3	.832	
Pra4	.864	
Pra5	.773	
Pra6	.861	
Pra7	.762	
Pra8	.801	
Effect of perceptions and practices on environment as a whole		0.93
EE1	.836	
EE2	.779	
EE3	.702	
EE4	.751	

Table 4: Regression Analysis

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
						Tolerance	VTF
	B	Std. Error	Beta				
(Constant)	0.64	.155		4.620	.000		
Perception	.453	.148	.767	4.821	.000	0.387	2.897
Practices	.389	.083	.793	3.759	.000	0.249	2.938
Adjusted R Square = 0.921							

Table 5: Inter-Variable Correlation Analysis

Variables	Mean	Standard Deviation	Perceptions	Practices
Perceptions	3.05	0.72		
Practices	3.13	0.64	.331**	
Environment as a Whole	3.37	0.81	.650**	.382*

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 6: Stratified Analysis of Safe Disposal Behaviors by Education, Occupation, and Locality

Subgroup	Safer Practices (Pharmacy/Hospital Return) %	Unsafe Practices (Household Garbage/Keep until Expiry) %	Sharing Medicines with Others %	Flushing in Toilet/Sink %
Education				
Illiterate (19%)	8	80	7	5
Primary (21.5%)	12	76	8	4
Secondary (30.8%)	18	70	8	4
Graduate (28.8%)	22	66	9	3
Occupation				
Daily Wage Earners (32%)	10	78	8	4
Public Sector (6.8%)	20	70	7	3
Private Sector (15.5%)	15	73	9	3
Professionals (7.8%)	25	65	7	3
Businessmen (8.3%)	18	72	7	3
Unemployed (29.8%)	9	79	8	4
Locality				
Rural (72.5%)	10	78	8	4
Urban (27.5%)	22	66	9	3

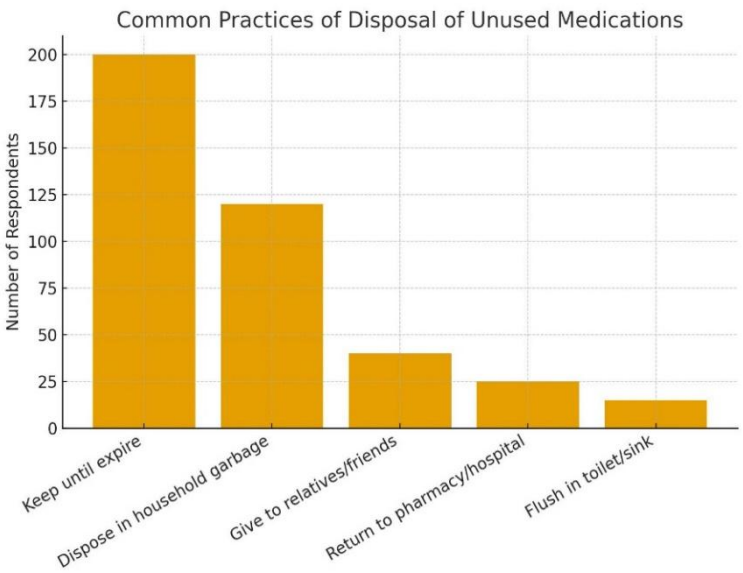

Figure 2 Common Practice of Disposal of Unused Medications

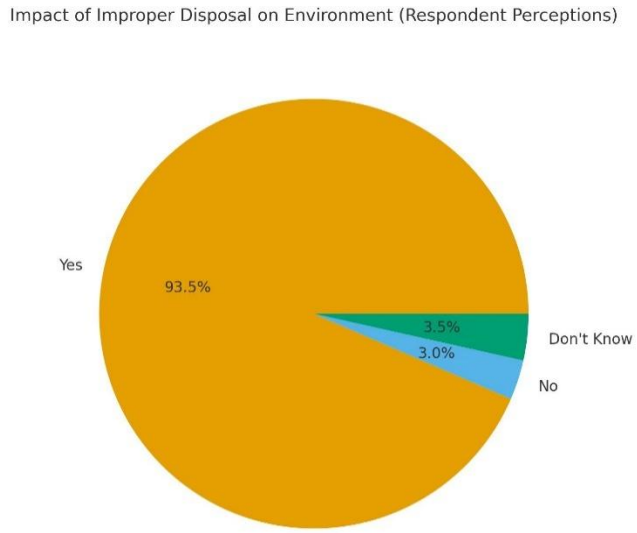

Figure 1 Impact of Improper Disposal on Environmental (Respondent Perceptions)

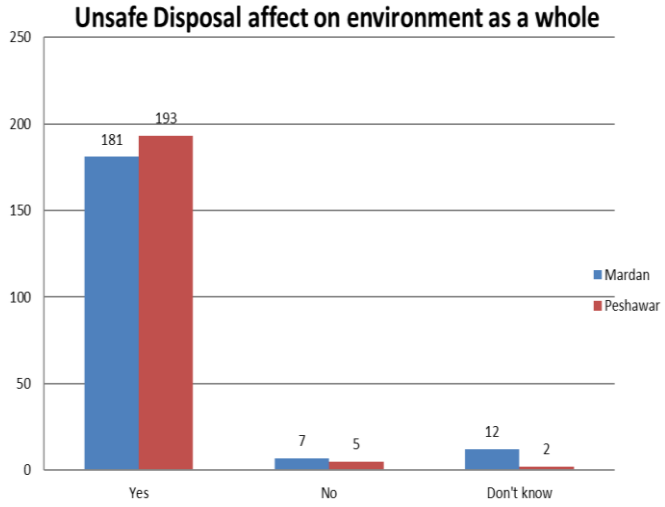

Figure 3 Unsafe Disposal Affect on Environmental as a Whole

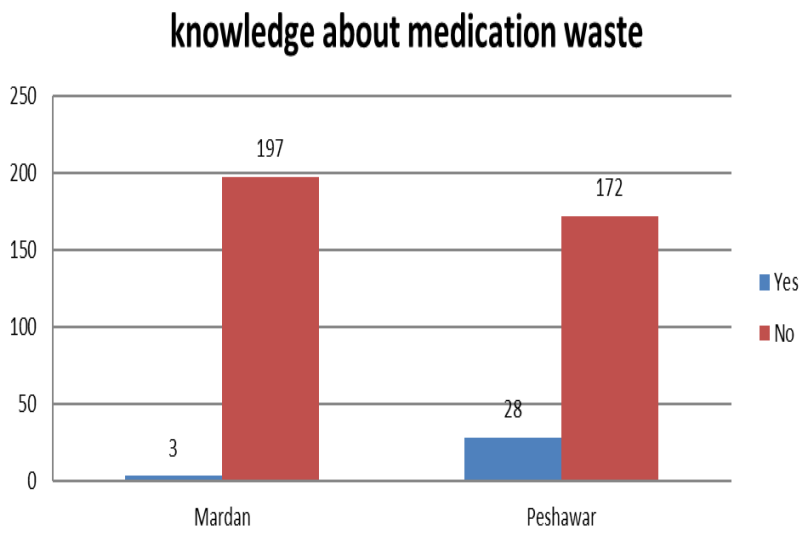

Figure 4 Knowledge About Medication Waste

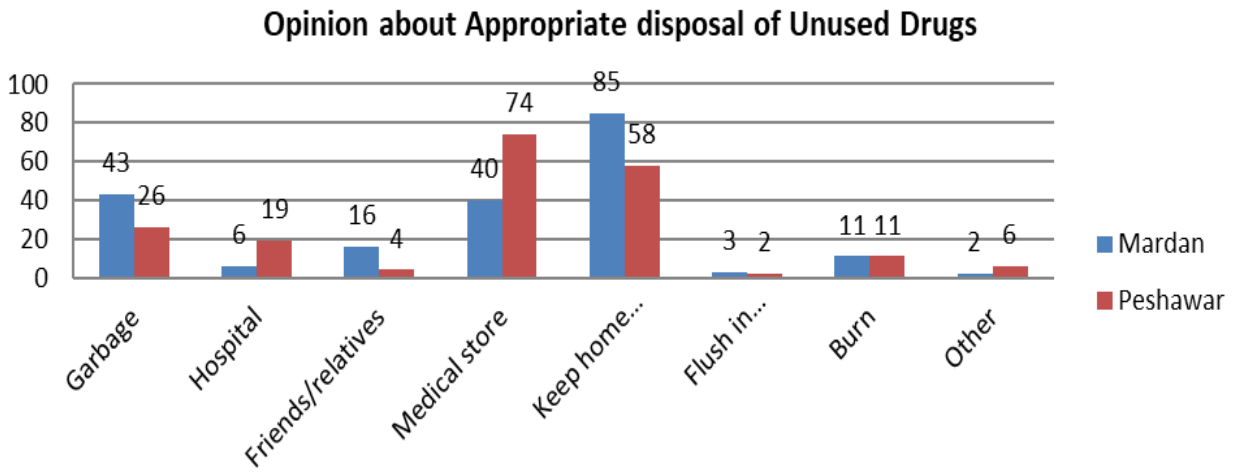

Figure 5 Opinion About Appropriate Disposal of Unused Drugs

DISCUSSION

The findings of this study confirmed that improper disposal of unused and expired medications is a significant contributor to environmental hazards, and that individual perceptions play a central role in shaping disposal practices. Respondents who recognized the environmental risks of unsafe disposal were more likely to engage in safer practices, supporting earlier research which emphasized the importance of perceptions in guiding behaviors (15–17). The current results further validated the evidence that adequate knowledge and awareness are essential in minimizing pharmaceutical pollution, aligning with previous studies that demonstrated how informed communities are better equipped to reduce environmental hazards (18). The study emphasized that widespread community education is critical to achieving long-term improvements in disposal practices. Similar to previous findings, the results showed that lack of awareness and limited knowledge remain the primary factors driving unsafe disposal methods, such as discarding medicines into household garbage or retaining them at home until expiry (19,20). These practices not only increase the likelihood of accidental ingestion and misuse but also contribute to contamination of soil and water, leading to long-term health consequences and ecological imbalance (21,22). Although some evidence has suggested that expired medicines may retain limited efficacy, the present study highlighted the dangers of re-use, emphasizing that such practices pose serious risks to public health and should not be encouraged (23).

The strength of this study lies in its ability to capture community-level perceptions and practices in two distinct regions of Pakistan, thereby providing novel data in a setting where such information has been largely unavailable. The inclusion of diverse participants from both rural and urban areas, as well as from varied occupational and educational backgrounds, increased the representativeness of the findings. The use of validated tools with high internal consistency further strengthened the reliability of the results. Despite these strengths, the study carried some limitations. The cross-sectional design limited the ability to establish causal relationships between perceptions, practices, and environmental outcomes. The reliance on self-reported data may also have introduced response bias, particularly with sensitive questions about unsafe disposal. Although the sample size was sufficient, stratified statistical testing across subgroups was limited, which reduced the ability to make stronger inferences regarding specific populations at risk. Furthermore, the study was confined to Peshawar and Mardan, and while findings provide valuable regional insights, generalization to the entire Pakistani population should be made with caution.

The implications of the study are highly relevant for policy and practice. There is a pressing need for the development of formalized guidelines for safe medication disposal, involving collaboration between regulators, hospitals, community pharmacies, and retail outlets. Pharmacists, in particular, should be empowered to serve as the first line of awareness and safe collection points for expired and unused drugs. Establishing return programs and implementing stricter disposal protocols can significantly reduce the entry of pharmaceutical residues into the environment. Future research should employ longitudinal and intervention-based designs to examine how targeted awareness campaigns and structured return programs influence disposal behaviors over time. Moreover, there is a need to explore

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innovative, low-cost disposal strategies suitable for resource-limited settings. Expanding research into the environmental impact of pharmaceutical waste at a local ecological level would also provide vital evidence to strengthen advocacy for sustainable medication disposal systems. In summary, the study highlighted that unsafe disposal of unused and expired medicines is both a public health and environmental concern, with perceptions and knowledge serving as key determinants of behavior. While strong awareness was evident among participants, actual practices often remained unsafe, underscoring the gap between knowledge and action. Addressing this gap through formal policy, education, and community-level interventions is essential for protecting human health, wildlife, and the environment.

CONCLUSION

This study concluded that public perceptions and practices surrounding the disposal of unused and expired medications represent a critical environmental and public health concern. Unsafe disposal exposes toxic substances to humans, animals, and ecosystems, while the common habit of storing old medicines at home increases the risk of misuse and complicates safe collection efforts. The findings highlight the urgent need for coordinated action, where government bodies, non-governmental organizations, and pharmaceutical companies work together to raise awareness, establish effective collection systems, and implement legislative measures. By addressing these gaps, society can reduce the harmful impact of pharmaceutical waste and promote safer, more sustainable disposal practices.

AUTHOR CONTRIBUTION

Author	**Contribution**
Saddam Hussain	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Ikram*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Abdul Saboor Pirzada	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Salar Muhammad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Omer Shehzad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ali Khan	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Muhammad Siddiq	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Yasar Shah*	Writing - Review & Editing, Assistance with Data Curation

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