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STUDY OF CONSUMER ATTITUDES AND PRACTICES TOWARD PHARMACEUTICAL WASTE DISPOSAL

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ABSTRACT

This study explores consumer perceptions of pharmaceutical waste management, focusing on the reasons behind non-compliance with disposal regulations and the level of awareness regarding environmental and public health risks. A structured questionnaire of 21 items was distributed to 100 individuals, of whom 63 responded (response rate: 63%). The survey included demographic variables, medicine consumption habits, disposal practices, and awareness levels. Results indicate that while most respondents acknowledge the risks of improper disposal, many still discard medicines with household waste rather than using collection points. Younger adults and individuals with higher education demonstrated greater awareness. The findings underline the gap between knowledge and practice, highlighting the urgent need for targeted awareness campaigns, improved infrastructure, and collaborative efforts among government, pharmacies, and the pharmaceutical industry.

INTRODUCTION

Pharmaceutical waste, defined as expired, unused, or improperly stored medicinal products, represents a significant concern for both environmental sustainability and public health. Inappropriate disposal of such waste-through household rubbish, toilets, or sewage systems-contributes to soil and water contamination, promotes antimicrobial resistance, and poses risks to ecosystems and human well-being (Baroka, 2024; Rogowska & Zimmermann, 2022). Pharmaceutical residues have been increasingly detected in surface water, groundwater, and even drinking water, raising serious concerns about long-term exposure and bioaccumulation (Salime et al. 2024).

At the European level, the Waste Framework Directive (Directive 2008/98/EC) established the foundation for waste hierarchy, emphasizing prevention, reuse, recycling, and environmentally safe disposal (EU, 2008). More recently, Regulation (EU) 2025/40 on packaging and packaging waste reinforced extended producer responsibility and introduced stricter sustainability criteria, including for pharmaceutical packaging (European Chemicals Agency, 2025). In Romania, Law no. 211/2011 on the Waste Regime transposed the EU directive, while Law no. 249/2015 regulated packaging and packaging waste (Romanian

Parliament, 2011, 2015). A major step forward was Law 269/2023, which specifically requires all hospitals, public and private, to collect expired medications. This aims to reduce water and soil pollution from pharmaceutical substances. Previously, pharmacies and drugstores managed disposal voluntarily, but now hospitals must organize dedicated collection spaces with accessible containers. In small towns without hospitals, these containers can be placed near dispensaries. Despite these efforts, the enforcement and public participation remain inconsistent, with citizens often unaware of or unable to access proper disposal channels (ANMDMR, 2024).

Empirical research consistently highlights the gap between awareness and practice. For instance, studies in Portugal demonstrated that households accumulate significant quantities of unused and expired medicines, while lack of convenient disposal infrastructure and habitual behaviors lead to their disposal with household waste (Dias-Ferreira et al. 2016). Similar findings were reported in Malaysia, where despite knowledge of the risks, a majority of pharmacy students still discarded medicines improperly (Wang et al. 2021; Salime et al. 2024). In Jordan and Iran, surveys revealed that although awareness of health and environmental risks is relatively high, actual use of collection programs remains low (Alhamad et al. 2022; Mostafanejad et al. 2025). A cross-European comparative analysis also showed wide differences between countries, with harmonization of pharmaceutical take-back systems still underdeveloped (Mitkidis et al. 2021, Nairat et al. 2023). In the Caribbean context, a study conducted in Trinidad and Tobago found that most patients discard expired or unused medication with household waste, although a high proportion expressed willingness to participate in pharmacy-based take-back programs (Jankie et al. 2022).

In Romania, recent studies suggest a similar pattern: while a considerable proportion of consumers acknowledge the hazards of pharmaceutical waste, many continue to discard medicines with household waste, and take-back programs are inconsistently applied across pharmacies (Ionescu & Cazan, 2024). This discrepancy emphasizes the importance of investigating public perceptions, behaviors, and the factors that hinder compliance with existing regulations.

The present study addresses this gap by analyzing consumer perceptions in Romania regarding pharmaceutical waste management. Specifically, it seeks to identify the reasons for non-compliance, to evaluate the level of awareness about the risks of improper disposal, and to explore demographic influences on these perceptions. By doing so, it aims to provide evidence-based recommendations that can support policy design, strengthen public education campaigns, and improve the implementation of waste management systems in line with national and European legislation.

MATERIAL AND METHODS

The present study was carried out in 2024 to investigate consumer perceptions and behaviors regarding the management of pharmaceutical waste. Its primary objectives were to identify the main reasons why individuals fail to comply with proper disposal regulations and to assess their awareness of the environmental and public health risks associated with pharmaceutical waste.

The collected data were processed and expressed as percentages, with results presented in figures to facilitate the identification of patterns and trends.

A quantitative research design was applied, based on a structured questionnaire created in Google Forms. The survey was distributed online between

March and April 2024 through social media platforms and e-mail. The instrument consisted of 21 items, most of which were mandatory closed-ended questions, complemented by a smaller number of optional open-ended questions that allowed respondents to provide additional insights or express personal preferences. The questionnaire was designed based on a review of relevant literature and aligned with the study objectives. A short pilot test with five individuals was conducted to ensure clarity and comprehensibility of the questions.

Participants were recruited using non-probability convenience sampling. Inclusion criteria required respondents to be aged 18 years or older and to reside in Romania at the time of the survey. Out of 100 individuals contacted, 63 completed the questionnaire (n=63), resulting in a response rate of 63 %. Participation was voluntary, and all responses were anonymous. Since no sensitive personal data were collected, formal ethical approval was not required.

Respondents represented diverse demographic categories in terms of age, gender, education, occupation, and income, allowing for a more comprehensive understanding of consumer behavior and perceptions. The questionnaire covered several key areas: demographic information (age, gender, education, occupation, income); medicine consumption habits (types of medicines used, frequency of checking expiration dates, methods of procurement); awareness of the risks associated with expired or unused medicines; disposal practices for unused and expired medicines;perceptions regarding the importance of pharmaceutical waste collection; and sources of information and perceived responsibility for public awareness.

The collected data were processed and expressed as percentages. Statistical analysis was limited to descriptive statistics (absolute and relative frequencies), and results were presented in figures to facilitate the identification of patterns and trends. Data processing was performed using Microsoft Excel 2019.

RESULTS AND DISCUSSIONS

The aim of this study is to analyze consumer perceptions regarding the management of pharmaceutical waste, identifying the main reasons why the population does not comply with disposal regulations, and assessing the degree of awareness of the negative impact of pharmaceutical waste on the environment and public health.

A structured questionnaire of 21 items was administered to assess consumer perceptions and behaviors regarding pharmaceutical waste management. Out of 100 individuals contacted, 63 completed the survey (response rate: 63 %).

Analysis of the collected data highlights several demographic characteristics that are relevant for understanding consumer behavior in this domain. Of the total respondents, 53.97% were women (n=34) and 46.03 % were men (n=29), indicating a slight predominance of female participants, which may suggest a stronger interest among women in environmental and health-related issues. Regarding marital status, 52.38 % were married (n=33), while 47.62 % were single (n=30). With respect to place of residence, 61.90 % of respondents lived in urban areas (n=39), whereas 38.10 % resided in rural areas (n=24). This distribution may reflect differences in access to information, infrastructure, and environmental initiatives between urban and rural populations, potentially influencing attitudes and behaviors toward health and environmental matters.

Regarding age distribution, 39.68 % (n=25) belonged to the 25-35 age group, 30.16 % (n=19) were aged between 36-49, 28.57 % (n=18) fell within the 18-24 category, and only 1.59 % (n=1) was over 50 years old. These findings suggest that young adults and middle-aged individuals show the highest degree of interest in pharmaceutical waste-related matters (Figure 1a).

These demographic data do not merely reflect the composition of the sample but also provide insights into behavioral implications concerning sensitivity toward pharmaceutical waste management. They offer a solid foundation for the design of awareness and education campaigns targeting the groups that demonstrate greater concern for this issue.

With respect to occupation, the majority of participants worked in the private sector (n=24, representing 38.10 %), followed by students (n=22, 34.92 %). Fifteen respondents (n=15, 23.81 %) were employed in public institutions, while two respondents (n=2, 3.17 %) identified themselves as freelancers (Figure 2 a).

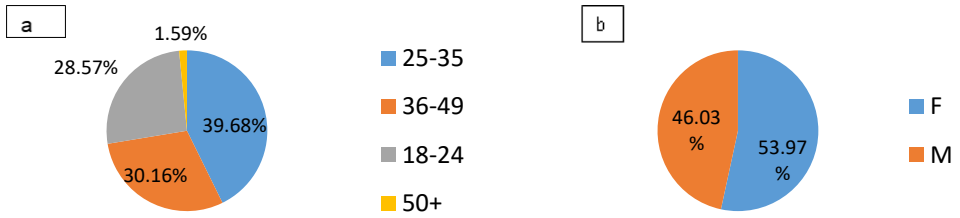

Figure 1. Respondents' demographic profile: (a) Age, (b) Gender

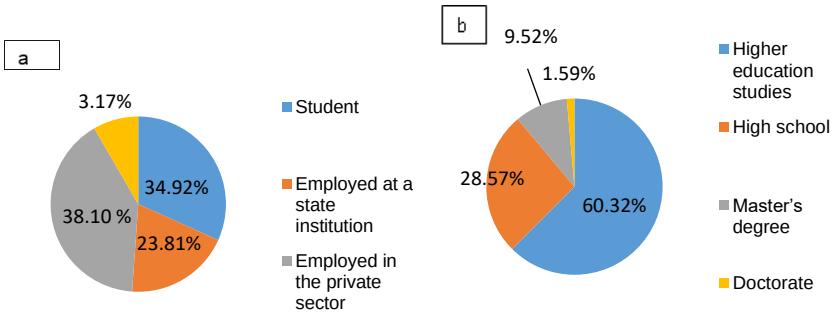

Figure 2. Respondents' educational profile: (a) Occupation, (b) Education level

In terms of education, 60.32 % of respondents (n=38) held higher education degrees, 28.57 % (n=18) reported having completed secondary education, 9.52 % (n=6) pursued Master's level studies, and 1.59 % (n=1) held a doctoral degree (Figure 2 b). This pattern supports previous research showing that individuals with higher education levels are more likely to demonstrate awareness of pharmaceutical waste management and engage in environmentally responsible practices (Nairat et al. 2023; Tegegne et al. 2024).

Regarding income levels, 34.9 % of respondents (n=22) declared a monthly income between 2,500 and 5,000 RON, 30.2 % (n=19) earned below 2,500 RON,

33.3 % (n=21) reported earnings between 5,000 and 10,000 RON, and 1.6 % (n=1) had incomes exceeding 10,000 RON (Figure 3).

Analysis of the responses indicates that 60.32 % of participants reported never having used special collection points for pharmaceutical or medical waste (Figure 4). This highlights a relatively low concern for the responsible disposal of such waste. This pattern is supported by studies in Malaysia and Romania, showing that individuals with higher education levels are more likely to demonstrate awareness of proper medicine disposal and engage in responsible practices (Ling et al. 2024; Wang et al. 2021; Manea et al. 2020; Ionescu & Cazan, 2024; Bungau et al. 2018). On the other hand, 15.87 % of respondents stated that they occasionally used these collection points, suggesting partial awareness of the importance of recycling and proper disposal. Additionally, 12.70 % reported using them rarely, reflecting an intermittent practice and the need for further educational efforts in this regard.

In contrast, 11.11 % of respondents declared that they frequently used collection points, demonstrating an active commitment to preventing pollution and health risks associated with improper disposal. This distribution shows that although a minority of consumers adopts responsible practices, the majority remain insufficiently informed or motivated to actively engage in pharmaceutical waste management.

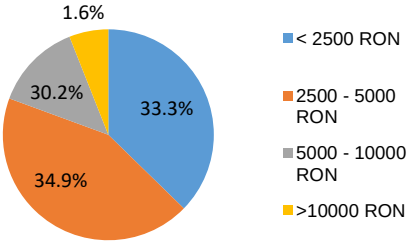

Figure 3. Income distribution

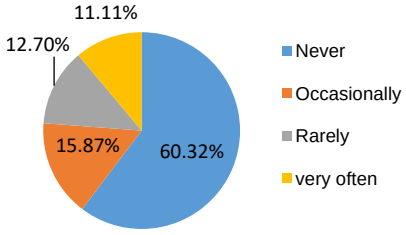

Figure 4. Use of special collection points

Such findings underscore the need for a shift in consumer mindset and behavior. Educational initiatives promoted by public authorities and environmental organizations are crucial in raising awareness of the environmental and health impacts of pharmaceutical waste. Furthermore, healthcare companies should develop strategies that encourage the correct use of collection points. Collaboration between public institutions, the private sector, and local communities is essential to promote responsible behavior and appropriate waste management practices.

When asked about the perceived effects of improper disposal of unused or expired medicines, 63 respondents answered this optional question. Out of these, 57 participants (90.5 %) stated that such practices have a negative impact on the environment. Meanwhile, 6 respondents (9.5 %) selected the option “I do not know,” which indicates a certain degree of uncertainty about the magnitude of the problem (Figure 5). Similar levels of awareness and uncertainty about environmental risks have been observed among other populations (OECD, 2022).

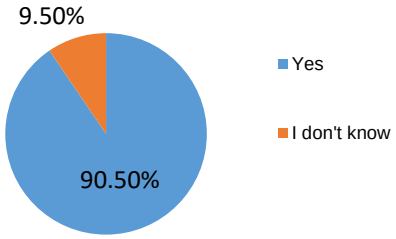

Figure 5. Perceptions of improper pharmaceutical waste disposal

Responses to the question on how participants usually obtain medicines revealed that 46 respondents (73 %) purchase medicines based on a medical prescription. Sixteen participants (25.4 %) reported acquiring medicines without a prescription, while one respondent (1.6 %) stated that they receive medicines from acquaintances (Figure 6). These results emphasize the importance of consulting healthcare professionals in the process of obtaining medicines and reducing the risks associated with self-medication.

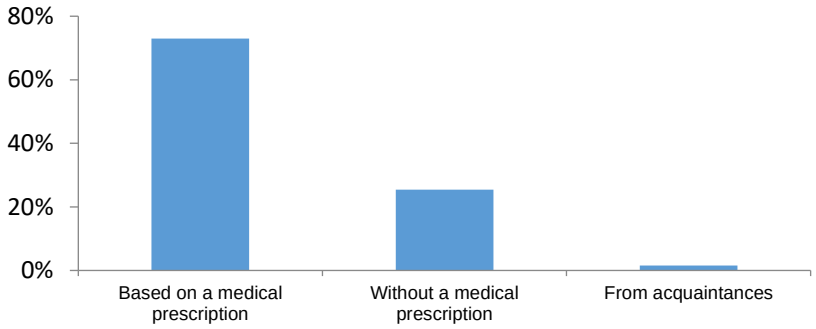

Figure 6. Methods of medicine procurement

A total of 63 individuals responded to the question regarding the types of medicines they most frequently use, resulting in 47 recorded answers. Respondents had the option to provide multiple selections. The distribution was as follows: 3 respondents (6.4 %) reported using antibiotics, 9 respondents (19.1 %) used non-steroidal anti-inflammatory drugs (NSAIDs), 7 respondents (14.8 %) used analgesics, 2 respondents (4.3 %) antihistamines, and 20 respondents (42.6 %) reported using supplements such as vitamins and minerals. Additionally, 6 respondents (12.8 %) mentioned that they do not use medicines at all (Figure 7).

These results highlight the diversity of pharmaceutical products consumed and reflect broader health-related trends among respondents. A notable preference for supplements indicates an increased interest in preventive healthcare and natural methods of maintaining health. At the same time, the significant percentage of individuals who do not use medicines suggests alternative approaches to health management, possibly involving holistic or lifestyle-based practices. This finding may also point to greater health awareness and a preference for maintaining a balanced lifestyle.

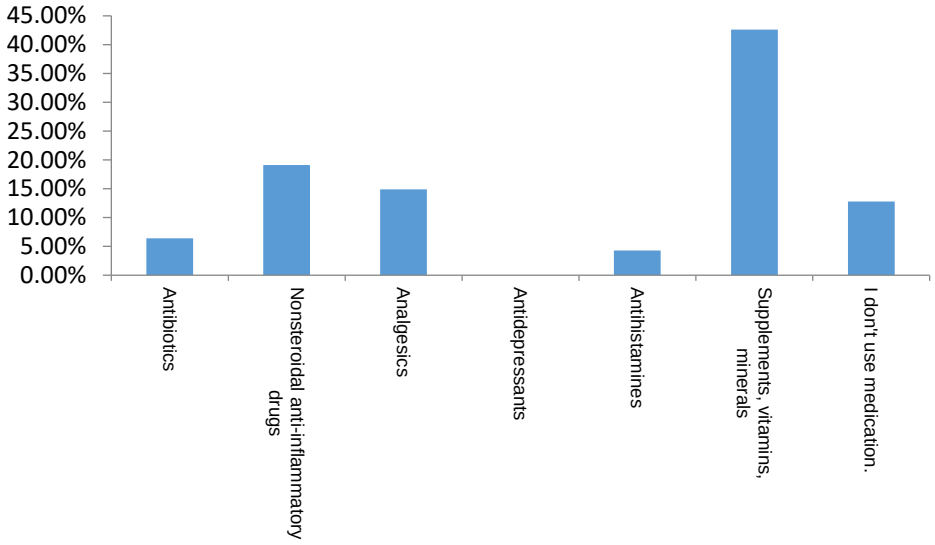

Figure 7. Types of medicines most frequently used

The study also investigated respondents' habits regarding the verification of medicine expiration dates (Figure 8). Out of 63 participants, 44 (70 %) stated that they always check expiration dates, 10 (16 %) mentioned that they sometimes do so, while 9 (14 %) reported checking rarely.

These findings reveal a high level of responsibility among most respondents concerning the safe use of medicines, suggesting good awareness of the importance of this practice for both personal health and public safety.

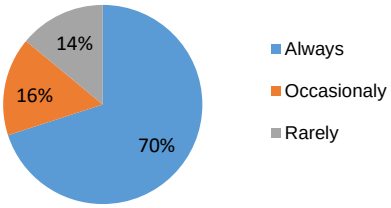

Figure 8. Verification of medicine expiration dates

When asked whether expired and/or unused medicines should be considered hazardous waste, 90.48 % of respondents answered affirmatively. In contrast, 6.35 % declared that they were unsure, while only 3.17% did not consider them hazardous (Figure 9).

A related question explored whether the improper disposal of expired medicines could affect the environment and public health. The majority of respondents (92 %) agreed, while 8 % indicated uncertainty (Figure 10). These results demonstrate a significant level of awareness regarding the potential risks associated with pharmaceutical waste.

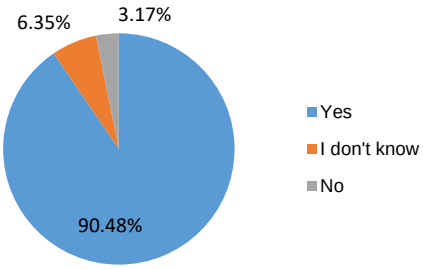

Figure 9. Medicines as hazardous waste

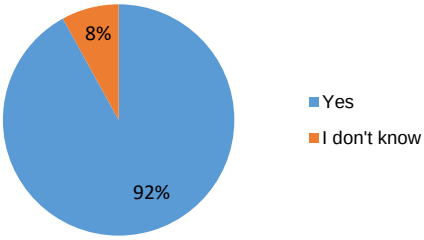

Figure 10. Improper disposal of expired medicines

A large proportion of participants (84 %) reported that they keep at home part of the medicines purchased after use, while only 16% indicated that they do not store medicines at home (Figure 11).

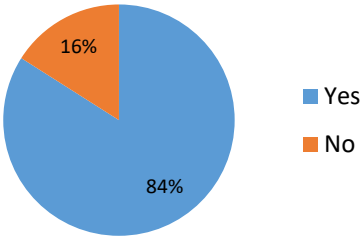

Figure 11. Retention of medicines at home

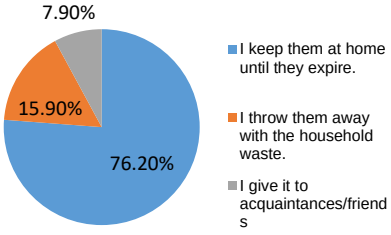

Figure 12. Management of unused medicines

When asked about the handling of unused medicines, 48 respondents (76.2 %) reported that they keep them at home until expiration. Ten participants (15.9 %) stated that they throw them away with household waste, while 5 respondents (7.9 %) mentioned that they donate them to friends or acquaintances (Figure 12).

As for expired medicines (Figure 13), the distribution was as follows: 33 respondents (55 %) throw them away with household waste; 22 respondents (36.7 %) return them to pharmacies; 3 respondents (5 %) dispose of them in toilets or sinks; 2 respondents (3.3 %) donate them to friends or acquaintances.

This distribution suggests that most respondents opt for environmentally unsafe practices by discarding medicines in household waste, while only a smaller proportion return them to pharmacies. Moreover, none of the respondents mentioned returning expired medicines to hospitals, which highlights a lack of awareness concerning the legal obligation of hospitals to receive and manage this category of waste.

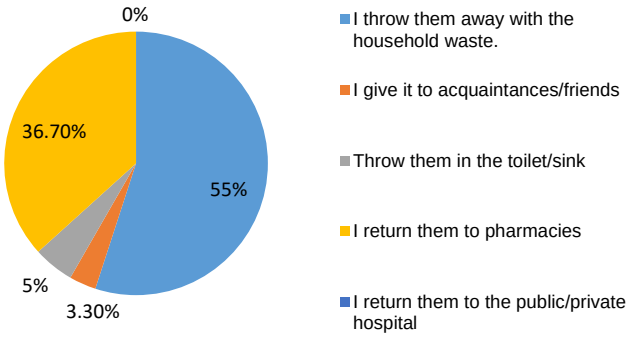

Figure 13. Management of expired medicines

Participants were also asked whether they had noticed changes in people's behavior concerning pharmaceutical waste management in recent years. Out of 63 responses, 49 (77.8 %) indicated that they had not observed any change. In contrast, 12 respondents (19 %) reported improvements, while only 2 (3.2 %) mentioned a deterioration in behavior (Figure 14).

These findings suggest that, overall, respondents perceive a lack of significant changes in public attitudes, with only a minority noticing progress in this field.

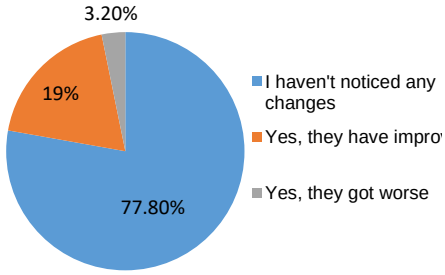

Figure 14. Perceived changes in behavior

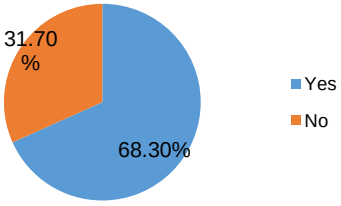

Figure 15. Access to information on pharmaceutical waste disposal

Out of the 63 participants, 43 respondents (68.3 %) stated that they had received information regarding the correct disposal of pharmaceutical waste, while 20 respondents (31.7 %) declared that they had not (Figure 15). This indicates that, although a significant proportion of the sample is informed, a considerable share of the population still lacks access to essential knowledge on this issue. The findings highlight the need for additional awareness and educational campaigns targeting broader community segments.

When asked who should bear the responsibility for informing the population about the proper disposal of unused or expired medicines, most respondents (41 participants, 65.1 %) identified the pharmaceutical industry. Sixteen respondents (25.4 %) pointed to the government, while six respondents (9.5 %) mentioned pharmacists (Figure 16).

These results suggest that participants expect pharmaceutical companies to take a proactive role in consumer education. However, the responses also underline the

importance of collaborative responsibility, where governmental bodies and pharmacists can play a complementary role in ensuring effective public communication.

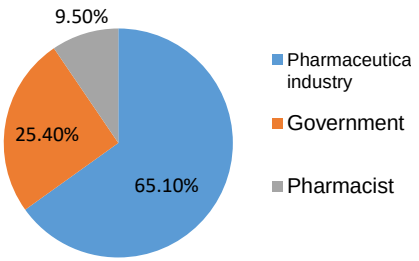

Figure 16. Responsibility for public awareness

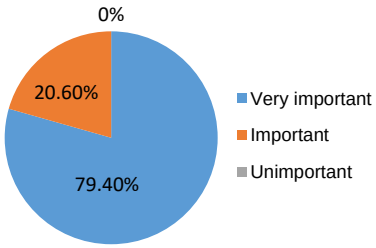

Figure 17. Importance of medical waste collection

The final question assessed the perceived importance of medical waste collection. Out of 63 respondents, 50 (79.4 %) considered it “very important,” while 13 respondents (20.6 %) regarded it as “important.” Notably, none of the participants selected the “not important” option (Figure 17).

These results reflect a high level of awareness among respondents regarding the necessity of proper medical waste collection, emphasizing its relevance for both public health and environmental protection. This finding also suggests strong public support for initiatives aimed at improving pharmaceutical waste management systems. Overall, the results of this study align with trends reported in other European countries, indicating that improper disposal of medicines is a widespread problem rather than a local one. This suggests that educational campaigns and policy interventions should be coordinated at both national and European levels (OECD, 2022).

CONCLUSIONS

The study highlights the complex relationship between demographic factors, consumer behavior, and awareness regarding pharmaceutical waste management. While most respondents acknowledged the risks associated with improper disposal, actual practices often remained inconsistent, with a significant proportion continuing to discard expired medicines in household waste rather than returning them to pharmacies. This gap between knowledge and practice underlines the urgent need to strengthen educational strategies, expand infrastructure, and foster collaborative efforts among governmental institutions, the pharmaceutical industry, healthcare professionals, and local communities.

Demographic analysis indicated that younger adults, particularly those aged 25-35, were more engaged with the issue, and higher education levels were associated with greater awareness. However, the limited use of collection points suggests the need for more accessible systems and stronger incentives to encourage responsible practices. Respondents also viewed the pharmaceutical industry as having primary responsibility for public education, followed by governmental institutions and pharmacists, pointing to the necessity of a coordinated, multi-stakeholder approach.

To improve current practices, several key measures are recommended: intensifying awareness campaigns through mass media, digital platforms, and healthcare institutions; expanding the role of pharmacies by providing accessible collection points and actively encouraging returns; ensuring governmental support through clear policies and incentives; engaging the pharmaceutical industry in funding and promoting collection systems as well as education initiatives; integrating pharmaceutical waste management into broader environmental and sustainability strategies; and promoting behavioral change by emphasizing the direct consequences of improper disposal on health and the environment. Implementing these measures would contribute to the establishment of a sustainable and efficient pharmaceutical waste management system that safeguards public health, protects the environment, and fosters responsible consumer behavior.

REFERENCES

Alhamad H., Jaber D., Abu-Farha R., Albahar F., Edaily S.M., Donyai P. 2022. Factors Influencing Public Willingness to Reuse the Unused Stored Medications in Jordan: A Cross-Sectional Study. Healthcare (Basel). 11(1):75.

Baroka A. 2024. Pharmaceutical waste management: sources, environmental impacts, and sustainable solutions. Pharm Rep. 76(1):1-12.

Bungau S., Tit D.M., Fodor K., Cioca G., Agop M., Iovan C., Cseppento D.C.N., Bumbu A., Bustea C. 2018. Aspects Regarding the Pharmaceutical Waste Management in Romania. Sustainability, *10*(8), 2788.

Dias-Ferreira C., Valente S., Vaz J. 2016. Practices of pharmaceutical waste generation and discarding in households across Portugal. Waste Manag Res. 34(10):1006-1013.

Ionescu A.M., Cazan C. 2024. Pharmaceutical Waste Management: A Comprehensive Analysis of Romanian Practices and Perspectives. Sustainability. 16(15):6571.

Jankie S., Barsatee N., Dookhan V., Sookdeo K., Hernandez S., Villarroel Stuart A. 2022. Patients' knowledge, attitudes and concerns regarding the disposal of expired/unused medication. Int J Pharm Pract. 30(3):247-252.

Ling J.Y., Ng P.Y., Shamsuddin A.S., Zulkifli A., Lee K.E. 2024. Medication disposal patterns and practices with awareness of environmental contamination caused by pharmaceuticals among the general public in Malaysia. Asian Pac J Cancer Prev., 25(8):2723-2734.

Manea G., Taloș A.-M., Vijulie I., Preda M., Mareci A., Cuculici R., Cocoș O. 2020. Assessing the attitude and behaviour regarding the disposal of expired or unused medicines. Case study: Bucharest, Romania. Human Geographies, *14*(2), 239-253.

Mitkidis K., Obolevich V., Chrysochou P., Mitkidis P. 2021. Harmonisation of Pharmaceutical Take-Back Systems in the EU. Eur J Health Law. 30:1-27.

Mostafanejad R., Ghassab-Abdollahi N., Derakhshani N., Rezapour R. 2025. Medication waste and disposal behaviors among Iranian households: A Cross-sectional study. Sci Rep.15(1):15714.

Nairat L.L., Abahri N.A., Hamdan Y.A. et al. 2023. Assessment of practices and awareness regarding the disposal of unwanted pharmaceutical products among community pharmacies: a cross-sectional study in Palestine. BMC Health Serv Res 23, 1035.

Rogowska J., Zimmermann A. 2022. Household pharmaceutical waste disposal as a global problem - A review. International Journal of Environmental Research and Public Health, 19(23), 15798.

Salime N.I., Anak Stanley J.S., Goh H.P., Long C.M., Ramli S., James R.J., Choo C.Y. 2024. Pharmacy student's awareness and perception of pharmaceutical disposal and its level in tap water. Pharmacy Education, *24*(1), 688–694.

Tegegne A.A., Genet G., Workie Limenh L., Yohannes L., Mohammed Seid A., Alemayehu T.T., Ayenew W., Simegn W. 2024. Public awareness, knowledge, and attitude regarding proper disposal of unused medicines and associated factors in Gondar city, northwest Ethiopia. Front Public Health, 12, 1372739.

Wang L.S., Aziz Z., Chik Z. 2021. Disposal practice and factors associated with unused medicines in Malaysia: A cross-sectional study. BMC Public Health, 21(1), 1695.

***2008, Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste (Waste Framework Directive), published in the Official Journal of the European Union, L 312, on 22 November 2008, 3–30.

***2024, Instruction No. 6226 of 4 April 2024 of the National Agency for Medicines and Medical Devices of Romania (ANMDMR) on the handling of unused and/or expired medicinal products from the population, published in the Official Gazette of Romania, Part I, No. 331, on 10 April 2024.

***2011, Law no. 211/2011 of 15 November 2011 on the Waste Regime. Romania.

***2015, Law No. 249 of 28 October 2015 on the management of packaging and packaging waste, published in the Official Gazette of Romania, Part I, No. 809, on 30 October 2015.

***2023, Law No. 269 of October 10, 2023, for amending and supplementing Law No. 95/2006 regarding reform in the health sector, published in the Official Gazette of Romania, Part I, no. 916, on October 11, 2023.

***2022,OECD, Management of Pharmaceutical Household Waste: Limiting Environmental Impacts of Unused or Expired Medicine, OECD Publishing, Paris.

***2025, Regulation (EU) 2025/40 of the European Parliament and of the Council of 19 December 2024 on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, published in the Official Journal of the European Union, L 40, on 22 January 2025.