

EXPLORING PUBLIC BEHAVIOR AND ATTITUDES TOWARD MEDICINE DISPOSAL: A COMMUNITY-BASED STUDY

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ABSTRACT

Objectives: To assess public knowledge, attitudes, and disposal practices for unused/expired medicines and to identify preferred channels for improving community awareness.

Methods: A community-based, cross-sectional survey was conducted using a pre-tested, structured questionnaire (18 items). The minimum sample size was estimated using a single-proportion approach with relative precision ($\alpha=0.05$; $p=0.774$; $\epsilon=0.05$), yielding $n=449$; ultimately, 472 respondents completed the survey. Descriptive statistics were reported as frequencies and percentages.

Results: Most respondents believed expired medicines become toxic (64.6%) and routinely checked expiry dates before purchase or use (94.3%). Despite this awareness, only 2.3% reported following a recommended disposal method, whereas 94.5% did not. Disposal in household trash was the most common practice (60.6%), whereas 2.1% reported flushing medicines in a toilet or sink. Although 95.8% reported storing expired medicines separately, 68.9% did not remove personal information from packaging before disposal. Responsibility for safe disposal was perceived as shared between government and healthcare personnel (83.5%). Awareness of formal take-back programs was limited (37.7%), yet willingness to participate was high (77.0%). Internet-based platforms were the most preferred route for education (79.9%), followed by electronic media (58.1%) and pharmacists (48.1%).

Conclusion: The community demonstrates good awareness of expiry-related risks but exhibits major gaps in safe disposal behaviors and program awareness. The high willingness to join take-back initiatives indicates the feasibility of community-pharmacy-government partnerships. Targeted risk communication, clear disposal guidance at dispensing points, and accessible take-back options are urgently needed to mitigate this public health and environmental issue.

Keywords: Medicine disposal, Unused medicines, Expired medicines, Public awareness, Take-back program, Community survey.

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INTRODUCTION

Medicines frequently remain unused in households because of symptom resolution, regimen changes, adverse effects, or non-adherence. When retained without a plan for disposal, these products may contribute to accidental exposure, diversion, and avoidable expenditure, while also increasing the risk of environmental contamination through inappropriate discarding or flushing [1,2]. Multiple community surveys have shown that the most common disposal route is household trash, and a smaller but important fraction of respondents report flushing medicines into sinks or toilets, both of which can introduce active pharmaceutical ingredients into waste streams [3,4].

Expired medicines are often perceived as ineffective or potentially harmful, and many consumers report checking expiry dates before using a product [1,3]. However, awareness of safe disposal instructions and access to structured take-back options remain inconsistent. Studies from diverse settings – including large urban regions and university populations – highlight that return-to-pharmacy behaviors are uncommon, even when respondents express positive attitudes toward formal collection programs [2,4,5]. These observations suggest a persistent knowledge-practice gap that is shaped by convenience, limited guidance at the point of dispensing, and the absence of easily accessible return infrastructure.

From a public health perspective, unsafe medicine disposal is not only an environmental issue; it intersects with household safety, medication misuse, and antimicrobial resistance pressures linked to pharmaceutical release into ecosystems [6,7]. Improving community behavior requires

evidence on current practices, perceived responsibilities, and preferred information channels, so that interventions can be tailored to local realities. Although several studies from metropolitan regions in India and other countries have evaluated public disposal practices, region-specific data from coastal Andhra Pradesh, particularly Visakhapatnam, remain limited. Visakhapatnam represents a rapidly expanding urban center with a mix of institutional healthcare facilities, private pharmacies, and surrounding peri-urban communities. Increased medicine accessibility, rising chronic disease burden, and over-the-counter availability may influence household medicine accumulation patterns. However, structured take-back infrastructure and standardized disposal messaging are not uniformly implemented in this region. In the absence of locally generated evidence, public health planning and pharmacy-led interventions cannot be optimally tailored. Understanding community behavior in this specific setting is therefore essential to inform regionally appropriate strategies for safe disposal, environmental protection, and responsible medicine stewardship.

Accordingly, this study explored public behavior and attitudes toward medicine disposal using a structured community survey. The objectives were to quantify knowledge and practices related to unused/expired medicines, assess awareness of take-back programs, and document preferred modalities for community education.

MATERIALS AND METHODS

Study design and setting

A community-based cross-sectional survey was conducted using an anonymous, structured questionnaire among adults affiliated with

Gandhi Institute of Technology (GITAM) (Deemed to be University), Visakhapatnam, Andhra Pradesh, India, including undergraduate and postgraduate students, faculty, administrative staff, and adult residents living in the surrounding campus locality. Data were collected over 2 months (December 2025–January 2026) in a single phase without follow-up. The study population represents an educated urban–peri-urban academic–community ecosystem with access to institutional health services and private pharmacies, and findings are interpreted within this defined setting.

Study population and eligibility criteria

Adults aged ≥ 18 years who were able and willing to complete the self-administered questionnaire were eligible. Participants who provided electronic informed consent and submitted the survey were included. Item-level completeness was assessed; responses with missing items were retained, and analyses were performed using the number of respondents answering each item as the denominator to maintain transparency.

Sample size estimation

The minimum sample size was calculated using a single-proportion formula with relative estimation error (relative precision), assuming a two-sided alpha level (α) of 0.05. The expected proportion (p) was set at 0.774 based on prior evidence, and the relative estimation error (ϵ) was fixed at 0.05 to ensure adequate precision of the prevalence estimate. The computation yielded a minimum required sample size of 449 participants. The formula applied was:

$$n \geq (Z_{1-\alpha/2})^2 \times [p(1-p)] / (\epsilon^2 \times p)$$

where $Z_{1-\alpha/2}$ is the standard normal deviate corresponding to the desired confidence level.

Study instrument

A pre-structured questionnaire consisting of 18 items was used to assess multiple domains: (i) Knowledge regarding medicine expiry and disposal, (ii) attitudes and perceived responsibility for safe disposal, (iii) awareness of take-back initiatives and guideline availability, (iv) household storage and segregation behaviors, and (v) usual disposal practices for expired medicines. A multiple-response item documented preferred modes for community education, including print media, electronic media, internet-based platforms, pharmacists, and physicians. The questionnaire was designed to be brief, easy to understand, and suitable for self-administration.

Data collection procedure

The questionnaire was disseminated as a self-administered electronic survey. Participation was voluntary, and respondents completed the tool independently without interviewer influence, thereby minimizing observer bias. Responses were automatically captured in a secure electronic format and exported to a spreadsheet/database for cleaning and analysis. No direct personal identifiers (name, phone number, and address) were collected. A single item assessed whether participants removed personal information from medicine packaging before disposal; this item did not require disclosure of any identifiable data.

Study variables and outcome measures

Primary outcome measures included: (i) The proportion of respondents reporting use of recommended disposal methods, (ii) awareness of existing take-back programs, and (iii) the most commonly reported household disposal routes for expired medicines. Secondary outcomes assessed beliefs about potential harm from expired medicines, perceived responsibility for disposal (government, healthcare professionals, and patients), willingness to participate in take-back programs if made available, and storage-related behaviors such as segregation of expired medicines and handling of tablets/containers before disposal.

Statistical analysis

Data were analyzed using descriptive and exploratory inferential statistics. Categorical variables were summarized as frequencies and

percentages. For items with missing responses, denominators were adjusted to reflect the number of respondents answering that specific question. Multiple-response items were analyzed as separate binary variables.

Exploratory subgroup analyses were performed to assess associations between selected demographic variables (e.g., gender) and key disposal practices using the Chi-square test. A value of $p < 0.05$ was considered statistically significant. Statistical analyses were conducted using standard spreadsheet-based tools.

Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee of GITAM Institute of Medical Sciences and Research (GIMSR) (Approval No. GIMSR/Admn./Ethics/approval/IEC-549/2025; dated 10.12.2025) before commencement of the study. Electronic informed consent was obtained from all participants before granting access to the survey instrument. Participation was voluntary, and respondents retained the right to withdraw at any stage without any adverse consequences. Anonymity and confidentiality were preserved by excluding direct personal identifiers, and access to the dataset was restricted to the research team for academic and analytical purposes only.

RESULTS

A total of 472 respondents completed the survey; the gender item was answered by 471 participants. Females constituted nearly two-thirds of respondents (65.0%), whereas males represented 35.0% (Table 1).

Knowledge regarding expiry and recommended disposal methods is shown in Table 2. While most participants checked expiry dates (94.3%) and considered expired medicines potentially harmful (64.6%

Table 1: Participant characteristics (gender distribution)

| Variable | Category | n | % |
|----------|----------|-----|-------|
| Gender | Male | 165 | 35.0 |
| Gender | Female | 306 | 65.0 |
| Total | | 471 | 100.0 |

Table 2: Knowledge about expiry and disposal of medicines (n=472)

| Item | Question | Response | n | % |
|------|---|------------------|-----|------|
| Q1 | Do you follow proper disposal methods for expired medication? | Yes | 11 | 2.3 |
| Q1 | Do you follow proper disposal methods for expired medication? | No | 446 | 94.5 |
| Q1 | Do you follow proper disposal methods for expired medication? | Maybe | 15 | 3.2 |
| Q2 | What happens if you use medicine after expiry? | Toxic | 305 | 64.6 |
| Q2 | What happens if you use medicine after expiry? | Remains same | 8 | 1.7 |
| Q2 | What happens if you use medicine after expiry? | Loses its effect | 159 | 33.7 |
| Q3 | Do you know the side effects of expired medicines? | Yes | 361 | 76.5 |
| Q3 | Do you know the side effects of expired medicines? | No | 47 | 10.0 |
| Q3 | Do you know the side effects of expired medicines? | Do not know | 64 | 13.6 |
| Q4 | Do you check expiry dates before buying/using medicines? | Yes | 445 | 94.3 |
| Q4 | Do you check expiry dates before buying/using medicines? | No | 14 | 3.0 |
| Q4 | Do you check expiry dates before buying/using medicines? | Do not know | 13 | 2.8 |

reporting “toxic”), only 2.3% reported following a recommended disposal method.

Perceptions about the drivers of unused medicines, responsible stakeholders, and system-level options are detailed in Table 3. Most respondents viewed education and guidance as central, and only 37.7% were aware of a take-back program.

Attitudes toward storage and preferred actions for unused medicines are summarized in Table 4. Returning to a medical store and donating to a welfare organization/hospital were equally preferred (35.8% each). A large share reported not keeping unused medicines at home (44.7%).

Preferred channels for improving community awareness are presented in Table 5. The internet was most frequently selected (79.9%), followed by electronic media (58.1%) and pharmacists (48.1%).

Reported disposal practices are summarized in Table 6. Disposal in household trash/dustbin was the dominant method (60.6%), whereas flushing was uncommon (2.1%). Willingness to participate in take-back initiatives was high (77.0%).

DISCUSSION

This community-based survey highlights a consistent pattern reported globally: Knowledge about expiry-related risk is comparatively better than actual safe disposal behavior. Nearly two-thirds of respondents believed expired medicines can become toxic, and most checked expiry dates, yet very few reported following recommended disposal methods.

Table 3: Perceptions and awareness regarding unused medicine management (n=472)

| Item | Question | Response | n | % |
|------|---|------------------------------|-----|------|
| Q5 | Main reason for accumulation of unused medicines at home | Decreasing number prescribed | 54 | 11.4 |
| Q5 | Main reason for accumulation of unused medicines at home | Donated | 56 | 11.9 |
| Q5 | Main reason for accumulation of unused medicines at home | Proper guidance to consumer | 362 | 76.7 |
| Q6 | Who is responsible for safe disposal of unused/expired medicines? | Government | 26 | 5.5 |
| Q6 | Who is responsible for safe disposal of unused/expired medicines? | Healthcare personnel | 52 | 11.0 |
| Q6 | Who is responsible for safe disposal of unused/expired medicines? | Both | 394 | 83.5 |
| Q7 | Do you know any official guidelines for medicine disposal? | Yes | 306 | 64.8 |
| Q7 | Do you know any official guidelines for medicine disposal? | No | 25 | 5.3 |
| Q7 | Do you know any official guidelines for medicine disposal? | Do not know | 141 | 29.9 |
| Q8 | Which formulation should not be disposed in dustbin? | Tablets/capsules | 248 | 52.5 |
| Q8 | Which formulation should not be disposed in dustbin? | Liquid formulation | 61 | 12.9 |
| Q8 | Which formulation should not be disposed in dustbin? | Do not know | 163 | 34.5 |
| Q9 | Are you aware of any take-back program? | Yes | 178 | 37.7 |
| Q9 | Are you aware of any take-back program? | No | 143 | 30.3 |
| Q9 | Are you aware of any take-back program? | Do not know | 151 | 32.0 |

Similar knowledge–practice gaps have been documented in tertiary-care consumer surveys and large urban populations, including India and other regions [1,2,7,8].

Programmatic awareness emerged as a key barrier. Fewer than four in ten respondents were aware of take-back programs, although three in four expressed willingness to participate if such programs were accessible. This finding aligns with evidence that community-based collection events can remove substantial quantities of medicines from circulation and may reduce diversion and unsafe household storage [6,9]. Where take-back infrastructure is limited, home-based disposal products and clear pharmacist counseling have been proposed to bridge the gap between intent and action [5,10].

Household disposal in trash remained the predominant practice, and a small but relevant proportion reported flushing medicines – an exposure pathway linked to environmental release of active pharmaceutical ingredients [3,11,12]. Environmental literature underscores that pharmaceutical residues can persist through treatment processes and contribute to downstream ecological effects, including selection pressure for antimicrobial resistance [11,13]. Therefore, behavioral interventions aimed solely at “checking expiry” are insufficient; disposal guidance must be explicit, convenient, and repeated.

The communication findings provide practical direction. The internet and electronic media were the most preferred awareness channels, indicating that digital risk communication could achieve a broad reach. However, pharmacists were also frequently selected, reinforcing the role of community pharmacies as trusted, point-of-care educators and potential collection hubs. Studies among students and healthcare

Table 4: Attitudes and intended actions related to unused medicines (n=472)

| Item | Question | Response | n | % |
|------|---|----------------------------|-----|------|
| Q10 | What do you do with unused medicines that are still usable? | Donate to welfare/hospital | 169 | 35.8 |
| Q10 | What do you do with unused medicines that are still usable? | Return to medical store | 169 | 35.8 |
| Q10 | What do you do with unused medicines that are still usable? | Keep at home until expired | 134 | 28.4 |
| Q11 | If you keep unused medicines, what is the main reason? | In case needed later | 120 | 25.4 |
| Q11 | If you keep unused medicines, what is the main reason? | Not sure how to dispose | 109 | 23.1 |
| Q11 | If you keep unused medicines, what is the main reason? | Do not want to waste | 15 | 3.2 |
| Q11 | If you keep unused medicines, what is the main reason? | To keep a stockpile | 17 | 3.6 |
| Q11 | If you keep unused medicines, what is the main reason? | I do not keep them | 211 | 44.7 |
| Q13 | Should the public be aware of proper disposal methods? | Yes | 455 | 96.4 |
| Q13 | Should the public be aware of proper disposal methods? | No | 17 | 3.6 |

Table 5: Preferred channels for awareness generation (multiple responses; n=472)

| Channel (multiple response) | n | % |
|-----------------------------|-----|------|
| Newspaper | 226 | 47.9 |
| Electronic media | 274 | 58.1 |
| Internet | 377 | 79.9 |
| Pharmacist | 227 | 48.1 |
| Physician | 208 | 44.1 |

Percentages do not sum to 100% because participants could select more than one channel

Table 6: Self-reported disposal practices and willingness to participate in take-back programs (n=472)

| Item | Question | Response | n | % |
|------|---|---------------------------|-----|------|
| Q14 | Do you remove personal details on the package before discarding? | Yes | 147 | 31.1 |
| Q14 | Do you remove personal details on the package before discarding? | No | 325 | 68.9 |
| Q15 | Do you keep expired medicines separately from other medicines? | Yes | 452 | 95.8 |
| Q15 | Do you keep expired medicines separately from other medicines? | No | 15 | 3.2 |
| Q15 | Do you keep expired medicines separately from other medicines? | Do not know | 5 | 1.1 |
| Q16 | Do you separate pills/tablets from their container before discarding? | Yes | 257 | 54.5 |
| Q16 | Do you separate pills/tablets from their container before discarding? | No | 215 | 45.5 |
| Q17 | How do you dispose of expired medicines? | Flush in toilet or sink | 10 | 2.1 |
| Q17 | How do you dispose of expired medicines? | Crushed before discarding | 65 | 13.8 |
| Q17 | How do you dispose of expired medicines? | Throw in dustbin | 286 | 60.6 |
| Q17 | How do you dispose of expired medicines? | Return to medical store | 61 | 13.0 |
| Q17 | How do you dispose of expired medicines? | Others | 50 | 10.5 |
| Q18 | Would you participate in a drug take-back program if available? | Yes | 363 | 77.0 |
| Q18 | Would you participate in a drug take-back program if available? | No | 109 | 23.0 |

trainees likewise show that targeted education can improve disposal attitudes, suggesting that sensitization within health systems can support wider community change [4,14-16].

Finally, the strong perception that responsibility is shared between government and healthcare personnel suggests public acceptance of coordinated interventions. Policy-level measures, including take-back regulations and standardized disposal messaging, have been advocated in multiple settings [17-19]. Collectively, the present findings support scalable, multi-channel strategies that combine public-facing education with accessible take-back options and pharmacy-led counseling to improve safe disposal.

Privacy deserves attention. Many respondents did not remove identifying details from packaging before discarding, which may facilitate disclosure or diversion. Simple steps – scratching out labels and sealing medicines – should be promoted in counseling and public messages [15,10,18].

Findings should be interpreted considering certain limitations. Disposal practices were self-reported and may be influenced by recall and social desirability bias. The cross-sectional design does not support causal inference between knowledge, attitudes, and behaviors. Item non-response led to variable denominators across questions. Further, the online, convenience-based recruitment within an academic-community ecosystem may have introduced selection bias, with possible over-representation of educated respondents with digital access; therefore, generalizability to the wider Visakhapatnam population and rural communities is limited. Future studies should consider stratified probability sampling and longitudinal or interventional designs to test whether targeted risk communication and accessible take-back options improve disposal behavior over time.

CONCLUSION

The survey demonstrates that the public is largely aware of medicine expiry risks and routinely checks expiry dates, yet safe disposal behaviors remain poor, and take-back awareness is limited. Trash disposal predominates, and a small proportion still flushes medicines. Willingness to participate in take-back initiatives is high, indicating readiness for implementation if programs are accessible. Integrating disposal counseling at dispensing points, expanding take-back mechanisms through community pharmacies, and delivering targeted digital/mass-media education may improve safe disposal and reduce environmental release.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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