Interventions to Manage Household Pharmaceutical Waste in Developing Economies – A Systematic Review

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ABSTRACT

Background: Household pharmaceutical wastes pose significant environmental and public health challenges, particularly in developing economies with limited formal disposal systems. This review evaluated interventions aimed at improving the management of such wastes in resource-limited settings.

Methods: This systematic review followed PRISMA 2020 guidelines. Studies were selected using the PICOS framework, focusing on interventional research on household pharmaceutical waste management in developing economies, published in English between January 2015 and July 2025. Searches were conducted in PubMed, ProQuest, ScienceDirect, and Google Scholar, supplemented by citation tracking. After duplicate removal and screening, eight studies met the inclusion criteria. Risk of bias was assessed using the Joanna Briggs Institute checklist.

Results: Eight studies were included from Malaysia (n=2), Kuwait (n=1), Egypt (n=3), Mangalore, India (n=1), and Nepal (n=1). Most studies (87.5%) implemented clinic-based educational programs, while one employed a take-back campaign. Half applied pretest–posttest designs without control groups. Sample sizes ranged from 100 to 500 participants, including patients with diabetes, community adults, students, and post-operative patients. All studies assessed practice; 62.5% measured knowledge, and 37.5% evaluated attitude. Educational interventions significantly improved knowledge. Practice and attitudinal changes were inconsistent. The multisectoral take-back campaign achieved the most promising improvement in safe disposal practices.

Conclusion: Effective management of household pharmaceutical waste in developing economies requires integrated strategies that combine education with accessible disposal systems. Future research should examine the long-term sustainability and scalability of such interventions across varied contexts.

Keywords: household pharmaceutical waste, developing economies, interventions, take-back campaign, multisectoral approach.

INTRODUCTION

Household Pharmaceutical Waste (HPW) represents an escalating global environmental, public health, and economic concern. (Rogowska & Zimmermann, 2022; Trueman et al., 2010). This issue is particularly concerning in developing countries due to underdeveloped waste management infrastructure and limited regulatory oversight. (Nazeer et al., 2016; Shewaye & Terefe, 2025)

HPW encompasses unused or expired prescription and over-the-counter medications, along with related accessories like syringes, needles, bandages, and packaging materials. (Magagula et al., 2022)

Improper disposal methods, such as flushing medicines or discarding them in household trash, (Auta et al., 2011) facilitate the leaching of active pharmaceutical ingredients into the environment. These contaminants are documented to harm aquatic life and wildlife (Hiew & Low, 2024), a problem compounded by inadequate wastewater treatment that allows pharmaceutical residues to persist and accumulate in ecosystems. (Chirisa et al., 2017; Hiew & Low, 2024)

Beyond environmental degradation, HPW poses direct risks to human health. Discarded sharps transmit infectious agents, including HIV and hepatitis, through needle-stick injuries and soil/groundwater contamination (Ugoeze et al., 2021; WHO, 2024). Unused medicines stored in homes increase the risk of accidental poisoning and misuse, particularly among vulnerable populations (Salim et al., 2022). Furthermore, the slow decomposition of associated plastics and packaging exacerbates pollution (Dey et al., 2024).

The economic consequences are equally pressing. While data for developing countries remains limited, the waste of medicines represents a substantial financial drain on already strained healthcare budgets, highlighting the need for better resource utilization and effective HPW management strategies (Hazel & Robson, 2015).

A key challenge is the dissonance between positive public attitudes and poor disposal practices in developing economies. (Hiew & Low, 2024) This gap is primarily attributed to a significant deficit in accessible disposal facilities and reliable guidance from healthcare professionals. (Hiew & Low, 2024) Effective interventions must, therefore, address these profound systemic barriers, not merely individual behaviour (Buffington et al., 2019).

While the prevalence and impacts of HPW are established, a comprehensive synthesis of effective interventions specific to developing economies remains a critical gap. Previous systematic reviews have focused on public knowledge, attitudes, and practices (Hiew & Low, 2024), broader recycling efforts, (Aquilina, 2024) or were predominantly based on studies conducted in developed nations (Alfian et al., 2024; Ma et al., 2025; Rahmadani & Kristina, 2021; Wang et al., 2024). Given the rapid increase in medicine accessibility and consumption in developing economies (Magagula et al., 2022; Malde & Noah, 2024; Rahmadani & Kristina, 2021) identifying feasible and sustainable HPW management strategies is an urgent imperative.

This systematic review aims to address this critical gap by comprehensively identifying, appraising, and synthesizing the available evidence on interventions designed to manage HPW specifically within developing economies. The findings will offer valuable insights for policymakers and public health professionals designing contextually appropriate mitigation strategies.

Specifically, this review attempts to answer the following research questions: What interventions have been implemented to manage HPW in developing economies? What were the reported outcomes of the implemented interventions? In which countries have those interventions been implemented?

METHODOLOGY

The methodology was guided by established protocols for conducting systematic reviews, aligning with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (Page et al., 2020). The protocol registration number for this review in the PROSPERO International Prospective Register of Systematic Reviews is CRD420251231202.

Eligibility Criteria (Inclusion and Exclusion)

The Population, Intervention, Comparison, and Outcome (PICOS) framework guided the selection of studies. The Population was restricted to studies conducted in developing economies focusing on household or consumer-generated pharmaceutical waste. Developing economies were defined according to the country classification in the United Nations' World Economic Situation and Prospects (WESP), 2019 edition (United Nations, 2019). This framework was selected because its grouping of developing economies aligned with the

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geographical scope of the review. Eligible Interventions included take-back programs, formal collection schemes, at-home disposal methods (e.g., deactivation pouches), public education campaigns, and relevant policy or regulatory actions. Comparison involved any comparator, including standard practice or no intervention. Outcomes encompassed effectiveness, adoption rates, public perception, implementation challenges, or documented environmental, health, or economic impacts. Only interventional studies reported in peer-reviewed journals and published between January 1, 2015, and July 31, 2025, in English were included. Exclusion Criteria eliminated studies focused on pharmaceutical waste from industrial or healthcare facilities (unless directly relevant to household settings), non-specified household medical waste, and observational, qualitative, or non-interventional designs.

Search Strategy and Information Sources

An extensive literature search was performed across PubMed, ProQuest, ScienceDirect, and Google Scholar to ensure broad coverage of the multidisciplinary research landscape. The PROSPERO database was also consulted to foster transparency and avoid research duplication. Search terms constructed using Boolean operators (AND, OR) and truncation, targeted core concepts and their synonyms related to HPW management. An iterative refinement process ensured keyword optimization for each database (Figure 1). Citation tracking and the "cited by" feature were additionally employed to systematically identify relevant foundational and recent literature.

1.PubMed: Results: 7831

Disposal[tw] OR Management{[tw] OR discard[tw] OR elimination[tw] OR destruction[tw] OR Improve[tw] OR Manage*[tw] OR Reduc*[tw] OR Dispos*[tw] OR Collection[tw] OR "Take-back"[tw] OR Program*[tw] OR Strateg*[tw] OR Practices[tw] OR "Awareness"[tw] OR Education[tw] OR Policy[tw] OR Regulation[tw] OR Recycling[tw] OR "Waste management"[tw] OR "Drug take-back programs"[tw] OR "Medication disposal programs"[tw] OR "Drug collection"[tw] OR "Drug return"[tw] OR "Mail back programs"[tw] OR "Public education campaigns"[tw] OR "Outreach programs"[tw] OR "Advocacy efforts"[tw] OR "Awareness-raising campaigns"[tw] OR "Sensitization campaigns"[tw] OR "Source reduction"[tw] OR "Waste minimization"[tw] OR Incineration[tw]

AND

"Household"[tw] OR Residential[tw] OR Domestic[tw] OR Home[tw] OR "Household unit"[tw] OR "Family unit"[tw] OR Private[tw] OR residence[tw] OR "Non-commercial"[tw] OR Consumer[tw] OR "In-home"[tw] OR Personal[tw] OR "Home-based"[tw] OR Community[tw]

AND

"Drug waste"[tw] OR "Medicat* waste"[tw] OR "Expired pharmaceuticals"[tw] OR "Unused medications"[tw] OR "Sharps waste"[tw] OR "Expired drugs"[tw] OR "Unwanted medications"[tw] OR "Damaged medications"[tiab:~0] OR "Damaged pharmaceuticals"[tiab:~0] OR "Damaged drugs"[tiab:~0] OR "Pharmaceutical Preparations"[Mesh]

2. Proquest: Results: 2055

(("pharmaceutical waste" OR "medication waste") AND ("household" OR "domestic") AND ("management strategies" OR "disposal methods" OR "reduction techniques" OR "take-back programs" OR "policies" OR "programs" OR "initiatives" OR “interventions”)) OR ("community-based pharmaceutical waste management" OR "household medication management") AND ("pharmaceutical waste reduction strategies" OR "medication disposal programs") AND ("household" OR "domestic" OR "community")

3. ScienceDirect: Results: 2433

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("Safe Disposal" OR "Household pharmaceutical Waste Management" OR "Unused Medication" OR "Expired medication") AND ("Household" OR "Domestic") AND ("Improvement" OR "Interventions" OR "Strategies")

4. Google Scholar (Advanced search). Results: 14400

("Safe Disposal" OR "Household pharmaceutical Waste Management" OR "Unused Medication" OR "Expired medication") AND ("Household" OR "Domestic") AND ("Improvement" OR "Interventions" OR "Strategies")

Figure 1: Search string for systematic review. Date: January 2015 – July 2025

Study Selection and Risk of Bias Assessment

All retrieved records were imported into Mendeley Reference Manager for automated and manual duplicate removal. The screening process adhered to PRISMA 2020 guidelines and occurred in two stages: initial review of titles and abstracts, followed by a rigorous full-text review against the predefined eligibility criteria to determine the final inclusion set. The methodological quality and potential for risk of bias in each included study were appraised using the Joanna Briggs Institute (JBI) checklists for quasi-experimental studies (Tufanaru et al., 2020) and that of randomised clinical trials (JBI, 2020) for one study that reported blocked randomisation. All authors independently conducted this appraisal, and any discrepancies in judgment were resolved through consensus-based discussion to ensure consistent methodological rigor.

Data Extraction and Synthesis

Relevant data were systematically extracted using a standardized data extraction MS-Excel form. This form was designed to capture key characteristics of the studies, including but not limited to: Author(s) and year of publication, country or region of study, type of intervention and study design, population demographics, characteristics of the intervention (e.g., type, duration) and results of the intervention. A narrative synthesis was selected for data integration in lieu of a meta-analysis.

RESULTS

The initial database search yielded 118 records (PubMed: n=32, ScienceDirect: n=17, ProQuest: n=20, Google Scholar: n=46), with an additional 3 records identified via reference list screening. After removing 43 duplicate records, 75 unique records underwent title and abstract screening, leading to the exclusion of 13 records. Of the 62 reports sought for full-text retrieval, 39 were inaccessible, leaving 23 full-text articles for detailed assessment against the eligibility criteria. Following full-text review, 15 articles were excluded due to reasons such as being purely theoretical/conceptual (n=6), focusing on non-household waste (n=2), model/technology development only (n=2), being conducted in a non-developing country (n=1), feasibility study only (n=1), focus on storage only (n=1), structural equation modelling (n=1), and a UN report (n=1). Ultimately, 8 studies met all inclusion criteria and were incorporated into the final narrative synthesis. This systematic selection process is illustrated in the PRISMA flow diagram (Figure 2).

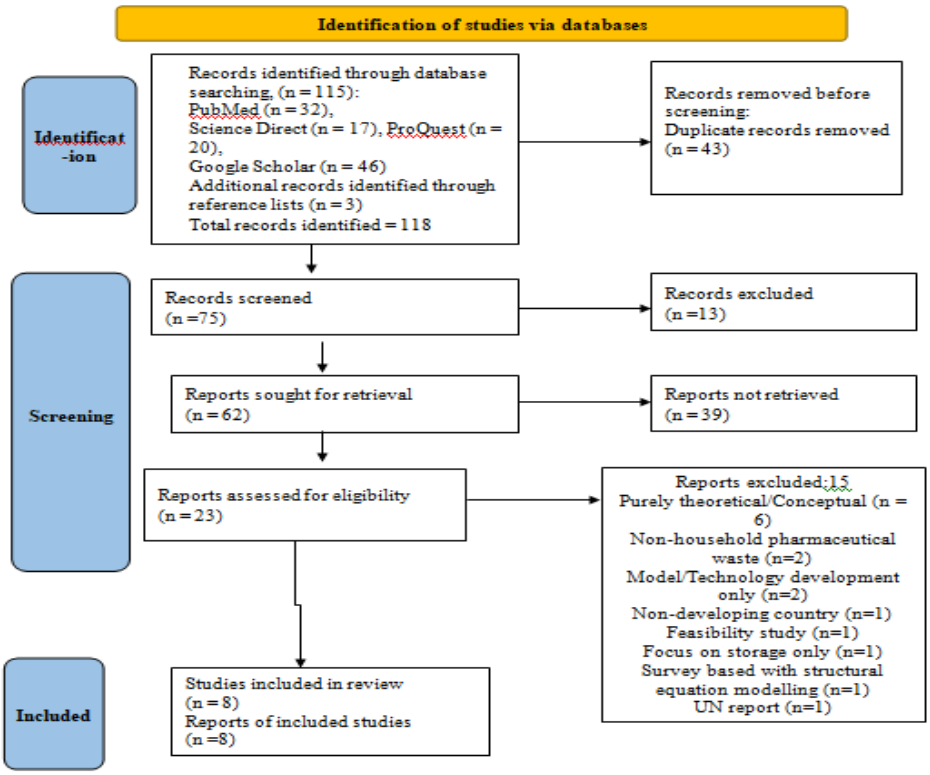


Figure 2: PRISMA flow diagram

From Table 1, the eight empirical studies included in the review, published between 2017 and 2024, originated from five developing economies: Egypt (n=3), Malaysia (n=2), and one each from Kuwait, Mangalore (India), and Nepal. Intervention Type: Most studies (n=7, 87.5%) implemented educational programs, with one study (n=1) employing a take-back campaign. The most common design was pretest-posttest without a control group (n=4), followed by pretest-posttest with intervention and control groups (n=3), and one posttest-only design (n=1). Interventions targeted diverse groups, most commonly diabetic patients (n=4), but also community-dwelling adults, post-operative patients, and paramedical students, with total participant numbers ranging from 100 to 500 across studies. The interventions were predominantly clinic-based (n=5). All eight studies assessed changes in practice, while a majority (n=5, 62.5%) measured knowledge, and a smaller proportion (n=3, 37.5%) evaluated attitude regarding HPW disposal.

Table 1. Location, design and study population

Variable	Frequency	Percentage
Location of study		
Egypt	3	37.5
Malaysia	2	25
Kuwait	1	12.5
Mangalore	1	12.5
Nepal	1	12.5
Study design		
Pretest posttest with one group only	4	50
Pretest-posttest with an intervention and control group	3	37.5
Posttest	1	12.5
Type of Intervention		
Educational sessions provided directly to study participants	7	87.5
Take-back campaign, including mass media	1	12.5

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Sample size		
100 - 300	5	62.5
301 - 500	3	37.5
Population		
Patients with diabetes	4	50
Post-operative patients	1	12.5
Community-dwelling adults	1	12.5
Paramedical students	1	12.5
Take-back campaign	1	12.5
Outcome measured and reported		
Knowledge	5	62.5
Attitude	3	37.5
Practice	8	100

Intervention delivery (Table 2) ranged from six educational posters with immediate reassessment in Lai et al. (2021) to lectures, discussions and demonstrations in Mohamed et al. (2017). El Gendi et al. (2017) addressed home insulin-injection waste management, while Nepal et al. (2020) provided pharmacist-led education over one week. Sandhra et al. (2024) evaluated education on opioid use, storage, handling and disposal among 180 postoperative patients and reported block randomisation into two groups of 90.

Hasan et al. (2019) and Soliman et al. (2024) combined sharps education with practical return arrangements.

Hasan recruited 136 participants and assessed outcomes at baseline, one month and three months. Soliman recruited 100 participants and conducted assessments at baseline, two months and four months. Mohamed included baseline, post-programme and follow-up assessments, although the interval to follow-up was not clearly specified. The Kuwait campaign used month-long multimedia publicity, with medicine collection undertaken over six working days and 56 aggregate collection-site hours.

Table 2. Characteristics of the interventions

Study	Setting	Design	Population	Delivery and timing
Lai et al. (2021)	Malaysia	One-group pretest–posttest	Community adults, 390 participants.	Six educational posters; immediate reassessment
Abahussain et al. (2024)	Kuwait	Uncontrolled campaign report	405 participating households	Multimedia publicity intervention lasted over 1 month, medicine collection; 56 collection hours
El Gendi et al. (2017)	Egypt	One-group pretest–posttest	500 adults with diabetes	Education on home insulin-injection waste. Study timeline not stated.
Sandhra et al. (2024)	India, Mangalore	Controlled pretest–posttest; reports block randomisation	180 postoperative patients; 90 per arm	Education on opioid use, storage, handling and disposal. Study lasted for 6 months.
Nepal et al. (2020)	Nepal	One-group pretest–posttest	150 undergraduate paramedical students	Pharmacist-led education. Intervention lasted a week. Study lasted for 7 months.
Soliman et al. (2024)	Egypt	Non-equivalent controlled study	100 adults with diabetes; 50 per arm at recruitment	Education and practical return pathway; assessments at 2 and 4 months post intervention

Hasan et al. (2019)	Malaysia	Controlled non-randomised study	136 adults with diabetes; 68 per arm at recruitment	Sharps education; baseline, 1 and 3 months
Mohamed et al. (2017)	Egypt	One-group pretest–posttest	100 adults with type 1 diabetes	Lectures, discussion and demonstrations. baseline with post and follow-up assessments. Study lasted for 3 months.

Table 3 summarises the measurement tools/methods and reported outcomes. Majority of the studies used questionnaires. Lai et al. (2021) reported an increase in median knowledge from 60% to 80%, with no significant overall attitude or practice change. El Gendi et al. (2017) reported increases in good knowledge, positive attitudes and good practice of 20.2, 47.0 and 15.0 percentage points, respectively, although conflicting knowledge means limited interpretation. Mohamed et al. (2017) reported mean knowledge and practice increases of 3.98 and 16.69 points at follow-up.

Among the controlled studies, Sandhra et al. (2024) reported reduced household-garbage disposal compared with controls from 59 down to 11 but only four intervention participants returned medicines to pharmacies, Soliman et al. (2024) reported four-month knowledge medians of 80% versus 60% and practice medians of 12 versus 4.4 in intervention and control groups. Hasan et al. (2019) reported a three-month knowledge mean difference of 22.65; 95% CI: 17.19, 28.12; $p < 0.001$.

Nepal et al. (2020) reported proper disposal increasing from 15.67% to 46.67%, based on disposal responses from 150 participants. Abahussain et al. (2024) collected 1,005 kg and 7,648 medicine items from 405 households, with expired and unused/unexpired medicines valued at 36,129 and 22,194 Kuwaiti dinars, respectively. These were collection outputs rather than comparative effects. Differences in tools, scales and assessment timing prevented direct comparison of changes across studies.

Table 3. Measurement methods and available descriptive changes

Study	Measurement	Reported outcomes or descriptive change
Lai et al. (2021)	Validated ReDiUM questionnaire; knowledge, attitude and practice domains; immediate posttest	Knowledge median 60% to 80%: +20 points on a 0–100 scale, p<0.001. Attitude 76% to 76%, p=0.764; practice 68% to 68%, p=0.183.
Abahussain et al. (2024)	Recorded medicines returned; quantity, weight and estimated value	1,005 kg and 7,648 items from 405 households. expired items cost was 36129 Kuwaiti dinars and that of unused/unexpired medications was 22194 Kuwaiti dinars.
El Gendi et al. (2017)	Interviewer-administered insulin-waste KAP questionnaire	KAP increased from 65.2%, 11.4% and 3% pre-education to 85.4%, 58.4% and 18% post-education. 57.08±27.84, 27.17±12.79 and 39.92±3.98 to 65.25±16.84, 46.75±14.55 and 42.83±5.56
Sandhra et al. (2024)	Questionnaire; 90 participants per arm; reported disposal categories	Disposal in household garbage: intervention 59/90 to 11/90, control 55/90 to 61/90. Pharmacy return: intervention 0/90 to 4/90, control 0/90 to 0/90.
Nepal et al. (2020)	Disposal questionnaire	Proper disposal from 15.67% to 46.67%.
Soliman et al. (2024)	Adapted Arabic interview questionnaire	At 4 months post intervention: increase knowledge in intervention group from median percentage of 60% pre intervention to over 80% post intervention. Practice from pre-to-post intervention was a median of 4.4 to 12. ($p <$ 0.001),
Hasan et al. (2019)		Baseline to 3 months follow up: Intervention: Knowledge: Adj. mean difference: 22.65; 95% CI: 17.19, 28.12; p <

	Validated knowledge and sharps-practice questionnaire; baseline, 1 and 3 months	0.001). Practice: $X^2(2) = 52.061$, $p < 0.001$ Control: Knowledge: not significant $p > 0.950$, Practice: $X^2(2) = 0.000$,
		$p > 0.950$.
Mohamed et al. (2017)	KAP questionnaire	Mean scores from baseline to 3 months posttest: Knowledge: 12.45±1.83 to 16.43±0.89; Practice: 6.78±2.68 to 23.47±4.70.

KAP = knowledge, attitude and practice; ReDiUM = Return and Disposal of Unused Medications. Numerical differences calculated for this revision are explicitly descriptive. Confidence intervals for paired changes cannot be recovered from marginal summaries without paired variance or individual transition data.

Table 4 compares the intervention approaches. Five studies evaluated education-only programmes, one evaluated a take-back campaign, and two evaluated combined approaches. Educational programmes generally reported improved knowledge or awareness, while attitude and practice findings were less consistent. The take-back campaign documented community participation and substantial medicine collection but did not measure changes in individual KAP.

The two studies combining education with sharps-return arrangements reported improvements in knowledge and disposal-related outcomes, with differences favouring the intervention over its respective control group at three or four months. These findings suggest potential benefit from combined approaches. However, neither study directly compared a combined approach with education alone nor take-back services alone; therefore, superiority over these alternatives cannot be established. No included study directly compared all three intervention approaches.

Table 4. Interpretation by intervention approach

Approach	Components and outcome pattern	Interpretation
Educational programmes (n=5) El Gendi et al., 2017; Mohamed et al., 2017; Nepal et al., 2020; Lai et al., 2021; Sandhra et al., 2024	Counselling, posters, leaflets, presentations or group teaching; some included demonstrations. Knowledge or awareness generally increased. Attitude and practice findings varied	Knowledge gains are more consistently described than changes in attitude or practice. Knowledge gains do not establish sustained disposal behaviour or environmental benefit.
Take-back campaign (n=1) Abahussain et al. (2024)	Multi-media publicity and pharmacist and/or student-supported collection at designated primary healthcare centres.	Encouraged participation at community level. Multifaceted approach might yield better results.
Combined approaches (n=2) Hasan et al., 2019; Soliman 2024	Structured sharps education plus clinic return arrangements. Soliman et.al. (2024) supplied free sharps disposal containers. Both reported better knowledge and disposal-related outcomes than comparison groups at three or four months.	Provides a means to act on advice, but the separate contribution of education and service access is not isolated.

Risk of Bias Assessment

Appraisal using the JBI Critical Appraisal Checklist for Quasi-Experimental Studies (Table 5) indicated that most eligible studies included in this review demonstrated clear descriptions of the intervention, appropriate follow-up, consistent measurements, and appropriate statistical analysis. A limitation across the other studies (62.5%) was the absence of a control group and there were no repeated measures pretest or posttest. The study by Sandhra et al. (2024) raises substantial concerns about risk of bias. Although described as a prospective interventional study, it reports block randomisation, with 90 participants in each arm. We therefore used the 13-

item JBI checklist for randomised controlled trials (JBI, 2020) (Table 6). The adequacy of randomisation remains uncertain.

Table 5: Risk of bias assessment using JBI checklist for quasi-experimental studies

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Lai et al. (2021)	Y	Y	N	N	N	Y	Y	Y	Y
Abahussain et al. (2024)	Y	NA	NA	N	N	NA	NA	U	Y
El Gendi et al. (2017)	Y	Y	U	N	Y	Y	Y	Y	Y
Nepal et al. (2020)	Y	Y	N	N	N	Y	Y	U	Y
Soliman et al. (2024)	Y	Y	N	Y	N	Y	Y	U	Y
Hasan et al. (2019)	Y	Y	N	Y	N	Y	U	Y	Y
Mohamed et al. (2017)	Y	Y	N	N	N	U	Y	U	Y

Y = Yes; N = No; U = Unclear; NA = Not applicable. Unclear denotes insufficient or conflicting reporting.

Q1 =Temporal sequence, Q2 = Comparable participants, Q3 = Other care or exposures, Q4 = Independent control, Q5 = Repeated measures before and after, Q6 = Follow-up and missingness, Q7 = Consistent measurement, Q8 = Reliable measurement, Q9 = Appropriate analysis.

Table 6: Risk of bias assessment using JBI checklist for randomised controlled studies for Sandhra et al. (2024).

No.	JBI criterion, abbreviated	Judgement
1	Random assignment	U
2	Concealed allocation	U
3	Baseline comparability	U
4	Participant blinding	N
5	Intervention-provider blinding	N
6	Outcome-assessor blinding	U
7	Equivalent care apart from the intervention	U
8	Complete follow-up or adequate handling of losses	U
9	Analysis according to original allocation	U
10	Consistent outcome measurement across groups	Y
11	Reliable outcome measurement	U
12	Appropriate statistical analysis	N
13	Appropriate trial design	Y

DISCUSSION

The findings of this systematic review reveal a complex and critical challenge in managing HPW within developing economies, underscoring the necessity of a comprehensive, context-specific approach. The limited number of identified studies highlights a significant global research disparity regarding HPW interventions in these regions (Alfian et al., 2024; Ma et al., 2025; Wang et al., 2024). While commonly attributed to financial, infrastructural, and regulatory deficits (Organisation for Economic Co-operation and Development [OECD], 2022; Rogowska & Zimmermann, 2022), this scarcity also reflects systemic research neglect in developing regions.

The review's most critical finding is that effective HPW management requires addressing both behavioral factors (knowledge and attitude) and systemic/infrastructural deficits. While educational and community-based interventions are lauded for improving knowledge, and, to a considerable extent, disposal practices which are consistent with the theoretical premise that informed individuals are more likely to adopt safe and

environmentally responsible behaviors (Galván-Mendoza et al., 2022; Manning, 2009), a critical analysis of the findings reveals their fundamental inadequacy. The success in raising awareness and improving knowledge is consistently undermined by a critical knowledge-practice gap, as demonstrated in the Malaysian study (Lai et al., 2021). This gap, also noted by Adedeji-Adenola et al. (2022), exposes the naive assumption that information alone can overcome entrenched behavioral, cultural, and infrastructural barriers. In other words, individuals cannot act on their knowledge of correct procedures and risks if there are no convenient collection points (Ehrhart et al., 2020). The success of the Kuwaiti take-back program (Abahussain et al., 2024) strongly reinforces this critique. By providing a temporary, accessible collection infrastructure, the campaign bypassed the knowledge-practice barrier and achieved significant, rapid results (Amster, 2016; Wang et al., 2024). Yet, the Kuwaiti case success is not a testament to a universal strategy but rather a direct function of Kuwait's high-income developing economy (Sharafuddin, 2023), which allowed for the mobilization of a well-funded, coordinated, and resource-intensive systemic intervention. Consequently, this example serves less as a blueprint for action and more as a stark reminder of the financial prerequisites that are fundamentally absent in most developing contexts.

Interventions targeting specific populations, like diabetic patients or healthcare students, were particularly effective. For instance, interventions embedded within clinical care (El Gendi et al., 2017; Soliman et al., 2024) and academic settings (Nepal et al., 2020) yielded substantial gains. These studies involved professionals who are uniquely positioned to educate patients on the environmental and health risks associated with improper disposal (Hiew & Low, 2024). Integrating pharmaceutical waste education into the training of healthcare students fosters a culture of environmental responsibility and equips future practitioners with the knowledge to guide communities effectively (Leonardi et al., 2024). Their engagement in awareness campaigns and take-back programs has been shown to improve disposal behaviors and reduce the accumulation of unused or expired medications in households (Abrons et al., 2010). This suggests that educational content tailored to the immediate needs and values of participants and reinforced by trusted educators enhances the translation of knowledge into practice (Gamage et al., 2021; Topping, 2022).

The review notes that changes in attitude were less uniformly reported. This is a critical observation, as behavior change is often driven not just by knowledge, but also by underlying beliefs, perceived risks, social norms, and self-efficacy (Albarracín et al., 2024; Davis et al., 2015). Lai et al.'s (2021) findings suggest that knowledge acquisition alone does not necessarily translate into improved attitudes or behaviors, a result that aligns with behavioral science theories such as the Health Belief Model and the Theory of Planned Behavior. Improving attitudes towards waste management is more difficult than enhancing knowledge or behavior (Ajzen, 1991). Thus, suggesting that deeper cultural, psychological, or systemic factors may influence willingness to engage in proper disposal practices.

STRENGTHS AND LIMITATIONS OF THE REVIEW

This systematic review adds to the limited evidence base regarding interventions for HPW management in developing economies, confirming that targeted education and take-back initiatives show promise. However, significant constraints limit the generalizability of the findings.

The primary limitation is the scarcity of interventional studies, which severely restrict geographical insights, particularly with the complete absence of data from regions such as Sub-Saharan Africa and Latin America. The included evidence was concentrated in a small number of Asian and North African countries, limiting its applicability to other developing economies. Differences in healthcare access, medicine-use practices, waste-management infrastructure, regulatory enforcement and the availability of medicine-return services may influence both intervention uptake and effectiveness. Studies from different settings have identified barriers related to disposal facilities, operational costs, unclear guidelines, public awareness and behavioural factors (Chong et al., 2022; Watkins et al., 2022; Viegas et al., 2023). Consequently, approaches that produced favourable outcomes in the included settings may require substantial adaptation before implementation elsewhere (Moore et al., 2021). This geographical gap reflects the evidence identified within the review's search and eligibility criteria; it does not establish that no relevant interventions exist in these regions.

The review is also limited by the databases searched and the publication period considered. Although several sources were consulted, relevant studies indexed in other databases or available through grey literature may have been missed. Restricting eligibility to publications from January 2015 to July 2025 may also have excluded earlier interventions and more recent evaluations. Expanding the databases and publication period could identify additional studies, potentially broaden the geographical coverage and influencing the synthesis and conclusions. However, whether such studies would meet the review's eligibility criteria remains uncertain.

Only eight studies were included overall, with fewer comparable studies for any specific outcome. Designs, measurement tools and assessment times differed substantially. Cochrane advises that asymmetry tests generally require at least ten studies in a comparable meta-analysis because power is low with fewer studies (Page et al., 2024). Publication bias and small-study effects, therefore, remain unassessed statistically; they cannot be declared absent. The English-language eligibility restriction may also have excluded relevant evidence. Registry and grey-literature searches, comparison of protocols with reports, and requests for unpublished findings could strengthen a future update.

Methodologically, the quality of included studies is limited by the absence of a clearly described randomized studies; most employed quasi-experimental designs, complicating the causal attribution of observed improvements. The absence of independent control groups in several included studies limits the extent to which observed improvements can be attributed to the interventions (Handley et al., 2018; Schmidt, 2017). Changes in knowledge, attitudes or disposal practices may partly reflect repeated exposure to the questionnaire, concurrent health education, or other changes occurring during the study period. Participants may also provide responses they believe the researchers expect, particularly when outcomes are self-reported. Consequently, statistically significant pre–post differences demonstrate change within the assessed group but do not establish that the intervention caused that change. Similarly, the Kuwaiti take-back campaign documented collection activity, but the absence of a baseline or comparator prevents estimation of its additional effect on disposal behaviour or medication safety.

Limited long-term follow-up further restricts conclusions and raises questions about about the durability of the findings. Although Hasan et al. (2019) and Soliman et al. (2024) assessed outcomes over three and four months, respectively, these periods provide limited evidence of sustained practice. Mohamed et al. (2017) included a follow-up phase, but its timing was insufficiently specified. In contrast, Lai et al. (2021) administered the posttest immediately after education, allowing assessment of immediate knowledge responses but insufficient opportunity for participants to demonstrate subsequent disposal behaviour. Initial improvements may diminish as information is forgotten, motivation declines or practical barriers persist. Longer observation could also reveal delayed benefits that immediate assessments would miss (Mueller et al., 2023). Measurement heterogeneity further limits comparison. Knowledge assessments differed in content, response format, scoring and thresholds, while attitude instruments covered different domains and were absent from several studies (El Gendi et al., 2017; Mohamed et al., 2017; Lai et al., 2021; Soliman et al., 2024). Practice outcomes included self-reported disposal choices, knowledge-application questions, observational checklists, clinic returns and quantities of collected medicines (Hasan et al., 2019; Nepal et al., 2020; Abahussain et al., 2024; Soliman et al., 2024). These measures capture related but distinct constructs. Expressing scores as percentages does not establish measurement equivalence, which requires consideration of instrument content and measurement properties (Prinsen et al., 2018). Similarly, collection quantities document programme activity rather than changes in individual behaviour. Uneven reporting of validation, reliability and scoring procedures adds uncertainty and limits the comparability of findings. These differences should remain explicit in the narrative synthesis (Campbell et al., 2020).

The role of pharmaceutical companies and industry-funded take-back programmes represents an additional gap in the included evidence. Although the studies examined education and collection activities, they did not establish how manufacturer involvement could influence programme financing, coverage or sustainability. Pharmaceutical companies could support collection containers, transport, public education and environmentally sound treatment of returned medicines. Such contributions may be voluntary or organised through extended producer responsibility, under which producers assume financial and/or organisational responsibility for managing their products after use. The OECD describes this approach as a means of supporting pharmaceutical-waste collection and treatment while shifting responsibility towards producers (OECD, 2022).

Industry funding could help maintain accessible return services beyond short-term campaigns, particularly where public resources are limited. However, its effectiveness should be evaluated rather than assumed. Programmes should have clear regulatory oversight, transparent financing and independently verified collection and disposal records (OECD, 2022; Viegas et al., 2023). Convenient collection points and free access for households are also important considerations in programme design (OECD, 2022).

Additionally, explicit use of behavioural theory was limited among the included interventions, restricting assessment of how programmes addressed determinants beyond knowledge. Research applying the Theory of Planned Behavior indicates that medicine-disposal intentions and practices are associated with attitudes, norms, perceived behavioural control and contextual factors such as convenience (Foon et al., 2020; Watkins et al., 2022). These findings suggest that knowledge-focused education alone may not address all barriers to appropriate disposal. However, this review cannot establish that limited use of theory caused the observed inconsistency between knowledge and practice.

These limitations weaken causal interpretation and confidence in the sustainability of reported improvements, without negating their preliminary value.

Implications for Research and Practice

The review's findings raise crucial considerations for both real-world implementation and future research investment.

Practice Implications

The persistent knowledge–practice gap demonstrates that educational interventions alone are insufficient.

Practitioners, including health workers and pharmacists, must adopt a dual strategy that integrates targeted awareness campaigns with accessible disposal infrastructure (e.g., pharmacy-based drop-off sites or community collection events). This approach is necessary to provide an actionable pathway for behavioral change.

Policy Implications

Policymakers must recognize that sustainable change requires moving beyond simple awareness. Policies should prioritize and fund integrated models that pair educational campaigns with take-back systems or government-supported disposal infrastructure. Furthermore, funding agencies must address research inequity by investing in context-specific research in underrepresented regions and incentivizing the use of behavioral models in program design to target the deeper social and psychological drivers of disposal behavior.

CONCLUSION

This review suggests that educational programmes can improve knowledge of HPW management, although improvements in attitudes and disposal practices were less consistent. Combined approaches that link education with accessible disposal services appear promising because they address both awareness and the practical opportunity to dispose of medicines appropriately. However, this interpretation remains tentative. The small, geographically limited evidence base, methodological weaknesses and heterogeneous outcomes do not establish the superiority of combined approaches over education or take-back services alone. More robust comparative evidence is required before recommending a preferred intervention model.

RECOMMENDATIONS FOR FUTURE RESEARCH

Future research should prioritise context-specific evaluations in Sub-Saharan Africa and Latin America. Where feasible, adequately powered cluster-randomised trials, with sufficient independently randomised clusters in each arm, should compare educational programmes, take-back services, combined approaches and usual practice. Studies should use validated measurement tools, repeated assessments over longer follow-up periods and independently verified disposal outcomes to establish whether behavioural improvements are sustained.

Evaluations should also examine cost-effectiveness, feasibility, equitable access and integration into existing healthcare and waste-management systems. Comparing industry-funded, publicly funded and jointly funded take-back models would clarify financing options and their influence on sustained participation, collection coverage and verified final treatment. The absence of these comparisons in this review limits conclusions about pharmaceutical companies' contribution; it does not indicate that industry-supported programmes do not exist. Such research would broaden the geographical relevance of the evidence and support locally appropriate policies for household pharmaceutical waste management. Until stronger evidence is available, the findings in this study should be interpreted as preliminary evidence of potential benefit rather than definitive evidence of sustained effectiveness.

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Competing Interests

The authors declare no competing interests.

Authors' Contributions

C.O. conceived the study, selected the topic, and developed the initial review protocol. D.O. and I.C. reviewed and refined the protocol. C.O. conducted the literature search; C.O. and D.O. performed data extraction and curation. All authors contributed to the synthesis and interpretation of findings. C.O. drafted the manuscript, which D.O. and I.C. critically reviewed and edited. All authors approved the final manuscript.

Consent

Not applicable. This systematic review did not involve direct recruitment of human participants.

Ethical Approval

Not applicable. This systematic review synthesized findings from previously published studies.

Data Availability

The data supporting the findings of this systematic review were obtained from previously published studies, all of which are cited in the manuscript. No new primary data were generated. The extracted and synthesised data are presented within the manuscript and its accompanying tables.

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REFERENCES

1. Abahussain, E., Alyahia, A., & Alajeel, N. (2024). A multisectoral approach to medication safety in Kuwait using the take-back campaign. Eastern Mediterranean Health Journal, 30(4), 304–311. https://doi.org/10.26719/2024.30.4.304
2. Abrons, J., Vadala, T., Miller, S., & Cerulli, J. (2010). Encouraging safe medication disposal through student pharmacist intervention. Journal of the American Pharmacists Association, 50(2), 169–173. https://doi.org/10.1331/JAPhA.2010.09208

3. Adedeji-Adenola, H., Adesina, A., Obon, M., Onedo, T., Okafor, G. U., Longe, M., & Oyawole, M. (2022). Knowledge, perception and practice of pharmaceutical waste disposal among the public in Lagos State, Nigeria. Pan African Medical Journal, 42. https://doi.org/10.11604/pamj.2022.42.106.34529
4. Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T
5. Albarracín, D., Fayaz-Farkhad, B., & Granados Samayoa, J. A. (2024). Determinants of behaviour and their efficacy as targets of behavioural change interventions. Nature Reviews Psychology, 3(6), 377–392. https://doi.org/10.1038/s44159-024-00305-0
6. Alfian, S. D., Adhinagoro, B., Winardi, D. O., Angela, F., Griselda, M., Gathera, V. A., & Abdulah, R. (2024). Pharmacist-led interventions in addressing improper disposal practices of unused and expired household medication: A systematic review. Heliyon, 10(18), e37764. https://doi.org/10.1016/j.heliyon.2024.e37764
7. Amster, E. D. (2016). Mitigating pharmaceutical waste exposures: policy and program considerations. Isr J Health Policy Res, 5(1), 58. https://doi.org/10.1186/s13584-016-0118-z
8. Aquilina, J. (2024). Public hospital waste segregation practices: A scoping review. [dissertation] University of Malta; 97p.
9. Auta, A., Omale, S., Shalkur, D., & Abiodun, A. H. (2011). Unused medicines in Nigerian households: Types and disposal practices. J Pharmacol Pharmacother, 2(3), 195-6. https://doi.org/10.4103/0976-500X.83290
10. Buffington, D. E., Lozicki, A., Alfieri, T., & Bond, T. C. (2019). Understanding factors that contribute to the disposal of unused opioid medication. J Pain Res, 12, 725-32. https://doi.org/10.2147/JPR.S171742
11. Campbell, M., McKenzie, J. E., Sowden, A., Katikireddi, S. V., Brennan, S. E., Ellis, S., Hartmann-Boyce, J., Ryan, R., Shepperd, S., Thomas, J., Welch, V., & Thomson, H. (2020). Synthesis without meta-analysis (SWiM) in systematic reviews: Reporting guideline. BMJ, 368, Article l6890. https://doi.org/10.1136/bmj.l6890
12. Chirisa, I., Bandauko, E., Matamanda, A., & Mandisvika, G. (2017). Decentralized domestic wastewater systems in developing countries: the case study of Harare (Zimbabwe). Appl Water Sci, 7(3), 1069–78. https://doi.org/10.1007/s13201-016-0377-4
13. Chong, K. M., Rajiah, K., Chong, D., & Maharajan, M. K. (2022). Management of medicines wastage returned medicines and safe disposal in Malaysian community pharmacies: A qualitative study. Frontiers in Medicine, 9, Article 884482. https://doi.org/10.3389/fmed.2022.884482
14. Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2015). Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review. Health Psychology Review, 9(3), 323–344. https://doi.org/10.1080/17437199.2014.941722
15. Dey, S., Veerendra, G. T. N., Babu, P. S. S. A., Manoj, A. V. P., & Nagarjuna, K. (2024). Degradation of plastics waste and its effects on biological ecosystems: A scientific analysis and comprehensive review. Biomedical Materials & Devices, 2(1), 70–112. https://doi.org/10.1007/s44174-023-00085-w
16. Ehrhart, A. L., Granek, E. F., Nielsen-Pincus, M., & Horn, D. A. (2020). Leftover drug disposal: Customer behavior, pharmacist recommendations, and obstacles to drug take-back box implementation. Waste Manag, 118, 416-425. https://doi.org/10.1016/j.wasman.2020.08.038
17. El Gendi, F. M., Elawady, A. M., Abed, A. H., & Eltaher, M. S. (2017). Effect of educational intervention on knowledge attitude and practice of home waste management of used insulin injections among diabetics attending Benha University Hospital. Eur J Prev Med. 5(1-1):1-6. https://doi.org/10.11648/j.ejpm.s.2017050101.11
18. Foon, P. Y., Ganesan, Y., Iranmanesh, M., & Foroughi, B. (2020). Understanding the behavioural intention to dispose of unused medicines: An extension of the theory of planned behaviour. Environmental Science and Pollution Research, 27, 28030–28041. https://doi.org/10.1007/s11356-020-09125-0
19. Galván-Mendoza, O., González-Rosales, V. M., Leyva-Hernández, S. N., Arango-Ramírez, P. M., & Velasco-Aulcy, L. (2022). Environmental knowledge, perceived behavioral control, and employee green behavior in female employees of small and medium enterprises in Ensenada, Baja California. Front Psychol https://pmc.ncbi.nlm.nih.gov/articles/PMC9806273/.
20. Gamage, K. A. A., Dehideniya, D. M. S. C. P. K., & Ekanayake, S. Y. (2021). The role of personal values in learning approaches and student achievements. Behav Sci (Basel), 11(7), 102. https://doi.org/10.3390/bs11070102

21. Handley, M. A., Lyles, C. R., McCulloch, C., & Cattamanchi, A. (2018). Selecting and improving quasi-experimental designs in effectiveness and implementation research. Annual Review of Public Health, 39, 5–25. https://doi.org/10.1146/annurev-publhealth-040617-014128
22. Hasan, U. A., Mohd Hairon, S., Yaacob, N. M., Daud, A., Abdul Hamid, A., Hassan, N., Ariffin, M. F., & Yi Vun, L. (2019). Effectiveness of diabetes community sharp disposal education module in primary care: An experimental study in North-East Peninsular Malaysia. International Journal of Environmental Research and Public Health, 16(18), 3356. https://doi.org/10.3390/ijerph16183356
23. Hazel, B., & Robson, R. (2015). Pharmaceutical waste reduction in the NHS. https://www.england.nhs.uk/wp-content/uploads/2015/06/pharmaceutical-waste-reduction.pdf
24. Hiew, S. Y., & Low, B. Y. (2024). The knowledge, attitude, and practice of the public regarding household pharmaceutical waste disposal: a systematic review (2013–2023). International Journal of Pharmacy Practice, 32(2), 120–132. https://doi.org/10.1093/ijpp/riae001
25. Joanna Briggs Institute (JBI). (2020). Critical appraisal checklist for randomized controlled trials [Checklist]. JBI Global. https://jbi.global/sites/default/files/2020-08/Checklist_for_RCTs.pdf
26. Lai, M. P. S., Tan, K. M., Lee, H. G., Wong, Y. Y., Wasi, A. N. A., & Sim, S. M. (2021). Effectiveness of an intervention to increase the knowledge, attitude, and practice regarding the return and disposal of unused medications. Malaysian Family Physician, 16(1), 56–63. https://doi.org/10.51866/OA1013
27. Leonardi, G. S., Zeka, A., Ashworth, M., Bouland, C., Crabbe, H., Duarte-Davidson, R., Etzel, R. A., Giuashvili, N., Gökdemir, Ö., Hanke, W., van den Hazel, P., Jagals, P., Khan, E. A., Martin-Olmedo, P., Pett, J., Ruadze, E., Santamaria, M. G., Semenza, J. C., Sorensen, C., … Lauriola, P. (2024). A new environmental public health practice to manage current and future global health challenges through education, training, and capacity building. Frontiers in Public Health, 12, 1373490. https://doi.org/10.3389/fpubh.2024.1373490
28. Ma, A. S. Bin, McLachlan, A. J., Abdel Shaheed, C., Gnjidic, D., Penm, J., Riley, T., & Mathieson, S. (2025). Effectiveness of interventions designed to increase safe medicine disposal: a systematic review and meta-analysis of randomised trials. Systematic Reviews, 14(1), 119. https://doi.org/10.1186/S13643-025-02820-4
29. Magagula, B. K., Rampedi, I. T., & Yessoufou, K. (2022). Household pharmaceutical waste management practices in the Johannesburg Area, South Africa. International Journal of Environmental Research and Public Health, 19(12). https://doi.org/10.3390/ijerph19127484
30. Malde, S., & Noah, N. M. (2024). Investigation of the household storage of medicines and disposal practices in Parklands sub-county in Nairobi, Kenya. Drug Science, Policy and Law. 10. https://doi.org/10.1177/20503245231225757
31. Manning, C. (2009). The psychology of sustainable behaviour. Tips for empowering people to take environmentally positive action. Gaffey T, Andre S, editors. https://www.pca.state.mn.us/sites/default/files/p-ee1-01.pdf.
32. Mohamed, A. M., Elalem, M. O., & Elsabour, A. M. (2017). Effect of educational programs on the knowledge, attitude, and practice of type 1 diabetic patients about proper sharps disposal at home. Port Said Scientific Journal of Nursing, 4(2).
33. Moore, G., Campbell, M., Copeland, L., Craig, P., Movsisyan, A., Hoddinott, P., Littlecott, H., O'Cathain, A., Pfadenhauer, L., Rehfuess, E., Segrott, J., Hawe, P., Kee, F., Couturiaux, D., Hallingberg, B., & Evans, R. (2021). Adapting interventions to new contexts—the ADAPT guidance. BMJ, 374, Article n1679. https://doi.org/10.1136/bmj.n1679
34. Mueller, J., Richards, R., Jones, R. A., Whittle, F., Woolston, J., Stubbings, M., Sharp, S. J., Griffin, S. J., Bostock, J., Hughes, C. A., Hill, A. J., Boothby, C. E., & Ahern, A. L. (2023). Supporting weight management during COVID-19 (SWiM-C): Twelve-month follow-up of a randomised controlled trial of a web-based, ACT-based, guided self-help intervention. International Journal of Obesity, 47, 51–59. https://doi.org/10.1038/s41366-022-01232-x
35. Nazeer, M., Tabassum, U., & Alam, S. (2016). Environmental pollution and sustainable development in developing countries. The Pakistan Development Review, 589–604. https://doi.org/10.30541/v55i4I-IIpp.589-604
36. Nepal, S., Giri, A., Nepal, S., Shastry, C. S., Chand, S., Aryal, S., Khanal, P., & Bhandari, R. (2020). Outdated and unused medicines disposal practice among the undergraduate paramedical students – a pharmacist's intervention. Le Pharmacien Hospitalier et Clinicien, 55(4), 327–333. https://doi.org/10.1016/j.phclin.2020.05.003

37. Organisation for Economic Co-operation and Development (2022). Management of pharmaceutical household waste: Limiting environmental impacts of unused or expired medicine Paris: OECD Publishing; https://doi.org/10.1787/3854026c-en
38. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ, n71. https://doi.org/10.1136/bmj.n71
39. Page, M. J., Higgins, J. P. T., & Sterne, J. A. C. (2024). Chapter 13: Assessing risk of bias due to missing evidence in a meta-analysis. In J. P. T. Higgins et al. (Eds.), Cochrane Handbook for Systematic Reviews of Interventions (Version 6.5). Cochrane. https://www.cochrane.org/authors/handbooks-and-manuals/handbook/current/chapter-13
40. Prinsen, C. A. C., Mokkink, L. B., Bouter, L. M., Alonso, J., Patrick, D. L., de Vet, H. C. W., & Terwee, C. B. (2018). COSMIN guideline for systematic reviews of patient-reported outcome measures. Quality of Life Research, Vol 27, 1147–1157. https://doi.org/10.1007/s11136-018-1798-3
41. Rahmadani, M. A., & Kristina, S. A. (2021). A scoping review of disposal of unused medicines in take-back programs. Journal of Management and Pharmacy Practice, 11(1), 73. https://doi.org/10.22146/jmpf.61343
42. Rogowska, J., & Zimmermann, A. (2022). Household pharmaceutical waste disposal as a global problem—A review. In International Journal of Environmental Research and Public Health (Vol. 19, Issue 23). MDPI. https://doi.org/10.3390/ijerph192315798
43. Salim, I., Jatau, A. I., Lawal, B. K., Haruna, A., Yunusa, I., Wada, A. S., Khalid, G. M., Jibril, K. Z., Sagir, M., & Mohammed, M. (2022). Assessment of unsafe disposal of unused and expired medicines practices among households in North-west Nigeria. The Nigerian Journal of Pharmacy, 56(2), 234–244. https://doi.org/10.51412/psnnjp.2022.26
44. Sandhra, R. N., Satish, S., & Ramakrishna, S. A. (2024). A hospital based interventional study to assess impact of patient education on usage, handling, storage and disposal of opioid analgesics. World Journal of Pharmaceutical Research, 13, 1323. https://doi.org/10.20959/wjpr202421-34536
45. Schmidt, W.-P. (2017). Randomised and non-randomised studies to estimate the effect of community-level public health interventions: Definitions and methodological considerations. Emerging Themes in Epidemiology, 14, Article 9. https://doi.org/10.1186/s12982-017-0063-5
46. Sharafuddin, H. A. (2023). Economic diversification in Kuwait macroeconomic implications. Journal of Sustainable Development, 16(6), 34. https://doi.org/10.5539/jsd.v16n6p34
47. Shewaye, A., & Terefe, G. (2025). The challenges and impacts of pharmaceutical waste management in low-income countries: A systematic review. International Journal of Management and Fuzzy Systems, 11(1), 21–32. https://doi.org/10.11648/j.ijmfs.20251101.12
48. Soliman, H. M. H., El-Zoka, A. H., Fetohy, E. M., & Hussein, M. F. (2024). The effect of an educational program on the knowledge and practices of diabetic patients regarding sharps waste disposal at home. Scientific Reports, 14(1), 30590. https://doi.org/10.1038/s41598-024-81308-y
49. Topping, K. J. (2022). Peer Education and Peer Counselling for Health and Well-Being: A Review of Reviews. International Journal of Environmental Research and Public Health, 19(10), 6064. https://doi.org/10.3390/ijerph19106064
50. Trueman, P., Lowson, K., Blighe, A., Meszaros, A., Wright, D., Glanville, J., Taylor, D., Newbould, J., Bury, M., Barber, N., & Jani, Y (2010). Evaluation of the Scale, Causes and Costs of Waste Medicines. York (UK): York Health Economics Consortium; https://discovery.ucl.ac.uk/1350234/1/Evaluation_of_NHS_Medicines_Waste__web_publication_version.pdf.
51. Tufanaru, C., Munn, Z., Aromataris, E., Campbell, J., & Hopp, L. (2020). Systematic reviews of effectiveness. In: Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis JBI; https://synthesismanual.jbi.global.
52. Ugoeze, K. C., Amogu, E. O., Oluigbo, K. E., & Nwachukwu, N. (2021). Environmental and public health impacts of plastic wastes due to healthcare and food products packages: A Review. Journal of Environmental Science and Public Health, 5(1), 1–31. https://doi.org/10.26502/jesph.96120114
53. United Nations. (2019). World economic situation and prospects 2019.

https://desapublications.un.org/publications/world-economic-situation-and-prospects-2019

54. Viegas, C. V., Bond, A., Pontes, A. T., Korzenowski, A. L., Bordin, R., Rosa, R. dos S., Coimbra, M. de A., & Bobek, P. R. (2023). Sustainability assessment of medicines reverse logistics in Brazil: Outcomes from the national and local systems. Sustainability, 15(20), Article 14675. https://doi.org/10.3390/su152014675
55. Wang, L. S., Aziz, Z., Wang, E. S., & Chik, Z. (2024). Unused medicine take-back programmes: a systematic review. Journal of Pharmaceutical Policy and Practice, 17(1). https://doi.org/10.1080/20523211.2024.2395535
56. Watkins, S., Barnett, J., Standage, M., Kasprzyk-Hordern, B., & Barden, R. (2022). Household disposal of pharmaceuticals: Attitudes and risk perception in a UK sample. Journal of Material Cycles and Waste Management, 24, 2455–2469. https://doi.org/10.1007/s10163-022-01494-7
57. World Health Organization (2024, October 24). Health-care waste https://www.who.int/news-room/fact-sheets/detail/health-care-waste.