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Review Article

Household pharmaceutical waste in South Africa: A Scoping Review of disposal practices, drivers, challenges, and potential solutions.

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Abstract

Background
Improper disposal of household pharmaceutical waste (HPW) poses significant health and environmental risks. In South Africa, many households retain unused and expired medicines, with unsafe disposal practices driven by limited awareness, over-prescribing, and easy access to medicines, particularly in rural communities. This review synthesises current evidence on disposal practices, drivers, challenges, and risks to inform policy development and support interventions for safer HPW management.

Methods
Following the Arksey and O'Malley scoping review framework and PRISMA guidelines, English peer-reviewed studies published between 2014 and 2024 were identified through PubMed, Google Scholar, ScienceDirect, and Sabinet. Studies addressing HPW generation, disposal, or management were included, while those published before 2014, not in English, or without full text were excluded. Data were extracted, charted, and synthesised thematically.

Results
Households frequently retained unused or expired medicines due to non-adherence, over-prescribing, large pack sizes, self-medication, and stockpiling. Unsafe disposal practices, such as discarding in household waste or flushing, were common. Structural and systemic factors, including limited public awareness, inadequate take-back systems, insufficient healthcare guidance, and weak regulatory enforcement, contributed to unsafe practices. The management of HPW is constrained by a combination of systemic, infrastructural, and behavioural factors. Together, these challenges impede the adoption of safe and sustainable disposal practices.

Conclusion
The HPW is influenced by multifaceted behavioural, structural, and systemic factors. Addressing these challenges requires coordinated interventions, including public education, improved regulatory frameworks, accessible take-back programs, and integration of disposal counselling into routine healthcare practice. These measures are critical to reduce risks, prevent environmental contamination, and promote sustainable HPW management.

Recommendations
Future efforts to manage HPW should prioritise the expansion of accessible take-back programs and the integration of disposal counselling into healthcare services. Continuous research and environmental monitoring should be conducted to inform interventions and support sustainable household waste management.

Keywords: *Household pharmaceutical waste, Disposal practices, Unused medicine, Expired medicine, Unwanted medication, South Africa*
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Introduction

Household pharmaceutical waste (HPW) refers to expired and/or unused medications frequently found at home. Correct disposal of HPW is vital as their long-lasting pharmacological effects can pose considerable health and environmental risks [1,2]. Globally, studies indicate that a large proportion of households retain leftover pharmaceutical products, often ranging from 40% to 60%, with antibiotics, analgesics, and remedies for common colds being the most frequently stored [3,4]. Key factors contributing to this accumulation include stopping treatment after symptom improvement, forgetfulness, self-medication, stockpiling, and, in certain instances, the death of the intended patient [5,6,7,8].

In South Africa, similar patterns have been observed. For instance, Mahlaba et al. [9] reported that 74.9% of patients attending primary healthcare clinics (PHCs) had unused medicines at home, yet 64.9% lacked knowledge of proper disposal methods, and 95.3% had never received guidance from healthcare professionals on how to dispose of such waste. Improper disposal contributes to environmental contamination, accidental poisoning in children, ecological harm, and antimicrobial resistance, as hazardous compounds discarded in household waste or sewage systems may persist and accumulate in the environment, posing significant public health risks [10,11]. Residual active pharmaceutical ingredients from antiretrovirals, analgesics, and neurological medication have been detected in South African surface water, groundwater, sediments, and marine species [12,13,14,15]. These compounds can bioaccumulate, exert toxic effects, and compromise ecological and human health. Despite these risks, national regulatory frameworks and monitoring systems for HPW remain limited, take-back programs are inconsistently implemented, and public awareness regarding safe disposal is low [16].

Several systemic and behavioural factors exacerbate the problem. At the provider level, many healthcare professionals lack training on medicine disposal and rarely counsel patients on safe disposal practices, while infrastructure for returning unused and expired medicines remains limited, particularly in rural areas [17]. At the household level, unsafe disposal practices are driven by limited awareness, self-medication, stockpiling, and retaining medicines for future use [9,18]. These behaviours are further exacerbated by over-prescribing, dispensing practices that provide quantities beyond patient needs, and large pack sizes, all of which increase the likelihood of leftover medicines [19,20]. Easy access to medicines through both formal and informal channels also promotes self-medication and stockpiling, amplifying household accumulation [9,16]. Collectively, these factors highlight HPW as a complex, multifactorial problem shaped by patient behaviours, healthcare system gaps, and regulatory shortcomings, underscoring the need for comprehensive evidence synthesis.

To curb environmental risks, several countries have introduced take-back initiatives such as pharmacy-based collection sites, drop-boxes, and mail-back systems for HPW [21,22,23]. Despite increasing attention to this problem, knowledge gaps persist in the South African context. Most studies address the management of healthcare waste within healthcare facilities, with comparatively little attention given to HPW. Where research exists, it predominantly focuses on urban populations, with limited investigation into rural and marginalised communities. This gap underscores the need for context-specific evidence to guide policy and support sustainable disposal strategies.

Accordingly, this scoping review maps available evidence on HPW in South Africa, focusing on disposal practices, drivers of accumulation, associated public health and environmental risks, and HPW management challenges. The review seeks to synthesise current knowledge to inform policy development and support interventions for safer HPW management.

Aim and objectives

This review aimed to conduct a scoping review of peer-reviewed literature to examine the disposal practices of HPW and to explore the drivers, associated risks, challenges, and potential solutions related to HPW in South Africa. This scoping review addresses the following research questions:

- What factors contribute to the accumulation of HPW in South Africa?
- What methods are currently used by South African households to dispose of HPW?
- What are the key challenges in ensuring the safe and appropriate disposal of HPW?
- What possible risks to human health and the environment exist with the current HPW disposal practices?

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- What interventions or strategies can be implemented to improve HPW management in South Africa?

Methods

This study employed a scoping review methodology to thoroughly map available evidence on the wide-ranging and multifaceted issue of HPW management. In the South African context, research on HPW is limited, particularly in rural settings. Utilising a scoping review facilitates the identification of these research gaps and supports the guidance of future research directions, policy formulation, and practical interventions [24]. The Arksey and O'Malley [25] framework was employed in this scoping review. Identifying the research question, finding pertinent studies, selecting studies, mapping the data, collating, summarising, and reporting the findings, and consulting with important stakeholders are all elements of the framework [25]. To achieve the aim of this review, only five of the six phases in the Arksey and O'Malley model were adopted. Furthermore, this review employed a systematic strategy to examine and synthesize existing data regarding gaps in the literature discussing the drivers, related risks, challenges, and potential solutions related to HPW management in South Africa.

Step 1: Identifying the research question

The main review question was: *What are the disposal practices, drivers, and challenges associated with HPW management in South Africa?*

Step 2: Identifying relevant studies

The authors independently searched PubMed, Google Scholar, ScienceDirect, and Sabinet to identify relevant studies from January 2014 up to December 2024. The search was restricted to English-language scholarly publications. The following keywords were used: "household pharmaceutical waste", "unused medicines", "unwanted medicines", "expired medicines", "drivers", "disposal practices", "challenges", "impacts", "management", "South Africa" and were combined using the Boolean operators "AND", "NOT," and "OR."

Step 3: Selecting studies

All the authors independently conducted the title and abstract screening as well as the full-text review of the eligible articles. Microsoft EndNote's duplication check was used to eliminate duplicates from the search results. To choose possibly pertinent citations, all authors then separately examined each search result through titles and abstracts. Following a discussion and comparison of the screened results, the full text was retrieved online and thoroughly examined, considering the inclusion criteria. As the authors agreed, (i) the inclusion and exclusion criteria were clarified with an emphasis on the scope and methodology of the articles; (ii) the justification behind each article's selection was discussed; (iii) the evidence presented in the articles was carefully examined in relation to the selection criteria; and (iv) the justifications for each article's final status were documented.

The following inclusion and exclusion criteria were applied:

Inclusion criteria

- The authors included English peer-reviewed articles published from January 2014 to December 2024, irrespective of their design. The timeframe was chosen to cover 10 years of literature documenting the disposal practices of HPW, improvements in health systems, and the development of environmental awareness. Restricting the review to this timeframe allowed for the inclusion of recent and contextually relevant evidence, while omitting older studies that may not reflect present-day practices or policy contexts.
- Articles that had at least one or more identified keyword in the title.

Exclusion criteria applied

- Studies that did not address HPW.
- Studies that were published over a decade before the start of this study, in languages other than English, or whose full texts were not available.

Step 4: Charting the data

The authors carried out the data extraction independently, and any disagreements were discussed and resolved by consensus. A Microsoft Excel spreadsheet was used to extract data on the study's properties and outcomes, and the accuracy of the data

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extraction process was verified. For each included study, data were captured on study characteristics (author, year, location, setting, design, and sample size) and key findings. Information was also collected on the types and frequency of unused or expired medicines, factors contributing to their accumulation (such as non-adherence, over-prescribing, stockpiling, and self-medication), and disposal methods (including returns to pharmacies, flushing, or household waste). Additional data included public awareness levels, the existence of take-back programmes, healthcare guidance, and the policy or regulatory context. Where reporting varied across studies, data were standardised into comparable categories to facilitate thematic synthesis. "Improper disposal" was defined as any practice posing potential health or environmental risks, while "take-back systems" referred to organised processes enabling medicine returns.

Step 5: Collating, summarising, and reporting the results

Critical data from included studies were compiled by the first author, who also evaluated their characteristics and thematically synthesised the study findings. To provide an understanding of the relative priority assigned to the drivers, HPW challenges, and disposal practices, a thematic framework was created and assessed. The co-authors then verified and approved the themes that were identified.

Step 6: Consultation with key stakeholders

Consultation was not incorporated in this study, as the primary objective was to analyse existing peer-reviewed literature on disposal practices, drivers, HPW challenges, and potential solutions associated with HPW management in South Africa.

Results

A total of 283 studies were identified by searching databases [PubMed (n=97), Google Scholar (n=136), ScienceDirect (n=35), and Sabinet 9n=10)], and five additional studies were identified through grey literature. Microsoft EndNote's duplication check was used to eliminate 50 duplicates from the search results. Following the title and abstract examination, 125 studies were removed because the content did not fit the scope of the review. After applying all exclusion criteria, seven studies met the inclusion requirements and were maintained for synthesis. Other studies were excluded from the study because they were conducted outside South Africa, were not related to HPW, and were not published in the English language (Figure 1).

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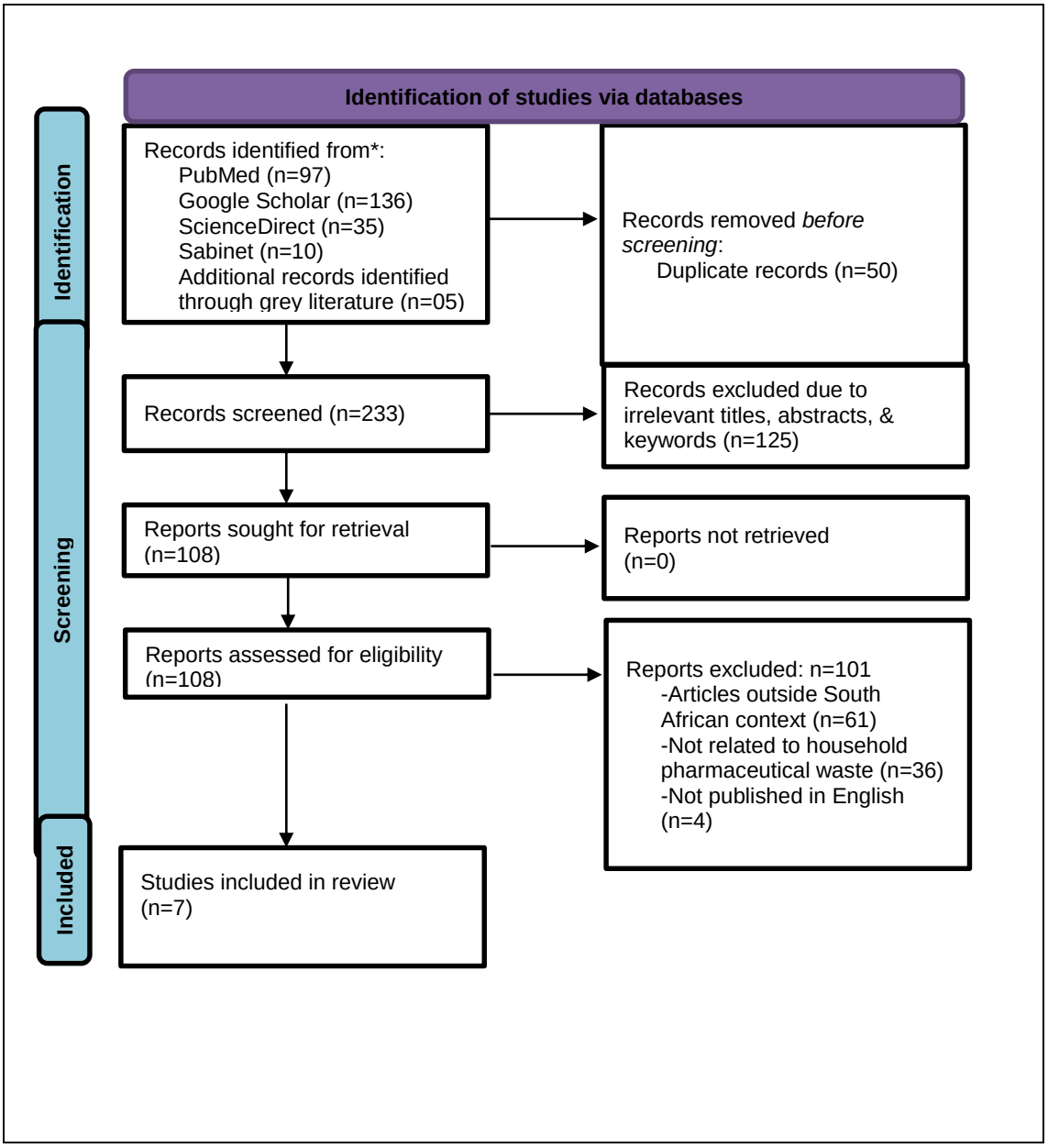

Figure 1: Study selection flow diagram

Table 1a and 1b provide information about the articles' characteristics, including the author and year of publication, the study's setting, sample size, the variables that contribute to their accumulation, and disposal procedures.

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Table 1a: Characteristics of included studies

Author (Year)	Location	Sample Size	Factors driving accumulation	Disposal practices
Mogajane et al. (2024)	Mamelodi Hospital, Gauteng.	370	Irrational medicine usage and treatment failures; Patients are not informed by their health care providers on proper disposal; Storing of medicines for future use.	Return to pharmacy/healthcare facility (44%); Throw in the trash bin, river, and bush (35%, 12%, & 10%, respectively); Flushing in the toilet (42%); Incineration (15%); Keep the medicines for future use (31%); Discard unused medicines into the sewage and sink (22% & 14%, respectively).
Matlakala (2024).	Tshwane, Gauteng province		Inadequate infrastructure and facilities; inadequate policy implementation; limited treatment infrastructure; cultural and Behavioural Factors; lack of public awareness; and inadequate regulations and enforcement regarding disposal.	Disposal practices were not discussed.
Mahlaba et al. (2022)	Tshwane, Gauteng Province	171	Non-adherence (33%, n=56); Limited guidance by healthcare providers about safe HPW disposal (95%, n=163); Lack of awareness on correct disposal of HPW (65%, n=111); Storing of medicines with the intention of using them at a later stage.	Flushing HPW down the toilet (26%, n=44) and in a basin/sink (6%, n=10); Municipal bin (24%, n=41); Designated collection task teams (25%); Dissolving of unused medicines in water (39%).
Magagula et al. (2022)	Johannesburg, Gauteng	371	Lack of awareness (23%, n=85); Lack of household waste segregation (33.4%); non-adherence seen by left-over antibiotics (33%, *n*=122).	Disposed of with their general household waste (~63%, n=235); Throw it outside the house (~20%, n=75); Incineration (~11%, n=40); Flushing medicines in kitchen sinks and toilet drains (~22%, *n*=83); Returned it to hospitals and pharmacies (~11%, n=40); Keep it indefinitely in the household (~23%, n=84).

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Table 1b: Characteristics of included studies

Author (Year)	Location	Sample Size	Factors driving accumulation	Disposal practices
Maharaj et al. (2020)	eThekwini Metro, KwaZulu-Natal.	484	Poor patient education from healthcare providers (75%); Lack of knowledge on proper disposal of HPW (62%); No counselling by healthcare providers about safe HPW disposal (76%); Storing of medicines with the intention of using them at a later stage (12%); non-adherence seen by left-over antibiotics (37%).	Throw medicines in the bin (56%); toilet (41%); sink (17%); Dumping in household refuse (34%); Return unused and expired medicines to pharmacy (31%) and hospital (34%).
Okonkwo Ihebe (2019).	Cape Town, Western Cape	162	Lack of knowledge on proper disposal methods (56%); Limited guidance by pharmacists about safe HPW disposal (68%); Storing of medicines for future use (58%); Felt better and discontinued treatment (19%); Medicines had expired (7%); Received an excess supply (6%); Discontinued treatment due to side effects (6%); Change of treatment (4%); Lack of an existing disposal program	Disposal into the trash bin (45%); Flushing down the drain (31%); Returned to pharmacy (21%); Gave the medicines to someone with a similar health condition (14%).
Mashiane (2017)	Johannesburg, Gauteng	202	Medicines had expired (58%, n=115); non-adherence to treatment (26%, n=51); Discontinued treatments due to side effects (14%, n=28); Felt better and discontinued treatment (51%, n=100); Received an excess supply of medication (3%, n=6); Doctor prescribed too many medicines (11%, n=21); Limited guidance about safe HPW disposal (72%, n=144); Limited public knowledge (72%, n=144).	Disposal into the trash bin (52%, n=102); Flushing down the sink/toilet (34%, n=66); Return the medicines to pharmacy (13%, n=26); Keep the medicine (16%, n=32).

The additional findings of the individual sources of evidence are summarised in Table 2 in alignment with the scoping review questions. Key challenges were weak policy implementation, lack of awareness, and absence of structured return systems. Reported risks included environmental contamination and accidental exposure. Suggested interventions centred on public education, pharmacist-led take-back initiatives, and improved regulatory frameworks. These findings informed the thematic synthesis presented in the subsequent subsections (Sections 4.1-4.3).

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Table 2: Synthesis of the key findings in relation to review questions.

Author	Key challenges	Risks to health and the environment	Suggested interventions
Mahlaba et al. (2022)	Limited provider communication; lack of disposal points.	Risk of water contamination; Community exposure.	Education and counselling at the facility level.
Magagula et al. (2022)	No take-back systems; Weak public participation.	Environmental pollution via landfill and water.	Community awareness and waste segregation campaigns.
Maharaj et al. (2020)	Weak regulation; No disposal infrastructure.	Contamination of sewage; Exposure to children and pets.	Pharmacist-led return programmes
Mashiane (2017)	Lack of awareness; No policy implementation.	Chemical pollution; Misuse.	National awareness campaign.
Okonkwo Ihebe (2019)	Inadequate public education	Human exposure and water pollution.	Pharmacist education role.
Mogajane et al. (2024)	Lack of clear communication channels.	Contamination from improper disposal.	Strengthened counselling & take-back systems.
Matlakala (2024)	Weak enforcement; Resource limitations.	Broader environmental risk.	Policy and system strengthening.

Factors contributing to the accumulation of household pharmaceutical waste.

High prevalence of leftover medicines due to non-adherence and improved symptoms or death of a patient.

The reviewed South African studies report a high prevalence of medicines retained at households, particularly painkillers, cold and flu remedies, and antibiotics [9,18]. Leftover medicines were commonly attributed to stopping treatment once symptoms improved, forgetfulness, or, in some cases, the death of the intended patient. However, existing evidence is limited, largely descriptive, and provides little understanding of the extent of accumulation across communities, the behavioural and health system factors behind treatment discontinuation. Few studies assessed the broader risk of retained medicines, including antimicrobial resistance, self-medication, or environmental contamination [1,12,13].

Comparable trends were observed in global surveys and systematic reviews, with a significant proportion of households retaining leftover medicines, most frequently antibiotics and analgesics, with treatment discontinuation following perceived recovery being the commonly cited reason for incomplete packs [2,3,4,8]. Similarly, household studies in low- and middle-income countries (LMICs) reported incomplete treatment courses and the practice of keeping medicines "for future use" as common contributors to accumulation [26,27]. The widespread retention of antibiotics is particularly concerning due to the potential for antimicrobial resistance if these medications are later used inappropriately.

Over-prescribing, over-dispensing, and the provision of larger quantities than needed

Systematic reviews and regional studies suggest that supplying medicines in quantities exceeding patients' needs due to over-prescribing, repeat dispensing without clinical review, or large commercially available pack sizes is a key factor contributing to the accumulation and eventual expiry of medicines in households [28,29]. Analyses of antibiotic pack sizes and distribution patterns also reveal discrepancies between recommended treatment durations and the quantities dispensed, increasing the likelihood of partially used packs remaining after therapy. Additionally, health system and supply chain studies, along with practitioner surveys, indicate that routine repeat dispensing, stockpiling from chronic prescriptions, and insufficient prescription review during refills contribute to the accumulation of surplus medicines in households [30].

In South Africa, several studies report high levels of unused medicines in households. Mahlaba et al. [9]

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found that 74.9% of patients attending PHCs had unused medicines at home, with very few returned to clinics. Analgesics, cold/flu remedies, and, in some instances, antibiotics were the most frequently retained medicines [18]. Despite some awareness of environmental risks, most unused medicines were reportedly disposed of improperly, including being thrown into household waste or flushed down drains. Dispensing practices varied across regions: pharmacists in Johannesburg often dispensed larger OTC analgesic pack sizes than physicians [19], while in Limpopo the average number of medicines per encounter exceeded WHO recommendations, indicating potential over-prescribing [20]. Collectively, these findings demonstrate consistently high prevalence of unused medicines across households, influenced by both supplier-side factors and household disposal practices.

Self-medication, stockpiling, and easy access to medicines

Household surveys in South Africa indicate that individuals often purchase or keep medicines for potential future use, particularly over-the-counter (OTC) products such as analgesics, antibiotics, and cough syrups. This behaviour is facilitated by easy access to medicines through both formal and informal supply channels, promoting self-medication and stockpiling [9,16]. Padayachee et al. [16] reported that 60-70% of beneficiaries submitted claims for OTC medicines obtained directly or recommended by a pharmacist, reflecting widespread self-medication.

Global evidence aligns with these trends, showing that self-medication and stockpiling are common in LMICs, facilitated by the availability of OTC medicines through pharmacies, retail outlets, and online platforms. Individuals frequently use drugs, herbal remedies, or home treatments on their own initiative or based on non-professional advice, often without consulting healthcare providers. For instance, studies across Sub-Saharan Africa show that individuals frequently self-medicated with OTC drugs, motivated by factors such as convenience, cost savings, prior experience with the medication, and mild symptoms [31,32,33]. These patterns contribute to the accumulation of HPW. While these practices may provide short-term convenience, they carry long-term risks, including medication misuse, adverse drug reactions, and environmental contamination.

Low public awareness and a lack of take-back systems

Household surveys in South Africa indicate that a substantial proportion of individuals lack knowledge of proper methods for disposing of unused or expired medicines. Mahlaba et al. [9] reported that most patients were unaware of appropriate disposal methods and had never received guidance from healthcare professionals regarding disposal. Similarly, Magagula et al. [18] and Maharaj et al. [34] found that most individuals had not been counselled on medicine disposal, and only a small fraction returned medicines to health facilities. These findings highlight that inadequate public awareness and limited access to convenient medicines take-back options are key drivers of the accumulation of HPW.

A review of South Africa's waste management policies alongside community practices further identified limited disposal infrastructure and insufficient public education, contributing to the retention of unused medicines in households [35,36]. Although South African regulations allow the return of expired or unused medicines to pharmacies, the absence of a coordinated national take-back system, coupled with low awareness among both the public and healthcare professionals, continues to restrict effective and safe HPW disposal [9,18,34]. These findings highlight that there is a need for implementing and promoting accessible take-back initiatives alongside targeted public education campaigns to minimise the risks linked with improper disposal of HPW.

Global evidence mirrors the patterns observed in South Africa. In the European Union, although member states are legally required to provide medicine take-back programs, variations in implementation, accessibility, and public awareness lead to inconsistent use of safe disposal methods [21]. Similarly, a systematic review of studies from the USA, Europe, Australia, Mexico, and New Zealand found that countries with clear legislation, readily accessible collection points, and strong public awareness initiatives achieved higher rates of medicine returns, whereas in settings with unclear regulations or weak supporting systems, unused medicines frequently accumulated in households and were disposed of unsafely [37].

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Comparable patterns are observed elsewhere in Africa, where low public awareness and limited access to organised medicine take-back systems drive the accumulation of HPW. For instance, in Ethiopia, only 23.8% of individuals reported receiving guidance on proper disposal, while 46.9% were unaware of the potential harms associated with improper disposal [38]. In Zambia, community pharmacies faced difficulties in implementing government-led take-back initiatives due to logistical challenges and low public participation [39]. Unsafe disposal practices, such as discarding medicines in household waste or flushing them, remain widespread due to limited knowledge of safe disposal methods and the absence of structured disposal programs [38]. These findings highlight that without both effective education and accessible, structured take-back programs, accumulation of HPW and improper disposal will remain widespread across the countries.

Disposal practices of household pharmaceuticals in South Africa

Evidence from South African studies indicates that HPW disposal practices are frequently unsafe. Common disposal practices include discarding unused or expired medicines in household waste, flushing them, storing them improperly, sharing with others, or keeping them for future use [9,18,35,36,40,41]. These practices are consistently associated with a lack of awareness of proper disposal methods, limited engagement with take-back programs, and insufficient guidance from healthcare professionals.

Evidence from international studies supports these observations. Household surveys in Europe and Asia consistently show that a significant proportion of unused medicines are discarded in household waste or flushed down sinks, despite awareness of environmental risks [8,42]. Factors such as large pack sizes, over-prescribing, and medication stockpiling are common contributors, indicating that unsafe disposal practices represent a global challenge rather than being confined to LMICs. Comparable patterns have been observed across other African countries. In Ethiopia, only 23.8% of households reported receiving guidance on proper medicine disposal, with nearly half unaware of the risks associated with unsafe practices [38]. In Zambia, community pharmacies reported challenges in implementing take-back programs due to logistical constraints and low public participation [39]. Similarly, studies from Ghana, Ethiopia, Tanzania, and Uganda indicate that self-medication and stockpiling of OTC medicines contribute to accumulation and improper disposal [7,26,33,43]. These findings highlight a consistent pattern across the continent, where limited awareness, absence of formal disposal systems, and informal storage practices drive unsafe disposal behaviours.

Although overall patterns are similar, important contextual differences exist. South African research consistently points to the lack of formal take-back mechanisms and limited guidance from healthcare professionals as key barriers [9]. By contrast, several high-income countries (HICs) have implemented structured take-back systems and pharmacy-driven initiatives, which have resulted in modest improvements in disposal practices [37]. Notably, few South African studies have quantified the proportion of households engaging in safe disposal initiatives, and limited research has evaluated the interventions aimed at improving disposal behaviours. Evidence from Europe demonstrates that structured take-back schemes and targeted interventions can significantly reduce unsafe disposal, offering valuable insights for South African policy and practice [29].

The HPW disposal practices in South Africa mirror trends observed across Africa and globally, with unsafe methods such as discarding in household waste, flushing, or retaining medicines informally being the most common practices. However, the South African context is characterised by pronounced gaps, including the absence of formal take-back initiatives, insufficient guidance from healthcare providers, and low public awareness.

Challenges in managing household pharmaceutical waste

The management of HPW in South Africa is constrained by a combination of systemic, infrastructural, and behavioural factors. Together, these obstacles impede the adoption of safe and sustainable disposal practices, even as awareness of the associated health and environmental risks continues to rise.

Systemic and policy challenges

In South Africa, no comprehensive national policy currently exists to specifically regulate the collection and disposal of unused or expired household medicines. While provisions such as Regulation 44 under the General Regulations of the Medicines and

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Related Substances Act (Act 101 of 1965) outline requirements for the safe destruction of pharmaceuticals by pharmacies, healthcare facilities, and waste management services, there is no coordinated or enforceable framework enabling households to return unwanted medicines or supporting structured community-level take-back systems [9,35]. Existing legislation, such as the National Environmental Management: Waste Act (NEMWA), classifies pharmaceutical waste as hazardous, but its provisions primarily target healthcare facilities rather than domestic sources. Enforcement is limited, and dedicated financial resources for collection, transportation, and treatment of HPW are lacking [35].

A further limitation is the absence of monitoring and evaluation systems for HPW disposal. Most available evidence comes from small-scale surveys or cross-sectional studies [9,18]. Without national surveillance, it is difficult to accurately assess the extent of HPW or to track disposal practices, leaving HPW unmonitored and increasing the risks to public health and the environment. The absence of a unified policy framework and inadequate resources contribute to inconsistent practices across regions and constrain the systematic collection of evidence to guide interventions.

Comparative evidence from other African countries indicates that South Africa's situation is not unique. In Ethiopia, reviews and household surveys report no national framework for HPW disposal, accompanied by widespread unsafe practices [3,7,27]. In Ghana, national oversight exists, but household surveys reveal continued disposal of medicines into domestic waste and minimal use of formal return mechanisms, reflecting gaps in enforcement and public awareness [44]. In contrast, Kenya has recently updated its regulations to explicitly govern pharmaceutical-waste management, demonstrating regional differences in policy approaches and the feasibility of national rules that address household sources [45].

Structural and healthcare system challenges

Within the healthcare sector, integration of HPW management into routine clinical practice remains a challenge. Studies show minimal involvement of healthcare professionals in patient education, with 75-95% of patients reporting they had never received guidance on medicine disposal [9,34]. Dispensing practices further aggravate this challenge, as over-prescribing, excessive dispensing, and the frequent supply of large pack sizes are reported drivers of unused medicines in households [19,20].

Infrastructure gaps also restrict safe disposal. Most community pharmacies and clinics, particularly in rural areas, lack designated facilities for medicine returns, or where present, bins are inconsistently provided, poorly labelled, or perceived as inaccessible, limiting public use [18]. This gap is further compounded by the lack of integration of pharmaceutical waste into municipal waste streams, leading to routine disposal of unused medicines in general refuse or sewage systems without treatment, with documented risks to public health and the environment [35,36]. Equally concerning is the absence of systematic evaluation of pilot take-back schemes. While anecdotal reports suggest that some pharmacies informally collect expired medicines, the lack of peer-reviewed evidence on their scale, effectiveness, or sustainability prevents the identification of best practices and hinders the design of scalable national interventions. Collectively, the absence of reliable infrastructure, insufficient professional involvement, and lack of systematic evaluation constrain South Africa's healthcare system.

Comparable patterns are reported in other African countries. For instance, in Ethiopia and Ghana, household surveys similarly identify low levels of guidance and frequent disposal, while in Zambia, pharmacists cite logistical and participation barriers to implementing state-led take-back programmes [38,39,44]. International studies provide further context, showing that medicines return programmes are most effective when supported by clear legislation, suitable financing, and accessible collection infrastructure, and where such elements are present, uptake remains low and evaluation weak [37]. OECD evidence further notes that disposal into household waste persists even in HICs, highlighting gaps in prevention, stakeholder roles, and financing [46]. Within the EU, while legislation obliges member states to provide collection systems, implementation differences result in uneven access and uptake [21]. By contrast, Australia's nationally coordinated NatRUM programme demonstrates a model structured, pharmacy-based, free-to-consumer returns with embedded monitoring and evaluation, providing evidence of system-wide impact [47].

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Behavioural and public awareness challenges

Unsafe HPW disposal in South Africa reflects broader systemic weaknesses in health communication, regulation, and community engagement. Limited awareness is a central driver, with many households believing that discarding medicines in household waste or flushing them down toilets is acceptable, largely due to the absence of clear, consistent guidance [9,18,41]. Self-medication, stockpiling, and the retention of leftover medicines further expose inefficiencies in prescribing and dispensing practices, with patients frequently storing unused antibiotics or analgesics for convenience or cost-saving, despite risks of misuse, accidental ingestion, and environmental contamination [9,16].

Internationally, similar behaviours have been reported in countries such as Nigeria, highlighting the global challenge of aligning prescribing practices with patient behaviours [11,48]. However, in regions with stricter prescription monitoring and pharmacist-led interventions, these risks are mitigated more effectively. A recurring theme across countries is that proper disposal practices do not always correlate with knowledge of the dangers posed by HPW. In Liberia, individuals frequently disposed of medications in the sewage or home trash while acknowledging the potential risks [10]. In Jordan, the public expressed contamination concerns but reported little guidance and logistical difficulties [49], whereas pharmacists in Malaysia identified inadequate infrastructure, regulatory gaps, and public demand as the primary barriers to safe disposal [30].

The evidence base within South Africa remains limited, dominated by cross-sectional studies in urban settings. Rural populations, sociodemographic determinants of disposal practices, and the impact of behavioural interventions such as pharmacy-based education or community awareness campaigns are underexplored [9,18]. This contrasts with countries like the United States and parts of Europe, where evaluations of public awareness campaigns and national take-back initiatives have generated valuable insights for scaling best practices [21,22]. The absence of similar research in South Africa limits the ability to design evidence-based, context-sensitive interventions, leaving a critical gap in both policy and practice.

The management of HPW in South Africa is shaped by a complex combination of behavioural, policy, and structural factors. Weaknesses at the systemic level, including fragmented legislation, limited enforcement, and inadequate funding, create conditions that hinder the consistent implementation of safe disposal practices. Within the healthcare system, deficiencies such as insufficient infrastructure, lack of professional training, and suboptimal dispensing practices contribute to the accumulation of HPW. At the community level, low public awareness, self-medication, and stockpiling further reinforce unsafe disposal behaviours, posing risks to both human health and the environment.

The findings of this study highlight the need for multi-faceted interventions that integrate strong policy frameworks, improved healthcare infrastructure, and targeted education initiatives. Establishing national take-back programs, expanding disposal facilities in community pharmacies, and raising awareness among both healthcare providers and the public are key measures to mitigate the risks of HPW. Additionally, systematic monitoring and evaluation of these interventions are necessary to provide evidence for scalable, context-specific solutions that enable South Africa to align with international best practices while addressing local needs. These observed behaviours highlight the importance of education and community engagement in promoting safe disposal practices. In the absence of targeted interventions, unsafe disposal is likely to continue, increasing both environmental and public health risks. In South Africa, the limited evidence base restricts the ability to design context-specific strategies, leaving policymakers and practitioners without clear guidance for reducing HPW accumulation and encouraging proper disposal.

Discussion

This scoping review highlights that HPW management in South Africa is shaped by an intricate combination of systemic, structural, and behavioural factors, which contribute to ongoing unsafe disposal practices. The findings of this study align with international evidence showing that improper disposal of unused or expired medicines is widespread due to limited consumer awareness of proper disposal methods and drug take-back programs, which weakens their effectiveness and leads to significant environmental contamination and public health risks [46,49,50]. Similar trends have been documented in African countries, such as Ethiopia, Ghana, and Zambia, where limited public

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awareness, weak enforcement of regulations, and the absence of organised take-back initiatives have led to prevalent reliance on environmentally hazardous disposal methods [7,43,51]. These findings suggest that South Africa mirrors broader patterns across several countries, where gaps in policy and public education facilitate the accumulation of HPW.

Nevertheless, South Africa presents some unique features. Despite a relatively strong pharmaceutical regulatory framework and greater health system capacity compared to some LMICs, these advantages have not translated into effective HPW management. The lack of a national medicine take-back program, coupled with inconsistent implementation of existing policies, results in a gap between regulatory intentions and actual household practices. Consequently, many households continue to dispose of medicines unsafely, such as flushing them or discarding them with general waste, thereby posing clear public health and environmental risks. This underscores that unsafe disposal is not merely a consequence of individual behaviour but is strongly influenced by structural and policy-level constraints.

Comparisons with HICs illustrate potential pathways for improvement. In the European Union, pharmacies and other approved entities serve as official HPW collection points, supported by well-defined laws and public awareness campaigns [21]. Similarly, several countries such as Australia, the United States of America, New Zealand, and Asian nations like Brunei and Malaysia have put in place official pharmaceutical waste take-back programs [22,42,46,52]. The fundamental principle of this pharmaceutical take-back program is that citizens hand over their HPW to authorised organisations that possess the resources and expertise needed to dispose of it responsibly and sustainably, to lower environmental pollution levels and, consequently, the detrimental effects on human and environmental health. It also aims to raise public awareness and have beneficial implications in terms of public safety [53]. Although these programs face operational challenges, they demonstrate that structured, well-regulated programs complemented by public education can significantly enhance safe household disposal practices.

The findings of this study highlight that systemic and structural barriers impede progress in HPW management. Fragmented legislation, limited enforcement, and insufficient funding constrain the uniform application of disposal practices across provinces. Within the healthcare sector, inadequate infrastructure, lack of professional guidance, and over-dispensing contribute further to the accumulation of unused medicines [9,40,54]. Additionally, behavioural factors, including low awareness, self-medication, and stockpiling, reinforce unsafe disposal practices, creating a self-perpetuating cycle that elevates environmental and health risks. While informal collection initiatives exist, their effectiveness is limited by a lack of systematic evaluation and integration with broader healthcare and municipal waste systems. Globally, similar patterns are evident in other LMICs, where self-medication, retention of leftovers, and large medication pack sizes are prevalent [7,8]. In contrast, HICs show that coherent policies, accessible take-back infrastructure, and targeted public education can mitigate these risks [21,23]. Furthermore, these findings align with studies identifying gaps in academic programs and training on medication disposal, which lead to inadequate awareness and attitudes among healthcare professionals and households [2,17]. The limited research evidence in South Africa constrains the development of context-specific interventions, leaving policymakers and practitioners with insufficient guidance to reduce household accumulation of unused medicines and promote safe disposal.

While South Africa's HPW disposal challenges reflect global trends, they also reveal significant local gaps in policy implementation, healthcare infrastructure, and public engagement. Drawing lessons from international experiences and adapting them to local conditions offers a pathway to sustainable improvement. A coordinated approach integrating regulatory reform, healthcare system involvement, public education, and evidence-based evaluation is necessary to mitigate the risks posed by HPW in South Africa.

Conclusion

This scoping review explored how households in South Africa dispose of pharmaceutical waste, highlighting systemic, structural, and behavioural challenges that contribute to unsafe HPW disposal methods, such as discarding medicines with general waste or flushing them into water systems. Although these challenges are consistent with those observed in other LMICs, South Africa's comparatively robust health system and regulatory framework provide an opportunity to advance more effective interventions. However, the lack of a national take-back system, low

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public awareness, and inadequate infrastructure continue to impede safe disposal practices.

To overcome these challenges, South Africa could leverage insights from international experiences where pharmacy-led collection programs, awareness campaigns, and stronger regulatory enforcement have proven effective. Tailoring these strategies to local conditions, alongside greater investment in public education, infrastructure, and research, holds potential to enhance safe disposal practices and mitigate related health and environmental risks. The HPW management ultimately necessitates an integrated national strategy that incorporates behaviour change initiatives, health system interventions, and regulatory changes. South Africa may advance toward sustainable solutions that protect the environment, protect public health, and comply with international best practices in HPW management by prioritising these initiatives.

Strengths and limitations

This review offers notable strengths. The review ensures scientific rigor and transparency by using a systematic approach in accordance with the PRISMA criteria and the Arksey and O'Malley framework. It incorporates a variety of perspectives from peer-reviewed and grey literature, thereby capturing a wide range of insights from policy documents, program reports, and research papers that are often excluded from reviews.

Despite its strengths, this review has limitations. By focusing solely on English-language studies, the review excluded studies published in other languages, which has narrowed the perspectives captured. In addition, there is a dearth of data from rural and peri-urban areas, where HPW disposal practices and infrastructure constraints may differ dramatically, and the geographic distribution of published studies is biased towards provinces like Gauteng, Western Cape, and KwaZulu-Natal. Furthermore, this study excluded broader consultation with significant stakeholders like community leaders, environmental officers, and pharmacists, which may have improved the findings' practical relevance and offered additional contextual perspectives. Therefore, the result drawn from this review should be interpreted as integrative rather than conclusive, providing a basis for additional empirical investigation and improvement.

Potential solutions and recommendations

Tackling HPW in South Africa calls for a holistic, multi-layered approach. At the policy and regulatory level, there is an urgent need for a national framework that sets out clear guidelines for household disposal. Strengthening enforcement of existing rules requiring pharmacies to accept expired medicines, alongside effective monitoring and the provision of financial or logistical support, could improve both compliance and accessibility. Within the healthcare sector, safe disposal practices could be reinforced by integrating disposal counselling into routine dispensing, ensuring that patients consistently receive guidance. Adjusting pack sizes to align with standard treatment durations may help minimise leftovers, while pharmacist-led prescription reviews and de-prescribing initiatives could further reduce accumulation, especially among those on long-term therapies.

Changing entrenched disposal behaviours also hinges on education and awareness. Nationwide campaigns should highlight the dangers of unsafe disposal and the advantages of returning medicines to designated points. These efforts could be complemented by school- and community-based programs, supported by civil society and media partnerships to maintain public engagement over time. Infrastructure development is another key pillar. Installing accessible take-back bins in pharmacies, clinics, and community centres, paired with safe treatment technologies such as high-temperature incineration, would create reliable disposal pathways. Incorporating pharmaceutical waste management into municipal waste systems could further enhance sustainability and reach.

Sustained progress will also depend on evidence generation. National surveys are needed to map disposal practices and identify vulnerable groups, while pilot projects such as pharmacy-based take-back schemes should be rigorously evaluated for effectiveness and scalability. Environmental monitoring of pharmaceutical residues in water and soil could help link household behaviours with broader ecological and health impacts. Overall, these actions highlight the importance of a coordinated national strategy that draws on global best practices while tailoring solutions to the South African context. By aligning policy reform, healthcare engagement, public education, infrastructure investment, and ongoing evaluation, the country can begin to overcome the

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systemic and behavioural barriers driving unsafe household pharmaceutical waste disposal.

An essential element of these recommendations is the development and reinforcement of medication take-back initiatives. This involves ensuring that regulations requiring pharmacies to accept unused and expired medicines are effectively implemented, with adequate oversight and resources to support adherence. Expanding the availability of clearly marked and convenient drop-off points in pharmacies, clinics, and community facilities would provide households with safe and accessible options for returning unused and expired medicines. To maximise impact, these measures should be coupled with nationwide awareness efforts and community-based education that emphasise the importance of proper return over unsafe disposal. Pilot projects, especially those based in pharmacies, should be systematically evaluated for their outcomes and scalability, generating evidence to guide the establishment of a long-term, sustainable national programme.

Implications for policy

At the local level, PHCs, pharmacies, and local municipalities should establish easily accessible HPW take-back programs, with monitored pickup and disposal processes. In regions with inadequate infrastructure and health literacy, such as rural areas, community health workers may educate individuals on proper HPW disposal procedures. Schools and non-governmental organisations can support these initiatives by running awareness campaigns and integrating HPW management into the curriculum, while municipalities should integrate HPW management into their current hazardous household waste collection programs.

At the national level, the South African Pharmacy Council (SAPC), the South African Health Products Regulatory Authority (SAHPRA), the National Department of Health (NDoH), and the Department of Forestry, Fisheries and the Environment (DFFE) should all offer regulatory direction and strategic control. Campaigns to raise public awareness in several languages should be launched, and incentives and enforcement systems should be used to track compliance. Integrating quantifiable goals into the National Waste Management Strategy will guarantee long-term sustainability and consistency.

To inform policy and practice, evidence should be produced at the academic and research level by universities, research councils, and professional associations like the Pharmaceutical Society of South Africa (PSSA). HPW management should be incorporated into university curricula to equip aspiring healthcare providers for stewardship positions. Innovative disposal technologies, the assessment of community-based initiatives, and the conversion of research results into useful recommendations for regional and national implementers should be the main areas of concentration.

Future research

The findings of this review highlight several directions for future research on HPW management in South Africa. Future research should address critical gaps in HPW management in South Africa, concentrating on rural and peri-urban communities with poor infrastructure and low health literacy. Such studies should look at the societal, economic, and behavioural aspects that influence household decisions in addition to disposal practices. Additionally, to assess how well community education programs, take-back programs, and public awareness campaigns promote safe disposal over time, longitudinal and intervention-based research is required. Multidisciplinary research should examine how HPW affects the environment and human health, particularly how it contributes to antibiotic resistance and contaminates food chains, water, and soil.

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List of abbreviations

HICs: High-Income Countries
HPW: Household pharmaceutical waste
LMICs: Low- and Middle-Income Countries
OTC: Over the counter
PHCs- Primary Healthcare Clinics

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No funding was obtained for this study.

Conflict of interest

The authors declare no conflict of interest.

Data availability

All the data used in this review are derived from peer-reviewed, publicly accessible journal papers that are listed in the reference list. No primary data was gathered or created by the authors.

Protocol and registration

This review was not registered in a public repository such as PROSPERO or OSF. However, it followed the Arksey and O'Malley framework and adhered to the PRISMA guidelines to ensure methodological transparency.

Author contributions

Conceptualization, T.A.C. B.N.S and L.P.C; methodology, T.A.C. B.N.S and L.P.C; validation, T.A.C. and L.P.C; analysis, T.A.C. and L.P.C; writing-original draft preparation, T.A.C. The final draft of the manuscript was written and edited by all authors, who also critically evaluated it for completeness and accuracy before approving its submission.

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