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Feasible Safe Disposal Strategies that Can Be Used to Manage Pharmaceutical Waste among Households in Nakuru City

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Abstract

This study documents feasible and safe disposal strategies for managing pharmaceutical waste among households in Nakuru City. Improper disposal of pharmaceuticals via garbage sites and wastewater systems can cause environmental contamination, expose humans and non-target organisms to harmful substances, and disrupt sewage treatment processes, particularly through antibiotics. A cross-sectional survey design was employed among 384 households in Nakuru City. Simple random sampling was used to select administrative units, snowball sampling to identify households, and purposive sampling to recruit key stakeholders. Data were collected using structured questionnaires containing closed- and open-ended questions and analysed using descriptive statistics in SPSS and Excel. The findings showed that the take-back programme was the most preferred and feasible strategy (54.7%), followed by return-to-pharmacy (38%) and drop-off (20.7%), while mail-back was least preferred (5%). Feasibility was influenced by cost, accessibility, and trust in disposal systems. Additionally, 65 per cent of respondents were unwilling to pay for pharmaceutical waste management, while 22.9 per cent of those willing to pay accepted any amount to support the system. 60 per cent of stakeholders were willing to accept pharmaceuticals from households and dispose of them according to pharmaceutical disposal guidelines. The study concludes that take-back programmes are the most practical strategy, whereas mail-back systems are least acceptable. It recommends public awareness and educational programmes on the safe management and environmental and human health impacts of unwanted pharmaceuticals.

Keywords: Pharmaceutical, pharmaceutical waste, safe disposal, take-back programmes.

1.0 INTRODUCTION

This study documents feasible and safe disposal strategies for managing pharmaceutical waste among households in Nakuru City. A pharmaceutical is a drug that is used to diagnose, cure, treat or prevent diseases. It becomes pharmaceutical waste when it is no longer usable for its intended purpose, or is being discarded for other reasons, e.g. contamination, already dispensed and expiration (Arke et al., 2025). Recently, researchers have found pharmaceuticals such as antibiotics, hormones and controlled substances in almost all environmental media. There is sufficient evidence that pharmaceuticals harm aquatic life and humans. Humans feed on aquatic organisms that live in water contaminated with antibiotics and hormones and also use the same water for domestic purposes, including drinking.

Unwanted pharmaceuticals are handled in many ways, including proper and improper methods of disposal. Improper disposal includes: flushing pharmaceuticals down the toilet and sink, throwing them in the trash, and storing unwanted pharmaceuticals in the house (Chit et al., 2026). The methods used to dispose of unwanted pharmaceuticals influence their persistence in the environment and the extent to which they may contaminate water resources. Households contribute to pharmaceutical waste-related environmental concerns by disposing of unwanted medicines through sinks, toilets, or general household waste. All of these methods have detrimental impacts on the environment. Globally, the disposal methods currently used are evident in various studies which have been conducted worldwide (Beckel et al., 2011)

Consequently, there exist safe methods for disposal of pharmaceuticals among households that are already practised in other countries. These include take-back programmes, which provide safe and environmentally friendly options for consumers. Other examples are mail-back programmes, where consumers send unused pharmaceuticals to a central location through postal services. This system is operational in various countries, including the United States. Another option is the drop-off model, where permanent collection sites exist, or one-day collection events are organised for consumers to surrender unwanted pharmaceuticals for recommended disposal (Siler et al., 2008).

Despite the availability of these safe disposal methods, household disposal of pharmaceutical waste remains a global challenge, particularly in developing countries such as Kenya. Knowledge of environmentally friendly and sustainable disposal methods for pharmaceuticals remains limited, and information on household pharmaceutical waste management is inadequate. The identification of practical pharmaceutical disposal strategies suited to the local context is therefore critical to mitigating environmental contamination and public health risks arising from inappropriate disposal practices.

2.0 LITERATURE REVIEW

Disposal of pharmaceutical waste among households is a global challenge, especially in developing countries. Globally, less than half of the patients are treated following the medical guidelines. However, more than half of all patients don't take their medication as prescribed by the physician, hence generating more pharmaceutical waste (Holloway, 2011). There exists a global challenge of poor adherence to medication as prescribed, with non-adherence of approximately 50 per cent in developed countries and even at a higher rate in developing countries. Many patients find it difficult to finish their medication as prescribed, making it a big burden of unwanted pharmaceuticals among households (Makki et al., 2019). Drugs accumulate unused for a number of reasons, which presents the need for disposal (Ruhoy & Daughton, 2007). These reasons range from patient non-compliance, which itself has a number of causes,

inefficient oversight of the prescribing process by medical practitioners, imprudent dispensing practices by retail pharmacies and the insurance industry and wasteful packaging by manufacturers (Daughton, 2003).

The methods used to dispose of unwanted pharmaceuticals significantly influence their release into the environment and their potential to contaminate water sources. At the household level, improper disposal practices, including discarding medicines down sinks, flushing them down toilets, or placing them in household waste, contribute to environmental pollution. All of these methods have detrimental impacts on the environment. Globally, the disposal methods currently used are evident in various studies which have been conducted worldwide (Beckel et al., 2011).

Research conducted in the United States, the United Kingdom, and New Zealand has revealed limited public awareness regarding the importance of safely disposing of unwanted pharmaceuticals by returning them to pharmacies or designated collection points (Vellinga et al., 2014). There is evidence that in Pakistan, 3.8 per cent of the population have no knowledge of what to do with unwanted pharmaceuticals in their homes. On the other hand, 80 per cent of the respondents showed their concern that improper disposal of pharmaceuticals can affect the environment and the health of the public (Radhakrishna et al., 2007).

In a study conducted in Pakistan, the respondents suggested various ways in which awareness of safe disposal of unwanted pharmaceuticals can be raised. Fifty-one per cent (51%) of the respondents suggested that electronic media should be used, while 20 per cent suggested newspapers should be used. On the other hand, the remaining 29 per cent suggested that pharmacies, physicians, and pharmaceutical industries should create awareness (Radhakrishna et al., 2007).

Despite the existence of environmentally-friendly pharmaceutical waste disposal methods, most households dispose of unwanted pharmaceuticals in the sewer system and trash cans. These methods are often preferred due to concerns such as protecting children and pets against accidental poisoning. Many people believe that disposing of unwanted pharmaceuticals via the sewer and municipal waste does not cause harm to the environment (Wilcox, 2013).

Risks of Pharmaceutical Waste

In the absence of timely and appropriate disposal of unwanted and expired pharmaceuticals, these products may be indiscriminately discarded, increasing the risk of environmental pollution, or diverted into the counterfeit pharmaceutical market. Toxicity from environmental exposure to pharmaceuticals has been reported in fish and vultures. If antibiotics are dumped, exposure to subtherapeutic concentrations of the drugs may lead to the selection of drug-resistant soil bacteria, which may then infect humans and even pass on their resistance genes to bacteria that are human pathogens. Mechanisms to deter the entry of pharmaceuticals into the environment need to be strengthened (Kadam et al, 2016).

Pharmaceuticals Poisoning

Keeping pharmaceuticals in the house is one of the most practised methods of handling pharmaceuticals; this poses several risks related to diversion from the initial use, accidental use and overdose, as well as the possibility of people consuming spoilt pharmaceuticals in case of an emergency (Siler et al., 2008).

Abuse of Pharmaceuticals

The presence of medication among households has contributed to a high rate of drug abuse in America, especially among teenagers. This is evident in a survey carried out in 2004, which showed that 14.5 per cent of young adults aged 18-25 misuse prescription drugs such as pain relievers, tranquillisers, stimulants and sedatives because of their availability in homes (Siler et al., 2008). Even though restrictions and control mechanisms are available in the prescription and drug delivery system to avoid drug abuse, pharmaceutical abuse and diversion of their use are on the rise. For instance, in America, it is estimated by the NIDA that 20 per cent of the population will misuse prescribed pharmaceuticals within their lifetime for nonmedical reasons; mostly, pharmaceuticals for the central nervous system, depressants, and also stimulants are the most commonly abused drugs (Simons, 2010). If pharmaceuticals are discarded insecurely in landfills, drugs may come into the hands of scavengers or children and be diverted for resale to the general public. Accumulation of unused medications and delayed disposal can also encourage self-medication and misuse of drugs, causing a serious threat to the health of a country's population (WHO, 2025).

Environmental Issues

pharmaceuticals have found their way into our surface water bodies and drinking water due to improper disposal. This is clearly shown in a 2002 study from the U.S Geological Survey, which reported that 80 per cent of the 139 streams studied had pharmaceuticals at detectable concentrations, including hormones and steroids, which are linked to reproductive problems as they lower immune response in fish and frogs (Simons, 2010). Pharmaceutical contamination of drinking water may pose several health and environmental risks, including the development of antibiotic resistance, human exposure to irritant or mutagenic anticancer agents, and disruption of reproductive processes in aquatic organisms through endocrine-disrupting compounds (Atinafu et al., 2014).

Trashing pharmaceutical waste into dustbins is not environmentally friendly, as the active pharmaceutical ingredients could eventually get into surface water and then may unconsciously get back to people through tap water and drinking water (Arkaravichien, 2014). Improper disposal of pharmaceuticals has serious consequences, such as interference with human sperm count, which, according to his study, has reduced up to 50 per cent on average since 1939. Also, there has been an increase in infertility, genital defects, cancers and neurological disorders in children, which are caused by hormones (Scsukova et al., 2016).

Legal Framework of Pharmaceutical Handling and Disposal

There exist guidelines which provide advice on safe disposal of unwanted pharmaceuticals. In countries where regional, national and laws on disposal of pharmaceuticals do not exist or are insufficient, expired pharmaceuticals cause a serious threat when they are improperly disposed leading to contamination of water, wildlife, or found by scavengers who might divert it to the market for resale and misuse (WHO,1999) The simplest and least expensive way to minimize pharmaceutical disposal is to reduce and avoid generating unused pharmaceuticals. During outreach activities, EPA had many ways of smart pharmaceutical management. For example, buying medicine in smaller quantities means fewer expire. By using vouchers from pharmaceutical sales representatives instead of using free "sample" pharmaceuticals, facilities can eliminate an entire waste stream (EPA, 2010).

According to the "Guidelines for Safe Disposal of Unwanted Pharmaceuticals in and after Emergencies" issued by WHO in 1999, pharmaceuticals are ideally disposed of by high-temperature (above 1,200°C) incineration. However, such facilities equipped with emission control are mainly found in industrialised countries. The Guidelines describe quite a number of alternative methods for safe disposal of unwanted pharmaceuticals suitable for developing countries. These methods include the use of landfills, encapsulation, burning in alternative incinerators and chemical decomposition (WHO, 1999).

Laws and Statutes Related to Pharmaceutical Waste in Kenya

In the Constitution of Kenya (2010), Article 42 states that every person has a right to a clean and healthy environment. It provides an enforcement mechanism in Article 70; hence, the way we dispose of our pharmaceutical waste should be in a safe and proper way. This will be in compliance with the Constitution since, as citizens, we have an obligation to keep our environment clean for our benefit and for the safety of fellow Kenyans (National Council for Law Reporting, 2010).

The Environmental Management and Coordination (Waste Management) Regulations, 2006 define the responsibilities of waste generators. It also defines the duties and the requirements for transport and disposal of waste. It provides for the mitigation of pollution and addresses hazardous and toxic waste. According to the Fourth Schedule of the regulations, medical waste is classified as hazardous and is required to be disposed of in accordance with NEMA guidelines, not through unsafe disposal practices (NEMA, 2006b).

The Environmental Management and Co-ordination (Water Quality Regulations, 2006) has set the standards for domestic water and wastewater. The regulations are meant for pollution control and prevention and provide for the protection of water sources. If pharmaceuticals are disposed of poorly, for instance, if flushed down the toilet, as is one of the methods commonly practised in disposal, it will pollute the water; hence, it will be against the Act (NEMA, 2006).

The Water Act, 2016, which deals with control and conservation of water resources, prohibits practices that may cause pollution to sources of water likely to be used for human consumption or domestic use or in the manufacture of food for human consumption. According to the provisions of this Act, pharmaceuticals should be disposed of in such a way that they don't cause pollution to water sources; hence, methods such as burying them or flushing them should be avoided since they will get into the waterway, polluting the water (Water Act, 2016).

The Food, Drugs and Chemical Substances Act (Cap. 254) prohibits the use or disposal of chemicals in ways that may contaminate food or water intended for human consumption and potentially endanger human health. Improper disposal of pharmaceuticals contradicts this Act (Food, Drugs and Chemical Substances Act, 1965).

The Public Health Act (2012) provides for maintaining and securing health. It defines what environmental nuisance is. Various health hazards are likely to emanate from improper disposal of pharmaceuticals, such as accidents in homes. If unwanted pharmaceuticals accumulate in the house, it might lead to child poisoning, air pollution if burnt in the open and water and land pollution if disposed of in the trash or flushed down the toilet. There is therefore a need for proper disposal to ensure a healthy environment.

The Draft Environmental Management and Co-ordination (Air Quality) Regulations (2008) establish provisions for the prevention, control, and reduction of air pollution to promote clean and healthy ambient air. The general prohibitions state that no person shall cause the emission of air pollutants that might interfere with air quality. If pharmaceuticals are poorly disposed of, they will compromise air quality by such unsafe methods as burning in the open (NEMA, 2008).

Research Gap

Other countries like Britain, Canada and the USA have responded to the gap in proper disposal options for pharmaceutical waste among households by coming up with safer ways of tackling the problem, such as take-back programmes. In the same way, this study was able to investigate the feasible strategies that can be used to manage pharmaceutical waste among households. This was achieved by asking the respondents to give suggestions on feasible strategies, why they think it is feasible and their willingness to support the system they suggest.

3.0 METHODOLOGY

The study adopted a cross-sectional research design in which data were collected at a single point in time using a survey method comprising both closed and open-ended questionnaires to examine differences among study subjects. The study was conducted in Nakuru City, located in Nakuru County, and targeted households across Milimani, Kaptembwo, and Free Area administrative units. The required sample size was established using the formula developed by Anderson et al. (2005). Based on a 95 per cent confidence level, a 5 per cent margin of error, and a population proportion of 0.5, a total of 384 households was determined.

To ensure representativeness, the population was first stratified by administrative units, and proportionate sampling was applied based on household distribution. Purposive sampling was applied to select key stakeholders, including six nurses, three medical officers, six clinical officers, and five pharmacists. The selection of the key stakeholders was based on their involvement and knowledge in pharmaceutical waste handling and generation.

Data were collected using structured questionnaires capturing socio-economic characteristics, pharmaceutical waste types, disposal practices, influencing factors, and proposed management strategies. Before the main study, the instruments were validated through expert review and pilot-tested on 20 households in Section 58, Rhonda, and Naka, which were excluded from the final sample. Reliability testing yielded a Cronbach's alpha coefficient of 0.765.

Data were coded, cleaned, and analysed using SPSS and Excel, with quantitative data summarised using frequencies, percentages, tables, and graphs. Ethical considerations were observed through informed consent, confidentiality, honesty, and impartiality throughout the study. The researcher also received research approval from the National Commission for Science, Technology and Innovation (NACOSTI).

4.0 FINDINGS AND DISCUSSION

Socio-Demographic Information of the Study Population

Sixty-four-point eight per cent (64.8%) of the respondents in the study area were female. The youngest respondent in the sample was 18 years old, and the oldest was 69 years old. The findings on household size revealed that the average household size in the study area was 4, with 25.3 per cent having 5 members (Table 1). Approximately 63 per cent of the respondents indicated that their total family income was between 0 and 20,000 Kenyan shillings per month (Table 1).

Table 1: Distribution of Respondents' Demographic Characteristics in Nakuru City

Demographic characteristics	Frequency	Percentage
Gender		
Male	135	35.2
Female	249	**64.8**
Total	384	100
Age		
18-27	133	34.6
28-37	189	**49.2**
38-47	40	10.4
48-57	21	5.
58+	1	0.3
Total	384	100
Education level		
None	12	3.1
Primary	102	26.6
Secondary	167	**43.5**
Tertiary	103	26.8
Total	384	100
Household size		
0-2	11	2.8
3-5	121	31.5
6-8	149	**38.8**
9-11	103	26.9
Total	384	100
Children under five		
0	165	**43**
1	110	28.6
2	90	23.4
3	19	4.9
Total	384	100
Household income		
0-20,000	241	**62.8**
20,001-80,000	113	29.4
>80,000	30	7.8
Total	384	100
Variables	Minimum	Maximum Mean
Age	18	69 31.35
Household size	1	9 4

Only 3 per cent of the respondents had no formal education, whereas 43.5 per cent had attained secondary level education (Table 1). The study reports a different finding from the 2019 Kenya Population and Housing Census (KPHC) for Nakuru County. According to KNBS (2019), approximately 6.8 per cent of the population in Nakuru County had never attended school, 33.3 per cent of the county population had attained primary education level, while 28.3 per cent had secondary educational attainment. When the county's level of education is compared to that of the study population, it is found that the level of education in the study population is higher than the county's. Illiteracy can affect disposal practices of unwanted pharmaceuticals among households. Those with education are likely to have some knowledge of safe disposal practices of unused pharmaceuticals.

Perception of Feasible Safe Disposal Strategies for Managing Pharmaceutical Waste

The objective entails opinions given by respondents on safe ways that can be used to dispose of unwanted pharmaceuticals among households, and that can be practical in Kenya, taking into consideration the level of awareness, financial ability and available resources. The methods are already operational elsewhere; for example, in British Columbia and Canada, there has been a successful take-back programme since 1996. The opinions are given in Figure 1 below.

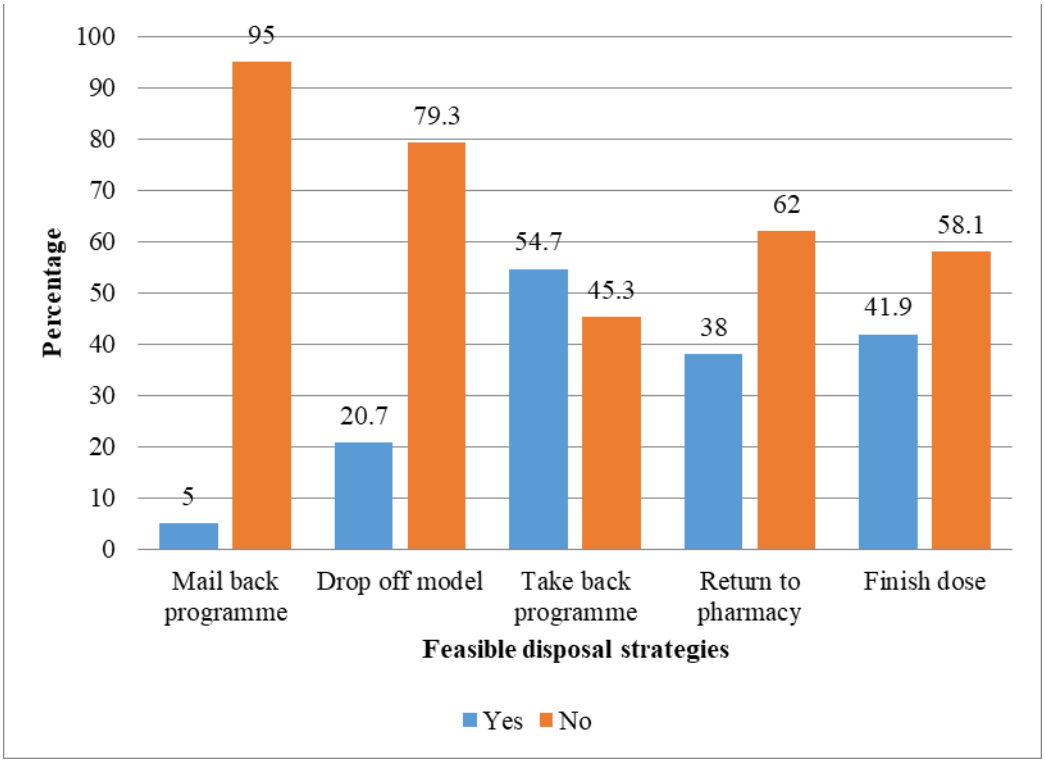


Figure 1: Feasible Strategies for Disposal of Unwanted Pharmaceuticals

The mail-back programme, where households (consumers) send their unused pharmaceuticals to manufacturers by use of postal services, was the least appealing among the respondents, who termed it as expensive, fear, resale and time-consuming. This method is, however, appealing and operational in many developed countries, including the United States (Siler et al., 2008).

The drop-off models are those where a permanent collection site exists and requires consumers to take their unwanted pharmaceuticals to be later disposed of in the recommended way. In this study, the majority rejected the method and gave the main reason as fear of resale of unwanted pharmaceuticals. For those who accepted the method, 20.57 per cent said it is easy and accessible, in addition to being affordable. These findings are in agreement with those in the National Guidelines for Medical Disposal that indicated that if pharmaceuticals are discarded haphazardly, they end up in the hands of scavengers and may be diverted for resale to the general public. (WHO, 1999).

A take-back programme involves taking unwanted pharmaceuticals back to the hospital for proper disposal. The majority of the respondents, 54.7 per cent, said the method is feasible and can work in Kenya. 35.9 per cent gave the major reasons why it can work, as it is easy to access, and 18.8 per cent indicated that it is affordable, while those who rejected the method cited distance and time as the main reasons.

Return to pharmacy involves consumers taking their unwanted pharmaceuticals to nearby pharmacies for proper disposal. Over 35 per cent indicated the fear of resale by the pharmacy as the main reason for not supporting it. Those who chose the method as the most feasible gave the major reasons as being easy and accessible.

Finish dose is when the patient adheres to his medications as prescribed by the physician by completing all the medication. 58 per cent (58.1%) of the respondents said that it is not practical to finish the dose always due to some reasons that cannot be avoided, such as patient death, intolerable effects and expiration before finishing the dose. These findings are consistent with those of Bain (2010), who indicated that unwanted pharmaceuticals cannot be avoided. Those in support of this disposal method indicated that it is feasible.

In terms of perception of the feasible strategies, the take-back programme was the most preferred. This is practical since in Kenya the high-temperature incineration facilities are available in hospitals, so at the hospitals the unwanted pharmaceuticals will be destroyed in a safe way. The programme has successfully existed in Canada since 1996 (Wilcox, 2013). Disposal by incineration, which is already available in Kenyan government hospitals, is an acceptable method worldwide since pharmaceuticals are ideally disposed of by high-temperature (above 1,200 °C) incineration. On the other hand, the mail-back programme was the most rejected, and the method is not practical in Kenya since the manufacturers are far away and the public cannot use their money to send the medication back to the manufacturers for proper disposal, though the method is practical in other countries.

The above perceptions on safe disposal of unwanted pharmaceuticals are necessary in the sense that despite the existence of safe disposal methods of unwanted pharmaceuticals among households in developed countries, households still use poor methods (Wilcox, 2013). This implies that the existence of programmes does not guarantee proper disposal, but rather the existence of methods with which the community are comfortable.

Respondents were further asked about their willingness to pay some money for proper management of unwanted pharmaceuticals among households. Over 65 per cent of the respondents indicated that they

were not willing to pay any money for proper disposal. 22.9 per cent of those who were willing to pay (35%) agreed to pay any amount to support the system. On the other hand, 60 per cent of the stakeholders were willing to accept the pharmaceuticals from households and dispose of them according to the guidelines for pharmaceutical disposal within their facilities. This is in line with what happens in other countries where stakeholders take responsibility for unwanted pharmaceuticals from households. Lithuanian pharmacies are obliged to collect household pharmaceutical waste, but Italian pharmacies are involved in voluntary collaborative efforts in their disposal (Siler et al., 2008). This implies that individuals can support the programmes of proper disposal if there is no money involved. The willingness of stakeholders to take unwanted pharmaceuticals from households is a positive step in the sense that if the programmes start, there is no need to construct expensive landfills or additional incineration for handling unwanted pharmaceuticals from households.

5.0 CONCLUSION AND RECOMMENDATIONS

Conclusion: The study concludes that the most feasible strategy for disposing of unwanted pharmaceuticals was taking them back to hospital for proper disposal (take-back programme). The method is feasible, and if financially supported by the government or any other body, it can be sustainable since the households are not willing to pay any amount to support the programme. On the other hand, the mail-back programme was the most rejected, and respondents gave their main reasons as being that the method is expensive and that they fear the manufacturers might sell the contaminated medication back to them.

The results imply that the successful implementation of the take-back programmes in households requires stronger institutional support, sufficient financing, public awareness, and availability of accountability mechanisms. Although Kenya has established policies governing the safe management and disposal of unwanted pharmaceuticals, unsafe disposal practices continue to occur, partly due to inadequate implementation and enforcement of existing policy provisions.

Recommendations: The study recommends the need to strengthen the enforcement and implementation of the already provided policies and legislation on pharmaceutical waste management in Kenya. There is also a need to increase public awareness and disposal education on the dangers of improper disposal of unused pharmaceuticals. The Ministry of Health and county governments should establish affordable and accessible take-back programmes at medical facilities centres, supported by proper handling of the pharmaceutical waste in or steps from collection, storage, transportation, treatment, and final disposal of the pharmaceutical waste. Implementation of close monitoring, accountability, and documentation systems should be established. To ensure effective implementation, monitoring, and sustainability of household pharmaceutical waste management programmes, there should be stronger coordination among the governments, health facilities, pharmaceutical manufacturers, pharmacies and other stakeholders.

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