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PREVALENCE AND FACTORS ASSOCIATED WITH POOR PHARMACEUTICAL WASTE DISPOSAL PRACTICES AMONG HOUSEHOLDS IN NANSANA MUNICIPALITY, WAKISO DISTRICT, UGANDA: A CROSS-SECTIONAL STUDY.

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Abstract

Introduction

The rising demand for pharmaceuticals globally raises concerns about poor disposal of pharmaceutical waste. Pharmaceutical waste lacks clear guidelines for its management, contributing to environmental pollution and high healthcare costs. While some countries implement effective pharmaceutical waste policies, many developing nations including Uganda, face challenges due to insufficient awareness, regulations, and infrastructure. This study determined the prevalence and factors associated with poor pharmaceutical waste disposal practices in Nansana Municipality Wakiso District, Uganda.

Methods

A cross-sectional study was conducted among 399 households in Nansana Municipality. Stratified sampling was conducted across the four divisions of Nansana Municipality, and a random selection of respondents was made. Data was gathered using a structured questionnaire that included demographics, knowledge, attitudes, and pharmaceutical waste disposal practices. Univariate, bivariate, and multivariable modified Poisson regression analyses identified the prevalence and factors associated with poor pharmaceutical waste disposal.

Results

The study revealed that 72.2% of Nansana Municipality households used poor pharmaceutical waste disposal, predominantly using toilets (91%). Several factors were significantly associated with poor pharmaceutical waste disposal practices in Nansana Municipality. Respondents aged ≥ 30 years were 1.33 times more likely to engage in poor disposal compared to those aged 20-25 years (APR = 1.33; 95% CI: 1.15-1.54). Household monthly income above USD 137 was linked to a lower likelihood of poor pharmaceutical waste disposal (APR = 0.76; 95% CI: 0.59-0.98).

Conclusion

The study found a high prevalence of poor pharmaceutical waste disposal in Nansana Municipality, Wakiso District Uganda. Given the influence of age, gender, education, and income on these behaviors, public health strategies must combine educational, economic, and infrastructural measures for effective impact.

Recommendation

Implementing voluntary take-back programs, enforcing producer responsibility for eco-friendly packaging, and raising public awareness of safe pharmaceutical waste disposal are needed.

Keywords: Prevalence, associated factors, households, take-back programs, pollution, Antimicrobial Resistance
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Introduction

Pharmaceutical products have evolved to improve the health conditions of people consuming them. These products have emerged since the discovery of penicillin and sulphanilamide in the early 20th century[1]. Pharmaceutical products contain different active ingredients and excipient materials that treat a patient's underlying conditions [2]. Globally, there is an increase in the consumption of pharmaceuticals[3] due to several reasons, including increasing outbreaks of emerging and re-emerging diseases, lifestyle changes, and demographic characteristics of people, among others[4]. This is expected to increase with the increasing global population predominantly in Africa. Commonly used drugs in homes include Paracetamol, used as painkillers,

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Coartem for malaria infection, Cotrimoxazole and Amoxicillin for bacterial infections, metronidazole, used to treat skin infections, rosacea and mouth infections [5]. The waste generated from these drugs has undergone poor management in many homesteads across the globe.

Pharmaceutical waste entails all expired drugs, nutraceuticals, unused medicines, discarded wellness products and even medicines that are no longer needed because patients have recovered or died from a disease[6]. Globally, the management of pharmaceutical waste has been a challenge and is expected to escalate with the increasing population and double burden of disease. Antibiotics have been detected in Asia-Pacific group countries, oestrogens in Africa, analgesics in Eastern Europe and a range of different pharmaceutical groups in Western Europe[7]. In East Africa, Uganda specifically, the most common pharmaceuticals sold in Kampala including antibiotics such as Sulfamethoxazole and Trimethoprim were in high concentrations in the Nakivubo wetland area[8]. The occurrence of such Active Pharmaceutical Ingredients in the environment poses a great risk of contamination of water resources, endangerment to aquatic life leading to loss of biodiversity and creating an environmental exposure pathway to Antimicrobial Resistance[9] unless it is addressed.

Several regulations on pharmaceutical waste detail a large scope which requires incineration of pharmaceutical waste to effectively detoxify and remove them from the environment[10]. However, little provision for safe pharmaceutical waste disposal at the household level exists. The WHO has not stipulated guidelines for the disposal of pharmaceutical waste at the household level. Setting up individual incinerators is economically unfeasible for everyone. With a rising prevalence of poor pharmaceutical waste disposal practices in developing countries, different reasons exist behind such. Studies revealed that 63% of respondents agreed to have mixed their pharmaceutical waste with other general domestic wastes[11] which practice is poor and has several effects on the environment. The public is therefore not aware of the harmful effects of pharmaceutical waste on the environment, health and even social welfare.

In Uganda, the management of pharmaceutical waste has largely focused on industrial, healthcare and drug storage facilities, with limited emphasis on household disposal practices. In 2022, the Ministry of Health in Uganda procured four waste management trucks to collect medical waste arising from the COVID-19 response activities due to the increasing COVID-19 patients[12]. However, their operations were limited to healthcare facilities. The same ministry installed several healthcare waste management incinerators in Mbarara, Lira, Mukono Fort Portal and Gulu for the safe disposal of hospital waste [13–15]. There was no stipulation for what the households within these areas could do with their household pharmaceutical waste. Whereas the National Drug Authority provides disposal guidelines aligned with WHO recommendations[16], these are also not well adapted for households, leading to a lack of proper disposal methods at domestic levels. Existing studies in Uganda have mainly examined pharmaceutical waste in healthcare settings or focused on home storage of unused medicines, such as a study in Northern Uganda[5].

Little research has explored the disposal practices at a household level despite growing evidence of pharmaceutical contamination of water bodies due to poor disposal practices. For instance, a study in Kampala found high concentrations of antibiotics in the Nakivubo wetland[8], yet there is a lack of understanding of how household-level disposal contributes to this pollution. Furthermore, public awareness of environmental and health risks associated with poor disposal is low, exacerbating the issue. This study addressed this gap by assessing the prevalence and factors associated with poor pharmaceutical waste disposal practices among households in Nansana Municipality, Wakiso District, aiming to contribute to better waste management strategies.

Methodology

Study area

The study was conducted in Nansana Municipality, which is one of the five municipalities of Wakiso District 17. Nansana Municipality is approximately 9.6km Northwest of Kampala's Central Business District on Kampala-Hoima Road. Currently, the municipality is composed of four divisions which include Nansana, Nabweru, Busukuma, and Gombe. The population of Nansana Municipality is made up of a variety of ethnicities including Ugandans, Congolese, and South Sudanese, among others of different tribes. There are also different institutions including religious units, schools, and business centres among others which are accessed by residents. In Nansana Municipality, pharmaceutical waste disposal practices are of great concern due to the potential environmental and health risks posed by the poor disposal of such waste materials.

Study design and population

This was a descriptive cross-sectional study that involved quantitative data collection. The study was conducted among heads of households or them

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designates in Nansana Municipality, Wakiso District in Uganda. The study included respondents who had lived in the selected division of residence for more than one month at the time of the study. One month was chosen because it was a sufficient incubation period for common diseases for a member to fall sick and for medicines to accumulate in homes.

Sample size and sampling procedure

The formula by Kish Leslie18 was used to determine the sample size (359) for the study, using a 95% confidence level, a 0.63 prevalence11, and 5% precision. Accounting for a 10% non-response rate, the final sample size was 399. Stratified sampling was applied using each division of Nansana Municipality as a stratum. Households were randomly selected from divisions of Nansana, Busukuma, Nabweru and Gombe. Population proportions from each division were calculated to maintain proportionality, resulting in sampling 41 households from Busukuma, 84 from Gombe, 116 from Nabweru, and 158 from Nansana. Therefore, the study recruited 399 participants who also completed the survey questions.

Data collection methods and procedures

A structured questionnaire was created to gather data on poor pharmaceutical waste disposal methods, covering socio-demographics, knowledge, attitudes, and disposal practices. Developed with academic supervision and based on existing literature, it was translated into *Luganda* (the most common local language used in the area) for use. The questionnaire was designed in Kobotoolbox, with an online link for data collection. Piloting of the questionnaire took place in the Kawempe Division to ensure comprehensiveness and ease of use. The tool was administered by the lead author and lasted 20 minutes.

Measurement of variables

The study focused on poor pharmaceutical waste disposal practices among households, defined as the use of pharmaceutical waste disposal methods not recommended by the World Health Organization (WHO). The 'Practice level' composite variable was created, scoring 1 for poor practices and 0 for good ones. It involved four variables. Disposal practice used which had seven responses where incineration was the correct one and scored 0. Poor disposal practices were scored 1. Other variables were storage area and frequency of disposal where storage in unsafe areas and disposal after longer periods were scored 1. The last variable was the transportation method of the pharmaceutical waste which included only poor options, all scored 1. The scores of these variables were combined to form the overall 'Practice Level' with a score of 1 indicating poor practices and 0 indicating good practices. For the attitude level composite variable, five questions were used (Table 3). A sum was calculated and the average was taken. Respondents scoring above the average were graded as having a positive attitude hence coded 1, while those below average were considered to have a negative attitude hence coded 0. Knowledge was similarly measured, with scores assigned based on familiarity with pharmaceutical waste, and awareness of disposal methods, effects, and regulations. Scores above average were classified as 'good', at average as 'fair' and below average as 'poor'.

Data management and analysis

Data was downloaded from Kobotoolbox, organized, and cleaned in MS Excel, after which was imported into STATA 14 for univariate, bivariate, and multivariable analyses. At the univariate level, descriptive statistics such as frequencies and percentages were calculated to determine the prevalence of poor pharmaceutical waste disposal practices. At the bivariate level, a chi-square test was run to examine the possibility of associations between the categorical dependent variable 'practice level' and each independent variable. Crude Prevalence Ratios (CPR) were then generated using modified Poisson regression for those variables that showed a statistical association (P-value $\leq$ 0.10). Key variables including sex, marital status, income, tribe, age, education, religion, knowledge level, and attitude level showed the association. At the multivariable level, Modified Poisson Regression was used to calculate Adjusted Prevalence Ratios (APR), to identify factors significantly associated with poor pharmaceutical waste disposal (P-value $\leq$ 0.05). The strengths of these associations were determined using prevalence ratios at a 95% confidence level, addressing the second objective: to identify factors associated with poor pharmaceutical waste disposal methods.

Ethical considerations

Permission to conduct the study was obtained from Makerere University School of Public Health as part of the Bachelor in Environmental Health Sciences program. In addition, permission to carry out the survey interviews was obtained from local leaders of each division in Nansana Municipality. All respondents were explained about the study before they consented verbally. All responses from the respondents were kept confidential.

Results

Socio-demographic characteristics

A total of 399 respondents from four divisions of Nansana Municipality, who had lived for an average of 20 months (±17.6) in the area, participated in this study.

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These included 75.9% (303/399) females, and 38.1% (152/399) aged between 20-25 years, with a mean age of 32 years (±7.4). Among the respondents, 67.4% (269/399) were married, and 43.4% (173/399) had attained a secondary level of education. The majority of the respondents 62.2% (248/399) had a temporary employment status and 43.1% (172/399) earned between 90-149 USD with an average monthly salary of USD 105.26 (±38.91). However, more than half 58.2% (232/399) of the respondents' households had a size of 5 members and more (Table 1).

Knowledge of respondents towards pharmaceutical waste disposal methods

The study revealed that almost three quarters of the respondents 72.4% (289/399) knew what pharmaceutical waste was. However, only 16% (46/289) of these respondents had a generally good knowledge level. Majority of the respondents 83% (331/399) did not know the recommended pharmaceutical waste disposal methods at household level, among whom, about a half 43% (141/331) generally had poor knowledge on pharmaceutical waste disposal. Over two thirds 70% (279/399) of the respondents knew that pharmaceutical waste had side effects when exposed to the environment (Table 2). The most commonly known side effect was drug poisoning to children by over 93% (370/399) of the respondents (Figure 1).

Table 1: Socio-demographic characteristics of respondents

Variable	Category	Frequency (n=399)	Percentage (%)
Age (years)	**Mean (STD)**	**32 (**±12.9**)**	
	20-25	152	38.1
	26-30	116	29.1
	≥ 30	131	32.8
Sex	Male	96	24.1
	Female	303	75.9
Marital Status	Single	130	32.6
	Married	269	67.4
Tribe	Muganda	245	61.4
	Musoga	97	24.3
	Mugisu	46	11.5
	Others	11	2.8
Religion	Catholic	152	38.1
	Muslim	76	19.1
	Anglican	91	22.8
	Others	80	20.1
Education level	None	17	4.3
	Primary	63	15.8
	Secondary	173	43.4
	University	146	36.6
Employment status	Unemployed	4	1
	Temporary	248	62.2
	Contract	147	36.8
Monthly income (USD)	Mean (STD)	105.26 (±38.91)	
	10-89	171	42.9
	90-149	172	43.1
	150 and above	56	14.0
Household size	Mean (STD)	5 (2)	
	1-2	24	6.0
	3-4	143	35.8
	5+	232	58.2
Duration lived (in years)	Mean (STD)	20.33 (±17.63)	
	1	106	26.6
	2	199	49.9
	> 2	94	23.6

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Table 2: Knowledge on pharmaceutical waste disposal attributes

Attributes	Knowledge of respondents on pharmaceutical waste disposal				
	Category	*Total N=399 (%)*	Good n=65 (%)	Fair n=169 (%)	Poor n=165 (%)
Knew what pharmaceutical waste was	Yes	***289 (72.4)***	46 (15.9)	127 (43.9)	116 (40.1)
	No	***110 (27.6)***	19 (17.3)	42 (38.2)	49 (44.5)
Checked for expiry dates before buying drugs	Yes	***113 (28.3)***	14 (12.4)	50 (41.6)	49 (43.4)
	No	***286 (71.7)***	51 (17.8)	119 (41.6)	116 (40.6)
Knew recommended methods for pharmaceutical waste disposal	Yes	***68 (17.0)***	9 (13.2)	35 (51.5)	24 (35.3)
	No	***331 (83.0)***	56 (16.9)	134 (40.5)	141 (42.6)
Pharmaceutical waste has side effects to the environment	Yes	***279 (69.9)***	45 (16.1)	120 (43.0)	114 (40.9)
	No	***120 (30.1)***	20 (16.7)	49 (40.8)	51 (42.5)
Usually asked for advice on disposal of pharmaceutical waste	Yes	***13 (3.3)***	3 (23.1)	4 (30.8)	6 (46.2)
	No	***386 (96.7)***	62 (16.1)	165 (42.8)	159 (41.2)
Knew where to report about pharmaceutical waste	Yes	***16 (4.0)***	3 (18.8)	9 (56.3)	4 (25.0)
	No	***383 (96.0)***	62 (16.2)	160 (41.8)	161 (42.0)
Aware of existing regulations on PWs	Yes	***6 (1.5)***	0 (0.0)	4 (66.7)	2 (33.3)
	No	***393 (98.5)***	65 (16.5)	165 (42.0)	163 (41.5)
Received guidance from leaders on pharmaceutical waste disposal	Yes	***6 (1.5)***	2 (33.3)	3 (50.0)	1 (16.7)
	No	***393 (98.5)***	63 (16.0)	166 (42.2)	164 (41.7)

Figure 1: Known effects of pharmaceutical waste when exposed to the environment

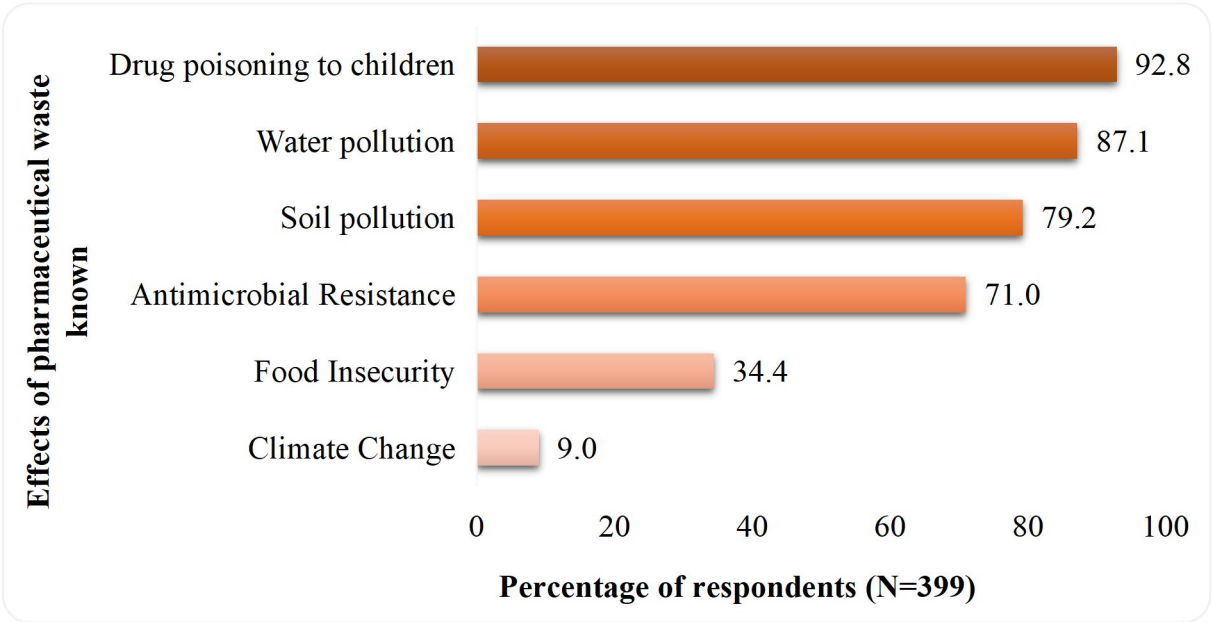

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Table 3: Attitude of respondents towards pharmaceutical waste disposal

	Attitude levels of respondents towards pharmaceutical waste disposal N=399 (%)					
Overall Attitude Scores	**Positive 297 (74.4%)**			**Negative 102 (25.6%)**		
Variable	**Agree**	**Neutral**	**Disagree**	**Agree**	**Neutral**	**Disagree**
Women play a role in pharmaceutical waste disposal	297 (76.6)	0 (0.0)	0 (0.0)	91(23.5)	11 (100.0)	0 (0.0)
People do not know what to do with pharmaceutical waste	297 (82.7)	0 (0.0)	0 (0.0)	62 (17.3)	17 (100.0)	23 (100.0)
There should be interventions to collect pharmaceutical waste alone	297 (82.0)	0 (0.0)	0 (0.0)	65 (18.0)	23 (100.0)	14 (100.0)
Healthcare workers try to give advice on pharmaceutical waste disposal	0 (0.0)	0 (0.0)	297 (77.8)	0 (0.0)	17 (100.0)	85 (22.2)
Current pharmaceutical waste disposal is not good	297 (82.5)	0 (0.0)	0 (0.0)	63 (17.5)	28 (100.0)	11 (100.0)

Table 4: Prevalence of pharmaceutical waste disposal practices

Variable	Category	**Prevalence of pharmaceutical waste disposal practices N=399 (%)**	
		Good	**Poor**
		111 (27.82)	288 (72.18)
Age (years)	**Mean (STD)**	**28** (±11)	**34** (±13)
	20-25	65 (42.8)	87 (57.2)
	26-30	32 (27.6)	84 (72.4)
	≥ 30	14 (10.7)	117 (89.3)
Sex	Male	47 (49.0)	49 (51.0)
	Female	64 (21.1)	239 (78.9)
Marital Status	Single	44 (33.9)	86 (66.2)
	Married	67 (24.9)	202 (75.1)
Tribe	Muganda	76 (31.0)	169 (69.0)
	Musoga	25 (25.8)	72 (74.2)

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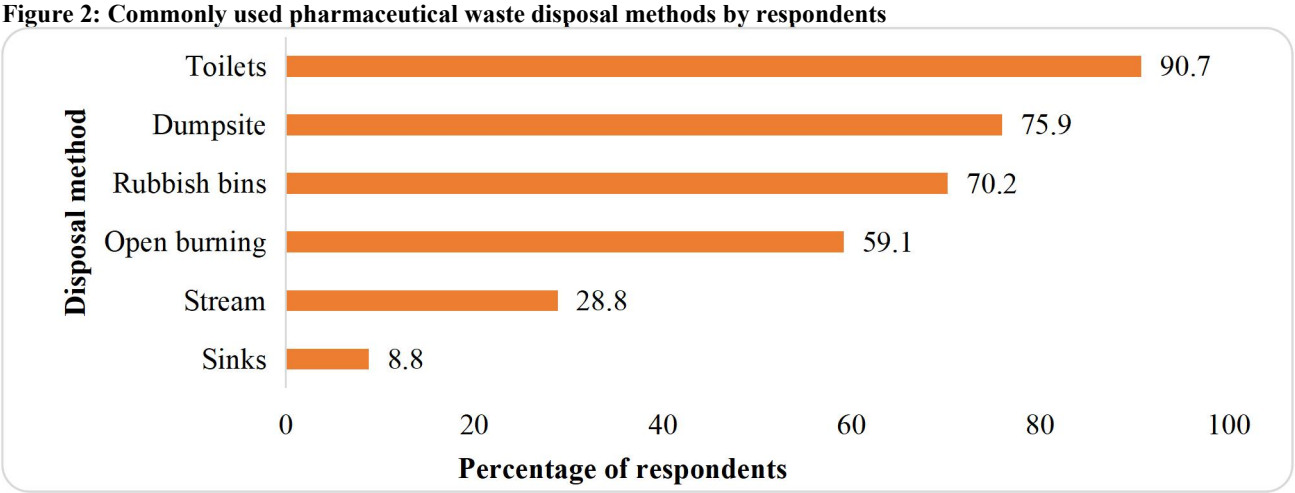
	Mugisu	8 (17.4)	38 (82.6)
	Others	2 (18.2)	9 (81.8)
Religion	Catholic	44 (29.0)	108 (71.1)
	Muslim	20 (26.3)	56 (73.7)
	Anglican	22 (24.2)	69 (75.8)
	Others	25 (31.3)	55 (68.8)
Education level	None	0 (0.0)	17 (100.0)
	Primary	5 (7.9)	58 (92.1)
	Secondary	46 (26.6)	127 (73.4)
	University	60 (41.1)	86 (58.9)
Employment status	Unemployed	2 (50.0)	2 (50.0)
	Temporary	57 (23.0)	191 (77.0)
	Contract	52 (35.4)	95 (64.6)
Monthly income	**Mean (STD)**	**112.6 (±39.6)**	**102.4 (±38.3)**
(USD)	10-89	41 (24.0)	130 (76.0)
	90-149	44 (25.6)	128 (74.4)
	150 and above	26 (46.4)	30 (53.6)
Household size	Mean (STD)	**4 (±2)**	**5 (±2)**
	1-2	14 (58.3)	10 (41.7)
	3-4	64 (44.2)	79 (55.2)
	5+	33 (14.2)	199 (85.8)
Duration lived	Mean (STD)	**15 (±13)**	**22** (±19)
(in months)	1 year	46 (43.4)	60 (56.6)
	2 years	52 (26.1)	147 (73.9)
	Above 2 years	13 (13.8)	81 (86.2)

Figure 2: Commonly used pharmaceutical waste disposal methods by respondents



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Attitudes of respondents towards pharmaceutical waste disposal

Table 3 reveals that 74.4% (297/399) of respondents had a positive attitude toward pharmaceutical waste disposal. Specifically, 76.6% (297/388) agreed that women play a role in pharmaceutical waste disposal. Furthermore, 82.7% (297/359) agreed that most people do not know what to do with pharmaceutical waste, and 82.0% (297/360) agreed that specific interventions should be introduced to collect pharmaceutical waste separately. Additionally, 77.8% (297/382) of respondents disagreed that healthcare workers try to give advice on pharmaceutical waste disposal and 82.5% (297/360) agreed that current disposal methods are inappropriate.

Prevalence of poor pharmaceutical waste disposal practices

Almost three quarters 72.2% (288/399) of the respondents engaged in poor pharmaceutical waste disposal practices. The most commonly used disposal methods noted by participants were toilets by 91% (363/399), dumpsites by 76% (303/399) and rubbish bins by 70% (280/399) (figure 2). More than three quarters 89.3% (117/131) of the respondents aged above thirty years and 79% (239/303) of the female respondents engaged in poor pharmaceutical waste disposal practices. The prevalence of engaging in poor pharmaceutical waste disposal methods decreased with increasing household average monthly income among the respondents. Over three quarters 76% (130/171) of respondents, who earned a monthly salary of USD 10–89, engaged in poor pharmaceutical waste disposal practices compared to over half 53.6% (30/56) of those who earned a monthly salary of USD 150 and above. Over three quarters 86% (199/232) of the respondents who lived in households of 5 or more people engaged in poor pharmaceutical waste disposal practices. (Table 4).

Factors associated with poor pharmaceutical waste disposal practices

At bivariate level of analysis, the factors that were positively associated with use of poor pharmaceutical waste disposal were; age groups of 26-30 years [Prevalence Ratio (PR) (95% CI) = 1.27(1.06-1.51)] and 30+ years [PR (95% CI) = 1.56(1.34-1.81)], being a female [PR (95% CI) = 1.55(1.26-1.90)] and having a married status [PR(95%CI) = 1.14(0.99-1.31)]. Living in a household with a size of 5 or more members [PR (95% CI) = 2.06(1.28-3.32)] as well as having lived for more than 2 years in the area at the time of the interview [PR(95%CI) = 1.52(1.26-1.83)].

Factors that showed a negative association with the use of poor pharmaceutical waste disposal included; primary, secondary, and university levels of education [PR (95% CI) = 0.92(0.86-0.99)], [PR (95% CI) = 0.73(0.67-0.80)] and [PR (95% CI) = 0.59(0.51-0.67)] respectively. Other negative associations were seen among respondents who earned a monthly salary of USD 150 and above [PR (95% CI) = 0.70(0.54-0.91)], having a positive attitude towards pharmaceutical waste disposal [PR (95% CI) = 0.74(0.67-0.83)] and having a high knowledge level [PR (95% CI) = 0.67(0.54-0.82)].

At multivariable analysis, the factors that were positively associated with poor pharmaceutical waste disposal included; age groups of 26-30 years [Adjusted Prevalence Ratio (PR) (95% CI) = 1.20(1.03-1.41)] and 30+ years [PR (95% CI) = 1.33(1.15-1.54)], as well as being a female [PR (95% CI) = 1.53(1.27-1.83)]. Living in a household with a size of 5 or more members [PR (95% CI) = 1.33(1.15-1.54)] as well as having lived for more than 2 years in the area at the time of the interview [PR(95%CI) = 1.85(1.20-2.86)].

Factors that showed a negative association with the use of poor pharmaceutical waste disposal methods at multivariable levels included: primary, secondary and university levels of education [PR (95% CI) = 0.78(0.64-0.95)], [PR (95% CI) = 0.71(0.57-0.88)] and [PR (95% CI) = 0.76(0.60-0.98)] respectively. Other negative associations were seen among respondents who earned a monthly salary of USD 150 and above [PR (95% CI) = 0.76(0.59-0.98)], having a positive attitude towards pharmaceutical waste disposal [PR (95% CI) = 1.29(1.08-1.54)] and having a high knowledge level [PR (95% CI) = 0.70(0.57-0.85)] (Table 5).

Table 5: Factors associated with use of poor pharmaceutical waste disposal practices

Factors	Total (N =399)	Use poor pharmaceutical waste disposal practices				
		Number (%) (n=288)	Crude Prevalence Ratios (CPRs) at 95% CI	p-value	Adjusted Prevalence Ratios (APRs) at 95% CI	p-value
Age-group (years)						
20-25	152	87 (57.2)	1.00		1.00	
26-30	116	84 (72.4)	1.27 (1.06-1.51)	0.009*	1.20 (1.03-1.41)	**0.019***
≥ 30	131	117 (89.3)	1.56 (1.34-1.81)	<0.001*	1.33 (1.15-1.54)	**<0.001***
Gender						
Male	96	49 (51.0)	1.00		1.00	
Female	303	239 (78.9)	1.55 (1.26-1.90)	<0.001*	1.53 (1.27-1.83)	**<0.001***
Marital Status						
Single	130	86 (66.2)	1.00		1.00	
Married	269	202 (75.1)	1.14 (0.99-1.31)	0.078*	0.99 (0.86-1.15)	0.967
Tribe						
Muganda	245	169 (69.0)	1.00		1.00	
Musoga	97	72 (74.2)	1.08 (0.93-1.24)	0.320	1.10 (0.97-1.26)	0.150
Mugisu	46	38 (82.6)	1.20 (1.02-1.40)	0.025*	1.40 (1.20-1.63)	**<0.001***
Other tribes	11	9 (81.8)	1.19 (0.87-1.59)	0.251	1.10 (0.86-1.41)	0.461
Education level						
None	17	17 (100.0)	1.00		1.00	
Primary	63	58 (92.1)	0.92 (0.86-0.99)	0.026*	0.78 (0.64-0.95)	**0.014***
Secondary	173	127 (73.4)	0.73 (0.67-0.80)	<0.001*	0.71 (0.57-0.88)	**0.002***
University	146	86 (58.9)	0.59 (0.51-0.67)	<0.001*	0.76 (0.60-0.98)	**0.035***
Monthly income (USD)	171	130 (76.0)	1.00		1.00	
10-89	172	128 (74.4)	0.98 (0.87-1.11)	0.731	0.96 (0.83-1.10)	0.548
90-149	56	30 (53.6)	0.70 (0.54-0.91)	0.008*	0.76 (0.59-0.98)	**0.035***
150 and above						
Household size						
1-2	24	10 (41.7)	1.00		1.00	
3-4	143	79 (55.2)	1.33 (0.81-2.18)	0.265	1.20 (1.03-1.41)	**0.019***
5+	232	199 (85.8)	2.06 (1.28-3.32)	0.003*	1.33 (1.15-1.54)	**<0.001***
Duration lived (years)	106	60 (56.6)	1.00		1.00	
1	199	147 (73.9)	1.31 (1.08-1.57)	0.005*	1.25 (0.79-1.98)	0.346
2	94	81 (86.2)	1.52 (1.26-1.83)	<0.001*	1.85 (1.20-2.86)	**0.006***
> 2						
Attitude Level						
Negative	102	91 (89.2)	1.00		1.00	
Positive	297	197 (66.3)	0.74 (0.67-0.83)	<0.001*	1.29 (1.08-1.54)	**0.004***
Knowledge Level						
Low	165	148 (89.7)	1.00		1.00	
Medium	169	101 (59.8)	0.66 (0.58-0.76)	<0.001*	0.69 (0.58-0.82)	**<0.001***
High	65	39 (60.0)	0.67 (0.54-0.82)	<0.001*	0.70 (0.57-0.85)	**<0.001***

*Statistically significant at ***p<0.05***

Discussion

The poor disposal of pharmaceutical waste presents a significant public health and environmental concern, particularly in urban areas of developing countries. This study found that a high proportion (72.2%) of households in Nansana Municipality engaged in poor pharmaceutical waste disposal practices, with the most common methods being the use of toilets 91%, dumpsites 76% and rubbish bins 70%. These findings underscore the urgent need for effective waste management strategies to prevent environmental contamination and mitigate health risks, especially as pharmaceutical compounds can persist in the environment, leading to various effects including those known by Nansana residents; drug poisoning to children 93%, antimicrobial resistance 71% and other ecological consequences. The study identified key sociodemographic factors such as average household monthly salary, gender and education levels associated with poor disposal practices, providing insights that could inform targeted interventions to improve public awareness and safe disposal behaviours.

This study found that many households in Nansana Municipality engaged in poor pharmaceutical waste disposal practices. Specifically, 72.2% of surveyed households disposed of pharmaceutical waste inappropriately, either by disposal in rubbish bins, dumpsites and toilets/latrines. This high prevalence highlights a critical pathway for Active Pharmaceutical Ingredients entering into the environment, causing serious public health and environmental risks. The prevalence observed in this study is consistent with findings from other developing regions such as Nigeria and India, where poor practices were similarly widespread, both having a prevalence of 73% of participants engaging in poor pharmaceutical waste disposal[19,20]. The slight difference from what this study found could be attributed to differences in population densities, urban infrastructure, waste management systems and the measurement of poor pharmaceutical disposal methods used. Larger cities with higher population densities such as Abuja and Delhi, tend to have higher rates of medical uptake and consequently more waste. This potentially explains the marginally higher prevalence of poor disposal in these areas. In contrast, some developed countries like Sweden have a significantly lower prevalence of poor pharmaceutical waste disposal, with only 3% of households disposing of pharmaceutical waste with other solid waste[21,22]. This disparity can largely be attributed to the comprehensive waste management systems in place in these countries, including well-regulated pharmaceutical take-back programmes, widespread public education campaigns and easily accessible disposal facilities[22]. Such systems are largely absent in some developed[21] and developing countries like Uganda, highlighting a critical need for improving both infrastructure and public awareness regarding proper pharmaceutical waste disposal. Importantly, addressing this issue requires not only infrastructure improvements but also cultural and behavioural changes towards more sustainable and responsible waste disposal practices.

This study also revealed significant environmental and health risks associated with poor pharmaceutical waste disposal in Nansana Municipality. Over 91% of respondents disposed of waste through toilets, 76% used dumpsites and 70% relied on rubbish bins, highlighting the gaps in household pharmaceutical waste management. The use of toilets is especially concerning as Active Pharmaceutical Ingredients pass through wastewater treatment plants and enter aquatic ecosystems where they disrupt aquatic life and re-enter water supplies[9]. These compounds such as antibiotics and contraceptives are not fully removed by water treatment processes, leading to public health risks like antimicrobial resistance and hormonal disruption including a reduction in male fertility[23,24]. The presence of high levels of antiretroviral drugs in chicken and pork in Uganda illustrates the dangerous impact of pharmaceutical residues entering the food chain. Over 25% of plasma samples contained ARV residues, with rural areas having a higher prevalence 47.6% than urban areas 19.1% [25]. Due to such practices, pre-treatment HIV-1 drug resistance has increased from 5% to 11.9% within 6 years[26]. Despite 93% of residents being aware of the risks of drug poisoning to children, poor disposal practices persisted, showing that knowledge gaps exist, with 30% of respondents unaware of the broader environmental and health effects of pharmaceutical waste. This reflects global trends, like in Ethiopia where a study found out that over 50% of their respondents had good knowledge about pharmaceutical waste however, 75% still threw such waste in household garbage[27]. This underscores the urgent need for targeted interventions, which requires infrastructure improvements alongside community education, with gender-sensitive approaches to empower women who are traditionally more involved in household healthcare to advocate for safer disposal practices. By combining improved waste systems and behaviour change efforts, public health and environmental sustainability can be safeguarded.

The likelihood of engaging in poor pharmaceutical waste disposal increased with the increasing age of the residents in Nansana Municipality, where individuals aged above 30 years were 1.33 times more likely than those aged 20 to 25 years. This finding aligns with studies that found that older individuals (> 30 years) were 60% more likely to engage in poor pharmaceutical waste disposal than young ones[28]. This can be because older adults may be less adaptable to new waste management guidelines, or even more aligned to traditional disposal methods that are not environmentally friendly[29]. Addressing these long-standing behaviours necessitates age-sensitive interventions tailored to the specific needs of different age groups, older populations inclusive. Public health initiatives must focus on raising awareness and promoting behaviour change, ensuring older adults transition to safe and more sustainable disposal practices. Gender disparities also played a significant

role, with females being more likely to engage in poor pharmaceutical waste disposal than males. This finding also resonated with other studies conducted such as one by Ocan who found that women were more likely to store drugs in homes than their male counterparts, which practice may align with the likelihood of disposing pharmaceutical waste[5]. In many low-income settings, societal norms dictate that women manage household waste, including pharmaceutical waste, which places them at high risk of poor disposal behaviours[30]. As primary healthcare givers in homes, women usually handle and manage medications, which further increases their exposure to poor pharmaceutical waste disposal practices[31]. These findings therefore highlight the importance of developing gender-sensitive educational strategies that not only inform women about the health and environmental risks of poor pharmaceutical waste disposal but also empower them with practical tools for safe disposal.

Educational attainment also proved to be a critical factor in reducing poor pharmaceutical waste disposal. Individuals with higher levels of education were significantly less likely to engage in poor disposal practices, underscoring the pivotal role education plays in fostering environmental stewardship. Educated individuals are generally more informed about the adverse health and environmental impacts of poor disposal, making them more likely to follow safe disposal guidelines. These findings are consistent with broader research that links higher educational attainment to improved health-related behaviours, including better management of pharmaceutical waste. Magagula et al found out that the willingness to return pharmaceutical waste was statistically significant with an increasing level of education[11]. To reinforce positive behaviours, strengthening educational campaigns in schools, universities, and community settings can help shape a future generation that prioritizes sustainable waste management. Integrating environmental education into formal curricula would also foster a culture of environmental responsibility, ensuring that proper disposal practices are rooted from a young age, thereby leading to long-term benefits. Similarly, income was another significant determinant, with higher-income earners demonstrating better disposal practices compared to lower-income households. Wealthier individuals tend to have better access to resources such as secure disposal facilities, enabling them to adopt improved waste management practices[32]. Economic stability also allows higher-income individuals to prioritize environmental and health considerations, while lower-income households may face competing priorities, such as economic survival, which can hinder their ability to engage in proper disposal methods[33]. This disparity underscores the need for urgent policy interventions that expand access to pharmaceutical take-back programmes and safe disposal options, particularly in lower-income communities. Universal access to disposal services is essential for ensuring equitable participation in proper pharmaceutical waste disposal practices, helping to bridge the gap and create a more sustainable and health-conscious society.

The study also revealed that positive attitudes towards pharmaceutical waste disposal and higher knowledge levels were strongly associated with better disposal practices. Awareness is a key driver of behaviour change, as evidenced by overwhelming support from respondents for interventions aimed at improving waste collection from households. Over 90% of respondents agreed on the need for a specific intervention to collect pharmaceutical waste from homesteads and similar sentiments were observed in studies like Gidey's, where 65.4% of participants supported the idea of mandatory take-back programmes[34]. However, knowledge should be coupled with attitude shifts that foster a sense of personal responsibility toward waste management. This highlights the importance of comprehensive educational campaigns that not only provide information but also encourage positive attitudes toward responsible disposal. These campaigns must emphasize the long-term public health risks of poor pharmaceutical waste disposal, including drug resistance, water contamination and harm to ecosystems, to drive home the urgency of proper disposal behaviours.

Conclusion

The study revealed a high prevalence of poor pharmaceutical waste disposal practices among residents of Nansana Municipality Wakiso District Uganda, indicating a high risk of environmental pollution and adverse health effects. This underscores the need for urgent interventions to improve pharmaceutical waste disposal practices in the area. The interplay of age, gender, education, and income factors with poor disposal behaviors indicates that public health strategies must be multifaceted, incorporating educational, economic, and infrastructure-based interventions to reduce poor disposal and safeguard both environmental and public health.

Study limitations

The measurements of respondents' attitudes might not have fully captured the complexities of respondents' underlying beliefs. Further qualitative studies could provide a richer understanding of the factors influencing their poor pharmaceutical waste disposal practices.

Recommendation

A voluntary take-back program for pharmaceutical waste is essential to encourage consumers to return unused drugs to pharmacies which then forward them

to collection points for industry-led high incineration. Pharmaceutical producers should bear responsibility for eco-friendly packaging and labeling. Public awareness campaigns should promote the safe disposal and segregation of hazardous waste.

Strengths of the study

A stratified random sampling approach was used to ensure equal representation across divisions. The interviewer-administered structured questionnaire used reduced bias when interviewers clarified ambiguous questions, ensuring everyone understood the same way. Data entry using Kobotoolbox further minimized errors during data collection.

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Conflict of interest

The authors declare no conflict of interest.

Abbreviations and acronyms

HH	Household
NDA	National Drug Authority
NMS	National Medical Store
MoH	Ministry of Health
WHO	World Health Organization

Data availability

Data used in this research study is available upon request from the corresponding author.

Author contributions

HL designed the study, conducted data collection, cleaned and analysed data and wrote the draft of the manuscript. JKBM supervised all stages of the study from conceptualization of the topic to manuscript writing and submission. DM supported in study conceptualization, general supervision and mentorship, as well as reviewing the manuscript.

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