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Management of pharmaceutical waste from hospitals and community pharmacies in Bahir Dar and Gondar cities, Ethiopia

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Abstract

Background Pharmaceutical waste (PW) generated in health facilities includes expired or unused medications, contaminated materials, and other pharmaceutical residues from diagnosis, treatment, immunization, compounding, and manufacturing. PW management (PWM) is critical for environmental protection and public health. Therefore, this study aimed to evaluate management of PW at hospitals and community pharmacies in Bahir Dar and Gondar cities, Ethiopia.

Methods A facility-based cross-sectional study was conducted in hospitals and private pharmacies in Gondar and Bahir Dar cities from July 2023 to September 2023. Hospitals and pharmacies were selected based on their significance as major urban centers in the Amhara region of Ethiopia. About 208 pharmacies and drug stores, both public and private, that were open during the data collection period and one pharmacy professional from each dispensary were included in the study. SPSS version 26.0 was used for analysis. Descriptive results are reported as the means with standard deviations (SDs), frequencies, and percentages. Binary logistic regression was used to identify predictors of PWM knowledge. A P value of 0.05 was considered statistically significant during the data analysis.

Results Most participants (59.6%) had good knowledge about PWM. Experience (AOR = 2.86, 95% CI: 1.26, 6.48) and regular PWM training (AOR = 3.60, 95% CI: 1.73, 7.49) were significantly associated with good knowledge about PWM. PWM practices were rated similarly by the participants, with good and poor scores of 52.9% and 47.1%, respectively. Experience (AOR = 3.33, 95% CI: 1.49, 7.47) and working at a hospital (AOR = 5.19, 95% CI: 1.95, 13.83) were significantly associated with good practices toward PWM. Most participants' facilities had different infrastructures for PWM, such as PW collection containers (90.9%), clean containers (88%), color-coded and labeled containers (73.6%), burial pits without liners (54.8%), personal protective equipment (79.3%), and access to municipal-level landfills (62%). However, only 47.6% of the participants' facilities had an incinerator for the disposal of ashes.

Conclusion Most participants had good knowledge and practices related to PWM. Experience with and training about PWM were significantly associated with the good knowledge of participants about PWM. Additionally,

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experience and working in hospitals were also significantly associated with the good practices of participants toward PWM. Participants who had more exposure to PWM practices demonstrated better adherence, and those working in hospitals exhibited superior PWM practices compared to those in community pharmacies. Improper disposal of pharmaceutical waste threatens environmental health, contaminating water and soil, harming ecosystems, and posing risks to vulnerable populations. To address this, regular training for pharmacy personnel on safe disposal and segregation is essential. Additionally, investing in infrastructure like incinerators and proper landfills is crucial for sustainable PWM, mitigating associated public health risks.

Keywords Pharmaceutical wastes, Pharmaceutical waste management, Hospital pharmacy, Community pharmacy, Bahir Dar, Gondar

Introduction

Pharmaceutical waste management (PWM) has become a global concern due to the environmental and public health risks posed by improper disposal practices. Pharmaceuticals, including expired, unused, and contaminated drugs, can enter the environment through various pathways, leading to pollution of water sources, soil, and even food chains [1]. In developed nations, robust systems for managing pharmaceutical waste (PW) have been established, supported by strict regulations and advanced infrastructure. For example, the European Union's Directive 2004/27/EC mandates member states to implement safe disposal measures, ensuring minimal environmental impact [2].

In contrast, developing countries face significant challenges in managing PW, including the high cost of proper disposal, inadequate infrastructure, insufficient regulatory frameworks, and limited public awareness, leading to contamination of water supplies and environmental degradation [3]. Ethiopia, for instance, grapples with similar challenges. Although the Ethiopian Food and Drug Authority (EFDA) has introduced guidelines for PWM, enforcement remains weak, and awareness among healthcare providers is limited [4].

Internationally, multiple guidelines address the management of PW. The World Health Organization (WHO) developed "Guidelines for Safe Disposal of Unwanted Pharmaceuticals in and after Emergencies," which emphasize the importance of proper disposal, particularly in resource-limited settings [5]. Agenda 21, adopted at the 1992 Rio Earth Summit, also underscores sustainable waste management, including hazardous waste like pharmaceuticals, to protect human health and the environment [6]. The Sustainable Development Goals (SDGs), especially SDG 3 (good health and well-being) and SDG 12 (responsible consumption and production), further highlight the importance of effective PWM for public health and environmental sustainability [7].

PW, which is generated by health facilities during the use of pharmaceuticals during diagnosis, treatment, immunization, compounding, and manufacturing, can be dangerous, eco-toxic, flammable, non-flammable, not-pharmaceutically active, and/or hazardous [8–11]. The improper disposal of these wastes causes environmental pollution, may enter the water system, and may harm the aquatic system [12, 13]. Moreover, pharmaceutical residues in water sources can lead to the development of antibiotic-resistant bacteria, compromising the effectiveness of treatments for human diseases [14]. Since disposal differs greatly from that of conventional garbage, specific precautions must be taken to dispose of PW. Except for some agents that need to be burned in a waste incinerator, PW is often drained [15].

If a landfill is unsecured, children and scavengers can get their hands on PW. Expired medications may be diverted into the market for resale and abuse because of theft from a stockpile of trash drugs or during sorting [10]. Separating materials such as food trash and recyclables from typical hospital waste would also help with effective waste management because it would make it possible to recycle paper and cardboard and create biomass from food waste. Properly recycling medical blister packing could lead to increased sustainability. The cost of the disposal of healthcare waste and factors such as contamination and pollution must be considered when this type of waste is being stored and transported, and decisions are being made on the correct technology for disposal. Color coding and recorded seals have proven to be efficient processes, and they follow the protocol of many legislations and policies that prevent the negative impact of healthcare waste on the environment [12]. Patients, waste workers, healthcare employees, and the public can all experience severe issues because of improper waste management in the healthcare industry. The provision of healthcare is affected by increased danger of medical waste and a lack of waste separation knowledge [13].

The main causes of improper management of infectious waste include a lack of information regarding waste collection and segregation, a lack of risk awareness, unsafe waste disposal, and a lack of financial resources [16]. Medical professionals who work in recycling companies, government administrations, policy development, quality assurance, etc., face a dilemma regarding managing PW effectively. Waste disposal is handled by all parties involved in the healthcare system, including doctors,

pharmacists, and nurses. The government, NGOs, and the public should collaborate with them to lessen the burden of PW in the environment [15, 16].

Africa has a wide range of economic and disposal strategies, such as color coding and recorded seals, which have been shown to be effective techniques, and they adhere to many laws and regulations that stop the harmful effects of medical waste on the environment. Despite studies on PW-related variables, the body of knowledge is still poorly synthesized and fragmented [17].

A systematic mechanism to retrieve damaged, expired, unused, and leftover medications from the downstream supply chain system has not yet been established in Ethiopia. Nevertheless, the Ethiopian government recently announced its intention to use reverse logistics. To develop strategies to advise stakeholders on how to write off toxic PW, it is crucial to study the level of awareness, practice, and understanding of the safe disposal practices of PW among consumers and practitioners [18]. Therefore, this study aimed to evaluate management of PW at hospitals and community pharmacies in Bahir Dar and Gondar cities, Ethiopia.

Methods

Study design, setting and period

A facility-based cross-sectional study was conducted in public and private pharmacies and drug stores in Gondar and Bahir Dar cities from July 2023 to September 2023. Gondar city is situated in the Amhara regional state's central Gondar administrative zone, 750 km northwest of Addis Ababa and 185 km from Bahir-Dar. The Gondar population is projected to be approximately 227,100, according to data from the 2007 National Census. Approximately 500,000 individuals in the town of Gondar are served by 78 community pharmacies and two public hospitals with 20 pharmacies. Bahir Dar is the capital city of the region, which is situated 565 km from Addis Ababa, the capital city of the country. The population of Bahir Dar was estimated to be approximately 339,683, and that of Gondar was 362,000 in 2020.

The University of Gondar Referral and Comprehensive Specialized Hospital has a bed capacity of approximately 960 beds and serves over 13 million people, managing more than 400,000 outpatient visits and 30,000 admissions annually. Ayra Hospital in Gondar has a capacity of 400 beds. In Bahir Dar, Felege Hiwot Comprehensive Specialized Hospital has 500 beds, Tibebe Ghion Specialized Teaching Hospital has 459 beds, and Addis Alem Primary Hospital has 47 beds. The range of medications that pharmacies and drug stores are permitted to stock or dispense, as well as the credentials of professionals who oversee retail locations, varies in Ethiopia. A licensed pharmacist with a minimum bachelor's degree in pharmacy oversees the pharmacy, and a licensed druggist or pharmacy technician with a minimum diploma in pharmacy runs the drugstore. The community drug retail locations provide patient-centered services such as treating symptoms, completing prescriptions, and providing counseling to patients. The two cities were chosen because they are the most populated cities in the region with better health care practices and availability and better access to health care information.

Population

The source population for the study consists of all pharmacy professionals working in both hospital and community pharmacies located in the urban areas of Bahir Dar and Gondar cities, Ethiopia, and involved in PWM during the study period from July to September 2023. The study population consists of pharmacy professionals who were working in selected public and private pharmacies in Bahir Dar and Gondar cities during the data collection period. This includes those who were available and willing to participate in the survey, covering professionals from both hospital and community pharmacies.

Inclusion and exclusion criteria

Every pharmacy that was open on the day of data collection was included, as were any practitioners who consented to take part in the research. Nevertheless, pharmacy professionals who did not voluntarily agree to participate in the study and pharmacies that were closed during data collection were not included in the study.

Sampling and sampling technique

There were a total of 239 pharmacies and drug stores in the two cities. From these, there were 28 hospital pharmacies, 47 community pharmacies, and 32 drug stores in Gondar city, and there were approximately 35 hospital pharmacies, 56 community pharmacies, and 41 drug stores in Bahir Dar city. All pharmacy dispensaries in the two cities that were open during data collection were included in the study, and one pharmacy professional from each pharmacy dispensary was selected to participate in the study, resulting in the participation of 208 pharmacy professionals from the two cities (Fig. 1).

Data collection procedures

A semi-structured, pretested, self-administered questionnaire was used to collect the required data. The PWM questions were adapted from another study that was used to collect data on PWM [13]. It came in four pieces. The study participants' sociodemographic characteristics were covered in the first section; questions evaluating the participants' knowledge of medicine disposal practices for PW were covered in the second section; questions addressing medicine disposal practices were covered in

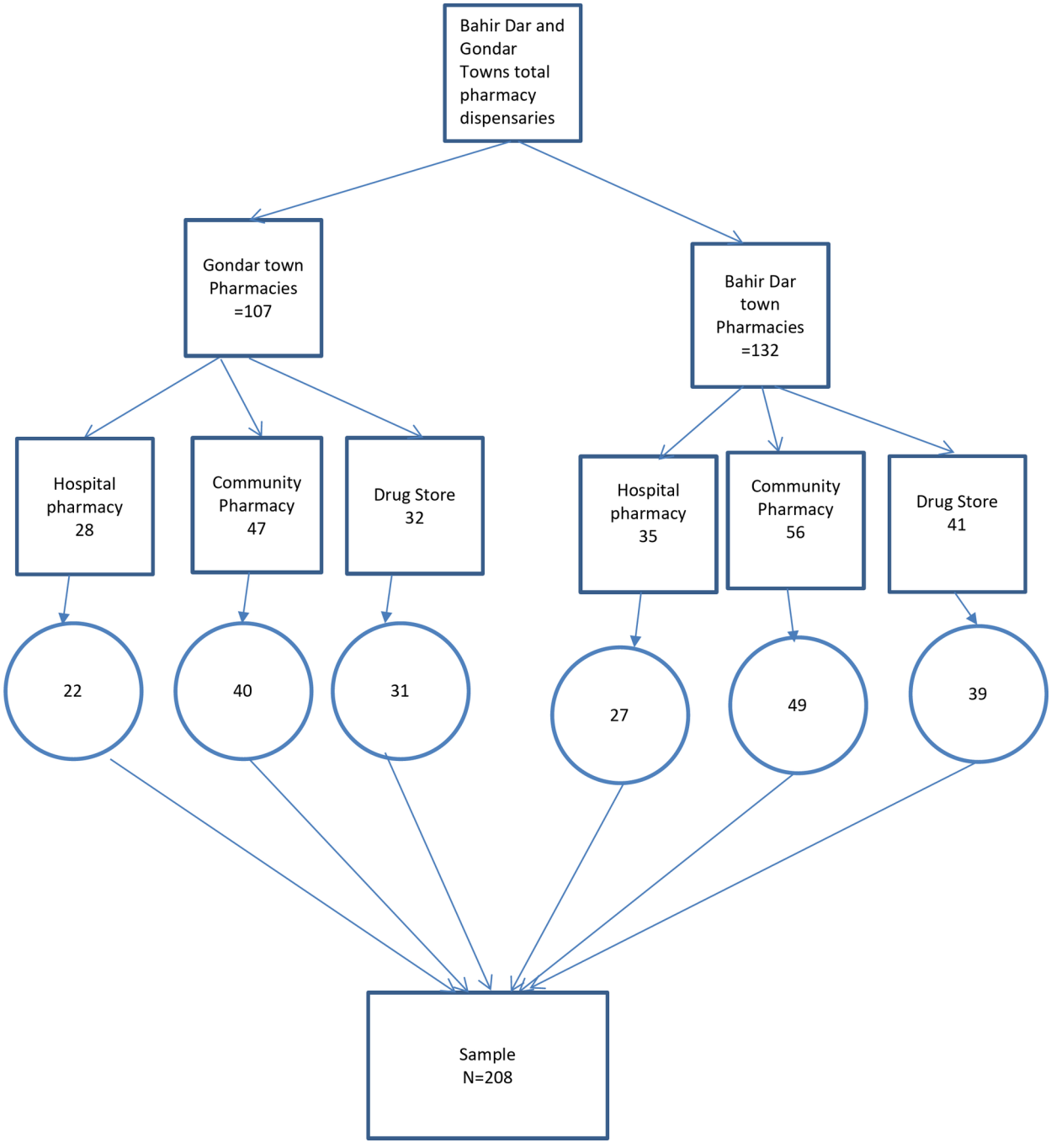

Fig. 1 Sampling procedure

the third section; and questions about the availability of infrastructure for PWM were included in the last section.

Data quality control

To ensure the cultural adaptability and internal consistency of the tools, the researcher aimed to verify their reliability via Cronbach's alpha coefficient. For every variable, the Cronbach's alpha coefficient was greater than 0.7, indicating a satisfactory level of internal consistency. Pretesting of the data collection instruments was performed in a sample of pharmacies outside the study area, which were chosen at random. Approximately 10% of all units were undergoing pretesting. Some modifications were made following the pretest in accordance with the objectives. The modifications made after pre-testing included rewording some questions for clarity, simplifying the language for respondents, and adjusting response options based on feedback. The

study's objectives and significance were explained by the principal investigator during a two-hour training session for the data collectors on how to obtain pertinent information. Each day's data collection was overseen by all the investigators, who also checked the questionnaires' accuracy at the conclusion of the day. Incomplete surveys were excluded, and the data collectors were instructed to assist respondents who needed an explanation. The information collected by the pretest was not included in the main study.

Data analysis

All the data were entered into Epi Data version 4.2 before being exported to SPSS version 26.0 for additional analysis. Descriptive results are reported as the means with standard deviations (SDs), frequencies, and percentages. Binary logistic regression was used to identify predictors of PWM knowledge and practices. A P value of 0.05 was considered statistically significant during the data analysis.

Operational definition

Knowledge

The respondents were asked 10 questions about PWM, such as the environmentally hazardous effect of dumped pharmaceuticals; the need to collect expired pharmaceuticals separately from sellable stock; the relationship between the development of resistance to antibacterial compounds and unsound PWM; the effect of PW on effective sewage treatment in the environment; the consideration of the return of unsold pharmaceuticals to suppliers as a good way to minimize PW; the burial of PW prevents the pollution of water sources with pharmaceutical compounds; the burning of PW may lead to the production of harmful persistent organic pollutants (POPs); the encapsulation of PW is necessary before landfilling during the disposal process; the inertization reduces the release of active pharmaceutical compounds into the aqueous environment; and the use of PPE is necessary during PW handling. Each correct response received one point, whereas incorrect responses received zero points. Owing to the normal distribution of the data, the sum was divided into good and poor categories according to the mean score. The mean score was 8.13. Study participants were deemed to have good knowledge if they received a score of the mean and above on the questions.

Practice

The respondents were asked 11 practice questions about PWM, such as having any guideline or policy regarding PWM that every worker at the pharmacy follows, having a separate container for storage of expired or damaged pharmaceuticals in their pharmacy, practicing having a color-coded or labeled container for PW collection, treating PW by burning, regularly treating PW by incinerating it, regularly disposing of PW by burying, premises connected to a septic tank, regularly wearing PPE during PWM, regularity of returning unsold stocks to your suppliers, practices of throwing PW on municipal trucks (noninfectious), and premises connected to the municipal sewage system. For each reported instance of improper and proper PWM, the respondents received 0 or 1 point, respectively. The data were normally distributed, and we used the mean to classify the practices into good and poor. The practice questions had a mean score of 6.63. Well-practiced study participants were those who received equal or greater than the mean value.

Pharmacy

It is an established retail medicine that is managed by a pharmacist registered with a relevant legal body and licensed to dispense prescribed and compounded medicines for humans [9].

Drug store

It is a medicine retail establishment managed by a druggist (a pharmacy professional with a diploma level of qualification) who is registered and licensed to dispense medicines for humans [7].

Pharmaceutical

They are substances used in the diagnosis, treatment, or prevention of disease and for restoring, correcting, or modifying organic functions. These may include chemical products, supplies, reagents, or packages [11].

Pharmacy professional

They are classified as druggists (with a diploma in pharmacy) or pharmacists (with a degree and above in pharmacy) based on the Ethiopian context. To accommodate both, the term "pharmacy professional" is used instead of "pharmacy pharmacist" throughout the document [10].

Pharmaceutical wastes

These are all wastes that are generated by health facilities during the use of pharmaceuticals during diagnosis, treatment, immunization, compounding, and manufacturing. They include pharmaceuticals that are expired or no longer needed, dispensed drugs that are unwanted or discontinued, and contaminated medicines. It also includes discarded objects that are significantly contaminated when handling medications, such as gloves, masks, and connecting tubing, as well as bottles, vials, and boxes that contain pharmaceutical residues [7–12].

Landfill

The act of directly disposing of untreated PW at a land disposal site, which is the most popular method of disposal of pharmaceuticals [19, 20].

Encapsulation

Encapsulation is the process of immobilizing pharmaceutical materials in a solid block inside a cleaned plastic or steel drum that is not used to contain explosive or dangerous materials. One-third of the capacity of drums is occupied by pharmaceutical items, with the remaining space being filled with cement, a mixture of cement lime, or bituminous sand [20].

Inertization

In a variant of encapsulation known as inertization, medications are ground and mixed with water, cement, and lime to form a homogenous paste. A concrete mixer truck then turns this into a liquid, and once it solidifies, it can be disposed of with municipal solid waste [20].

Sewer

Certain liquid medications, such as syrups and intravenous fluids, can be flushed into sewers in relatively small amounts over time and diluted with water without endangering the environment or public health. Disposing of undiluted antiseptics, disinfectants, or antineoplastics should not be performed with this method [20, 21].

Incineration

Incineration is a purpose-built process that breaks down the organic content of wastes by using thermal decomposition at high temperatures (usually 900 °C or higher). This technique allows for a 90% reduction in volume and a 70% reduction in mass [20, 22].

Table 1 Sociodemographic characteristics of the participants ($n=208$)

Variables		Frequency (*n*)	Percentage (%)
Age in years	20–29	113	54.3
	30–39	67	32.2
	≥ 40	28	13.5
Gender	Female	117	56.3
	Male	91	43.8
Marital status	Married	89	42.8
	Single	110	52.9
	Divorced	6	2.9
	Widowed	3	1.4
Qualification	Diploma	80	38.5
	Degree	101	48.6
	Master	27	13.0
Experience	≤ 10 years	142	68.3
	Above 10 years	66	31.7
Ownership	Owner	42	20.2
	Partner	15	7.2
	Employee	151	72.6
Years of facilities since establishment	0–5 years	104	50.0
	6–10 years	40	19.2
	11–15 years	32	15.4
	> 15years	32	15.4
Type of facility respondents work in	Drug store	70	33.7
	Community Pharmacy	89	42.8
	Hospital pharmacy	49	23.6
Weekly working hours	1–16	28	13.5
	17–31	29	13.9
	32–40	50	24.0
	> 40	101	48.6
Regularity of medical education	Yes	99	47.6
	No	109	52.4

Results

Sociodemographic characteristics of the participants

We used 208 pharmacy professionals for our study. Most participants (54.3%) were in the age range of 20–29. The female participants were the majority (56.3%) in our study. The qualification of most participants (48.6%) was a degree, followed by a diploma (38.5%). Most participants (68.3%) had 10 years of experience or less. Approximately 72.6% of the participants worked as employees, and 20.2% of the participants were owners of the study facilities. Most participants' facilities (50%) were established in the past five years. The participants' facilities were dominated by community pharmacies (42.8%), followed by drug stores (33.7%). Only 47.6% of the participants had received regular training about PWM (Table 1).

Participants' knowledge of pharmaceutical waste management

The responses to the items in the questionnaire revealed that the majority of the participants understood the following statements: dumped pharmaceuticals are environmentally hazardous (97.1%); they are necessary to collect expired pharmaceuticals separately from sellable stock (95.2%); the relationship between the development of resistance to antibacterial compounds and unsound PWM (56.7%); the effect of PW on effective sewage treatment in the environment (77.9%); the return of unsold pharmaceuticals to suppliers as a good way of minimizing PW (72.6%); the burying of PW prevents the pollution of water sources with pharmaceutical compounds (69.7%); the burning of PW may lead to the production of harmful POPs (77.9%); the encapsulation of PW is necessary before landfilling during the disposal process (80.8%); the inertization reduces the

Table 2 Responses to the items related to the participants' knowledge of PWM ($n = 208$)

Knowledge of PWM	Yes *N* (%)	No *N* (%)
1. Are dumped pharmaceuticals environmentally hazardous?	202 (97.1)	6(2.9)
2. Is it necessary to collect expired pharmaceuticals separately from sellable stock?	198 (95.2)	10(4.8)
3. Is there any relationship between development of resistance to antibacterial compounds and unsound management of PW?	118(56.7)	90(43.3)
4. Is there any effect of PW to effective sewage treatment in the environment?	162(77.9)	46(22.1)
5. Do you consider return of unsold pharmaceuticals to the suppliers a good way of minimizing PW?	151(72.6)	57(27.4)
6. Does burying of PW prevent pollution of water sources with pharmaceutical compounds?	145(69.7)	63(30.3)
7. Does burning of PW may lead to production of harmful POPs?	162(77.9)	46(22.1)
8. Is encapsulation of PW is necessary before landfilling during disposal process?	168(80.8)	40(19.2)
9. Does inertization reduce/delay the release of active pharmaceutical compounds into the aqueous environment?	187(89.9)	21(10.1)
10. Is PPE is necessary during PW handling?	199(95.7)	9(4.3)

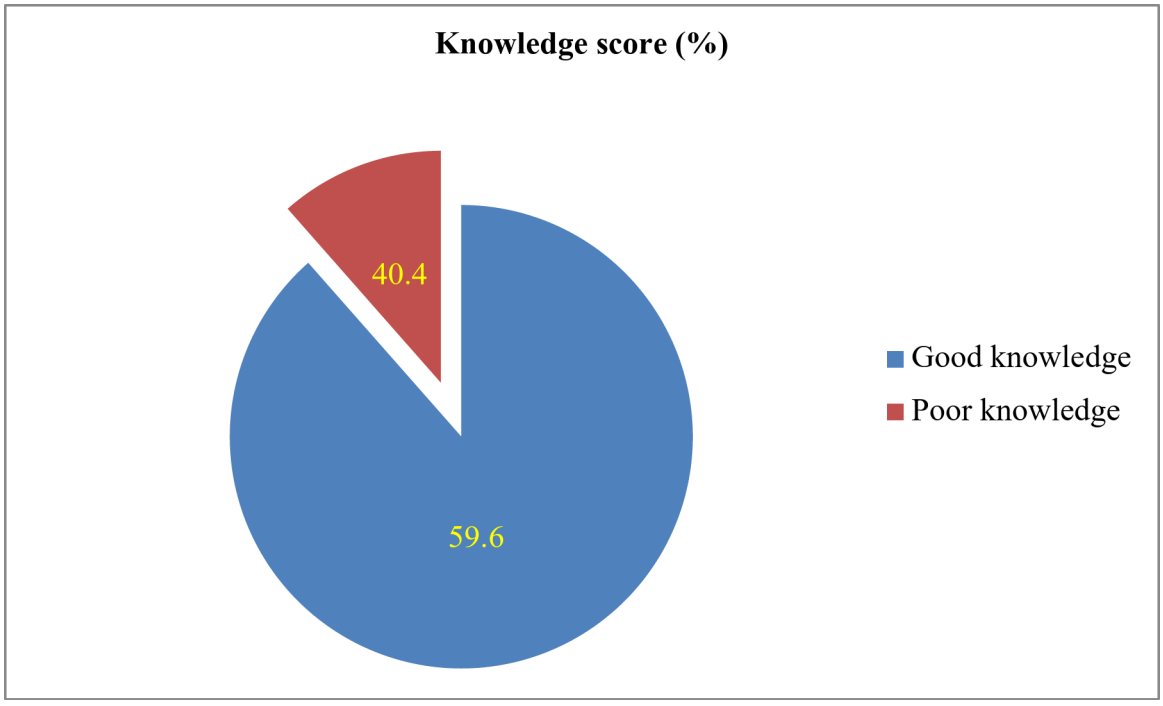

Fig. 2 Knowledge scores of the participants ($n = 208$)

release of active pharmaceutical compounds into the aqueous environment (89.9%); and PPE is necessary during PW handling (95.7%) (Table 2).

Most participants (59.6%) had good knowledge about PWM, whereas approximately 40.4% of the participants had poor knowledge about PWM (Fig. 2).

Factors associated with participants' knowledge of pharmaceutical waste management

In the bivariate analysis, qualification, experience, year since establishment, type of facility, and regularity of training about PWM were the candidate variables for multiple logistic regression ($p < 0.2$). In the multiple logistic regression, experience and regularity of training about PWM were significantly associated with PWM knowledge ($p < 0.05$). The participants who had more than ten years of experience were 2.86 times (AOR = 2.86, 95% CI: 1.26, 6.48) more likely to have good knowledge of PWM. Additionally, participants who had taken regular PWM training were 3.60 times (AOR = 3.60, 95% CI: 1.73, 7.49) more likely to have good knowledge about PWM (Table 3).

Practices of participants toward pharmaceutical waste management

The responses to the items in the questionnaire revealed that most of the participants had practiced the statements. With any guideline or policy regarding PWM, every worker at the pharmacy follows (66.3%), has a separate container for the storage of expired or damaged pharmaceuticals in the pharmacy (79.3%), practices having a color-coded or labeled container for PW collection (67.8%), treats PW by burning (53.8%), regularly treats PW by incinerating it (61.1%), regularly

Table 3 Associations of participants' pharmaceutical waste management knowledge with sociodemographic characteristics ($n = 208$)

Variables		Knowledge		COR (95% CI)	AOR (95% CI)
		Good	Poor		
Qualification	Diploma	33 (41.3)	47 (58.8)	1	1
	Degree	72 (71.3)	29 (28.7)	0.96 (0.38–2.43)	0.95 (0.32–2.82)
	Master	19 (70.4)	8 (29.6)	3.38 (1.32–8.65)	1.52 (0.50–4.63)
Experience	10years and below	69 (48.6)	73 (51.4)	1	1
	above 10years	55 (83.3)	11 (16.7)	5.29 (2.56–10.94)	2.86 (1.26–6.48)*
Year since establishment	0–5	51 (49.0)	53 (51.0)	1	1
	6–10	24 (60.0)	16 (40.0)	0.59 (0.18–1.91)	0.47 (0.13–1.74)
	11–15	26 (81.3)	6 (18.8)	1.70 (0.63–4.62)	1.71 (0.51–5.68)
	> 15	23 (71.9)	9 (28.1)	2.66 (1.12–6.28)	1.71 (0.62–4.67)
Type of the facility	Drug store	27 (38.6)	43 (61.4)	1	1
	Pharmacy	59 (66.3)	30 (33.7)	1.76 (0.79–3.92)	1.09 (0.42–2.82)
	Hospital pharmacy	38 (77.6)	11 (22.4)	5.50 (2.41–12.56)	1.94 (0.72–5.22)
Regularity of training about PWM	Yes	80 (80.8)	19 (19.2)	6.22 (3.31–11.68)	3.60 (1.73–7.49) **
	No	44 (40.4)	65 (59.6)	1	1

Abbreviations: COR crude odds ratio, *CI* confidence interval, *AOR* adjusted odds ratio

Note: *$p < 0.05$ and **$p < 0.01$

Table 4 Participants' practices of pharmaceutical waste management ($n = 208$)

PWM practices	Yes *N* (%)	No *N* (%)
1. Do you have any guideline/Policy regarding PWM which every worker at the pharmacy follows?	138 (66.3)	70(33.7)
2. Do you have a separate container for storage of expired or damaged pharmaceuticals in your pharmacy?	165(79.3)	43(20.7)
3. Practices of having color coded or labeled container for PW collection	141(67.8)	67(32.2)
4. Do you or your pharmacy regularly return unsold stocks to your suppliers?	92(44.2)	116(55.8)
5. Do you or your coworker usually treat PW by burning it?	112(53.8)	96(46.2)
6. Practices of throwing PW on municipal truck(noninfectious)	98(47.1)	110(52.9)
7. Do you or your pharmacy regularly treat PW by incinerating it?	127(61.1)	81(38.9)
8. Do you or your coworker regularly dispose of PW by burying it?	112(53.8)	96(46.2)
9.Is your premises connected to municipal sewage system?	74(35.6)	134(64.4)
10. Is your premises connected to a septic tank?	144(69.2)	64(30.8)
11. Do you regularly wear PPE during PW handling?	174(83.7)	34(16.3)

disposes of PW by burying (53.8%), premises connected to a septic tank (69.2%), and regularly wears PPE during PWM (83.7%). However, the responses to some of the items in the questionnaire revealed that the participants had not commonly practiced the following statements: regularity of returning unsold stocks to their suppliers (44.2%), practices of throwing PW on municipal trucks (noninfectious) (47.1%), and premises connected to the municipal sewage system (35.6%) (Table 4).

PWM practices were rated similarly by the participants, with good and poor scores of 52.9% and 47.1%, respectively (Fig. 3).

Factors associated with participants' practices related to pharmaceutical waste management

In the bivariate analysis, age, qualification, experience, year since establishment, type of facility, and regularity of training about PWM were the candidate variables for multiple logistic regression ($p < 0.2$). Multiple logistic regression revealed that experience and working in the hospital were significantly associated with good PWM practices ($p < 0.05$). The participants who had more than ten years of experience were 3.33 times (AOR = 3.33, 95% CI: 1.49, 7.47) more likely to have good PWM practices. Additionally, participants who had worked at hospital pharmacies 5.19 times (AOR = 5.19, 95% CI: 1.95, 13.83) were more likely to have good practices toward PWM (Table 5).

Availability of infrastructures used for pharmaceutical waste management

Most participants' facilities had different infrastructures for PWM. Approximately 90.9% of the facilities had PW collection containers; 88% of facilities had clean containers; 73.6% of the facilities had color-coded and labeled containers for PW segregation; 54.8% of the facilities had burial pits without liners; 79.3% of the facilities had PPE; and 62% of the facilities had access to municipal-level landfills. However, only 47.6% of the participants' facilities had an incinerator for the disposal of ashes (Fig. 4).

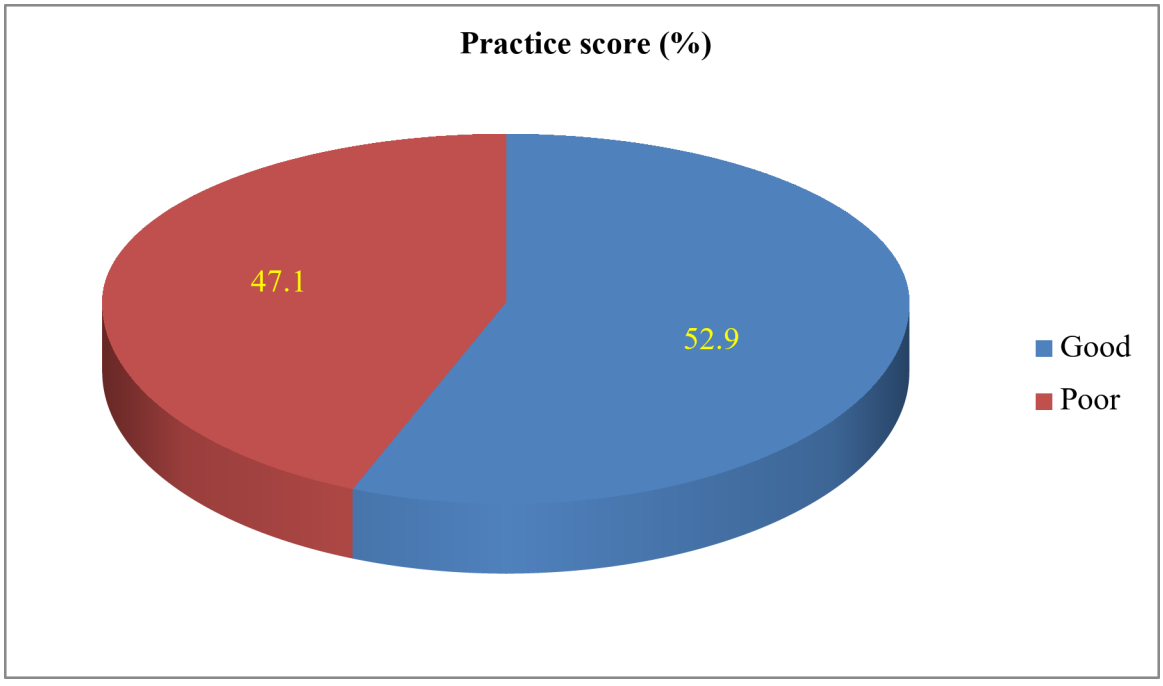

Fig. 3 Practice scores of the participants ($n=208$)

Table 5 Associations of participants' pharmaceutical waste management practices with sociodemographic characteristics ($n=208$)

Variables		Practices		COR (95% CI)	AOR (95% CI)
		Good	Poor		
Age	20–29	50 (44.2)	63 (55.8)	1	1
	30–39	37 (55.2)	30 (44.8)	3.73 (1.27–10.99)	2.54 (0.76–8.54)
	≥Above 40	23 (82.1)	5 (17.9)	5.80 (2.06–16.33)	2.95 (0.91–9.55)
Qualification	Diploma	33 (41.3)	47 (58.8)	1	1
	Degree	56 (55.4)	45 (44.6)	2.81 (1.05–7.56)	2.90 (0.89–9.44)
	Master	21 (77.8)	6 (22.2)	4.99 (1.81–13.70)	1.80 (0.54–6.03)
Experience	10years and below	59 (41.5)	83 (58.5)	1	1
	above 10years	51 (77.3)	15 (22.7)	4.78 (2.46–9.31)	3.33 (1.49–7.47) *
Years since establishment	0–5 years	44 (42.3)	60 (57.7)	1	1
	6–10 years	21 (52.5)	19 (47.5)	1.16 (0.40–3.40)	0.93 (0.25–3.41)
	11–15 years	22 (68.8)	10 (31.3)	2.31 (0.86–6.22)	2.09 (0.59–7.42)
	> 15 years	23 (71.9)	9 (28.1)	3.49 (1.47–8.26)	2.19 (0.76–6.37)
Type of the facility	Drug store	15 (21.4)	55 (78.6)	1	1
	Pharmacy	58 (65.2)	31 (34.8)	1.65 (0.75–3.61)	1.13 (0.46–2.78)
	Hospital pharmacy	37 (75.5)	12 (24.5)	11.31 (4.76–26.88)	5.19(1.95–13.83) *
Regularity of training about PWM	Yes	69 (69.7)	30 (30.3)	3.82 (2.14–6.80)	2.00 (0.96–4.19)
	No	41 (37.6)	68 (62.4)	1	1

Note: *$P<0.01$

Discussion

The knowledge and practice of pharmacy professionals with respect to PW are essential to performing effective PWM because the improper disposal of unused medicines is a growing problem throughout the world. Pharmacists can use a range of approaches to stock management, including effective purchasing, preparation of medication, and dispensing processes. In addition, PW can be mitigated in the leftover stage via the re-dispensing of unopened medication packages. The automated expiration date checks, followed by accelerated dispensing of medication close to its expiration date, minimize PW. Moreover, exchanges with other pharmacies could help prevent PW that are not often distributed [23].

Our participants responded that dumped pharmaceuticals were environmentally hazardous (97.1%, 95% CI: 94.7, 99), which is higher than that reported in a

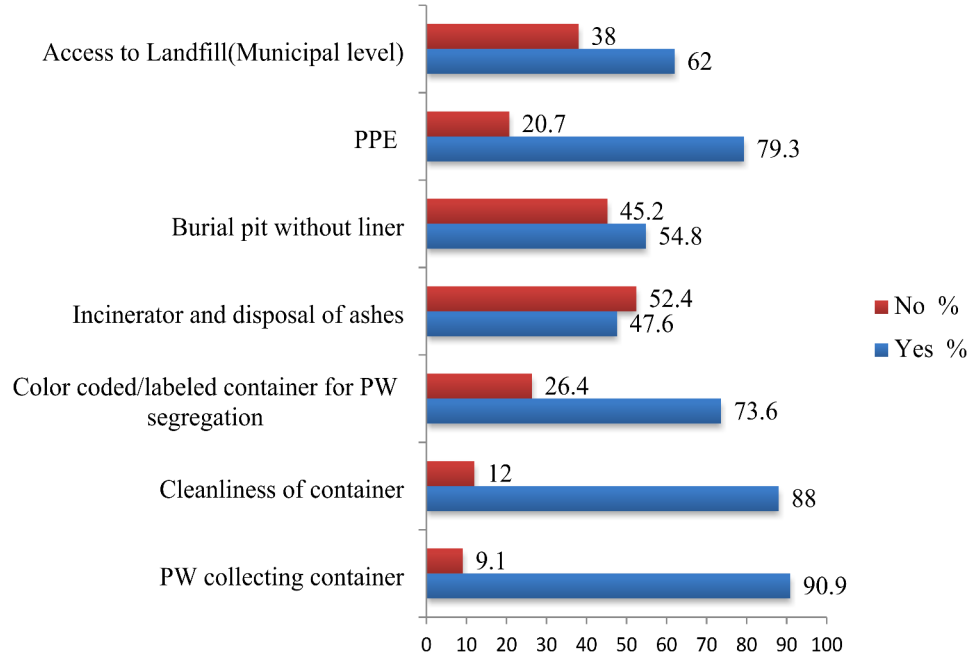

Fig. 4 Availability of infrastructures used for pharmaceutical waste management ($n = 208$)

study performed in India, which revealed that 79.3% of respondents correctly identified that improper disposal of pharmaceuticals can have negative implications for planetary health due to contamination of soil and water supplies [24]. Our result is also higher than that of a study performed in Tamil Nadu, which revealed that 67% of hospital pharmacists were aware of the environmental hazards caused by improper disposal of medicines, but only 32% of community pharmacists were aware of the same [25]. This percentage is also higher than that reported in a study performed in Jimma city, Ethiopia, which revealed that 41.7% of the participants reported that safe disposal of damaged or expired medicines would prevent environmental pollution [18].

In our study, the explanation for the relationship between the development of resistance to antibacterial compounds and the unsound management of PW was 56.7% (95% CI: 50.0, 63.5), which was lower than that reported in a study conducted in Tamil Nadu, which showed that unsafe disposal of medicines could lead to antibiotic resistance. Approximately 67% of hospital pharmacists and 33% of community pharmacists answered positively [25].

Our study revealed that greater consideration of the return of unsold pharmaceuticals to suppliers was a good way of minimizing PW (72.6%, 95% CI: 66.3, 78.4) than a study performed in Tamil Nadu, which revealed that approximately 65% of hospital pharmacists and only 30% of community pharmacists stated that returning drugs to the source was the best method of unwanted drug disposal [25]. This number is also higher than that reported in a study performed in the United Arab Emirates, where more than a quarter of the participants reported returning these drugs to distributors [26].

In our study, 44.2% (95% CI: 37.0, 51.0) of the respondents returned unsold stocks to suppliers, and 47.1% (95% CI: 39.9, 53.8) of the participants returned PW on municipal trucks (noninfectious), which was lower than that reported in a study conducted in Nepal, which revealed that the majority of pharmacists (94.1%) had practices of returning unsold and expired pharmaceuticals to suppliers and that 76.5% of pharmacies threw their noninfectious PW on municipal trucks [7].

Our participants' practice of regularly wearing PPE during PWM was 83.7% (95% CI: 78.4, 88.5) lower than that reported in a study performed in Phuket, Thailand, which reported 93.6% regular use of PPE [16].

Approximately 53.8% (95% CI: 47.1, 60.1) of our participants treated PW by burning and burying, which was higher than that reported in a study conducted in Jimma, Ethiopia, in which approximately 38.2% of the respondents reported burning separately and 19.5% reported burying underground [18].

Proper PWM requires separating and storing waste at the point of generation. In our study, approximately 79.3% (95% CI: 73.6, 85.1) of the participants had a separate container for the storage of expired or damaged pharmaceuticals, and approximately 67.8% (95% CI: 61.1, 74.0) had a color-coded or labeled container for PW collection, which was higher than that reported in a study conducted in Dessie, Northeast Ethiopia, which reported nearly two and one-third of the respondents' labels

and stores on PW, respectively [13]. Our findings were also greater than those of a study performed in Ghana, which revealed that most hospitals did not comply with the color-coding system and that there was no separate container for the collection of PW [27]. This percentage is also higher than that reported in a study performed in Abu Dhabi, UAE, where 46% of the waste handlers practiced waste segregation correctly and effectively; the nonavailability of proper color-coded containers affected the practice of segregating healthcare waste [28].

Our participants regularly treat PW by incineration (61.1%, 95% CI: 53.9, 67.3), which was better than the findings of a study performed in Ghana, which revealed that PW is disposed of at landfill sites where the waste materials are crushed and buried together with other solid waste and incinerated or open burning [27].

In our study, approximately 62% (95% CI: 54.8, 68.3) of the facilities had access to municipal-level landfills, which was comparable to the findings of a study conducted in Ghana, which revealed that disposal at dumping sites or landfills through the municipal authority is the most common method employed by hospitals in the disposal of PW [27]. In most developing countries, landfilling remains the main option for disposing of waste. Disposal at dumping sites or landfills through the municipal authority is the most common method employed by hospitals in the disposal of solid waste, i.e., infectious, general, and pharmaceutical waste [27, 28].

In our study, only 47.6% (95% CI: 41.3, 54.8) of participants' facilities had an incinerator for the disposal of ashes, which was in line with a study performed in Ghana that showed that hospitals do not commonly use incineration for PW disposal, which was attributed to the unavailability of incinerators and the danger of burning waste materials in the open air [27].

Multiple logistic regression revealed that experience and training were significantly associated with good knowledge about PWM ($p < 0.05$). The participants who had taken regular PWM training were 3.60 times (AOR = 3.60, 95% CI: 1.73, 7.49) more likely to have good knowledge about PWM. The participants who had more than ten years of experience were 2.86 times (AOR = 2.86, 95% CI: 1.26, 6.48) more likely to have good knowledge of PWM. This result is comparable to that of a study performed in the United Arab Emirates, where it was demonstrated that pharmacists' years of experience were correlated with their knowledge of accurate disposal practices ($p < 0.05$) [26]. Additionally, experience and types of facilities were significantly associated with PWM practices ($p < 0.05$). The participants who had more than ten years of experience were 3.33 times (AOR = 3.33, 95% CI: 1.49, 7.47) more likely to have good PWM practices. The participants who had worked at hospital pharmacies were 5.19 times (AOR = 5.19, 95% CI: 1.95, 13.83) more likely to have good practices toward PWM. This result was comparable with a study performed in Tamil Nadu, which showed that pharmacists practicing in the hospital pharmacy setting had significantly better practices for the safe disposal of unwanted medicines than those practicing in the community did ($P < 0.005$) [25].

PW has a negative impact on the environment and a significant effect on healthcare budgets. Therefore, one intriguing strategy to achieve sustainable medication supply and use is to stop medication from being unused throughout the pharmaceutical chain. By extending the shelf life of their products, selecting the most environmentally friendly storage options, and modifying package sizes, manufacturers can help ensure a sustainable supply and use of pharmaceuticals. Distributors are responsible for optimizing stock management and relaxing shelf-life regulations. Prescribers can respond by agreeing to rational prescribing practices, which include taking prescription quantity and shorter duration into account. Pharmacists can make a difference by redistributing unused medication, improving medication preparation procedures, and streamlining the dispensing process. To encourage thoughtful medication ordering and to foster the willingness to participate in waste-minimizing interventions, patients' awareness of medication waste needs to be increased. Finally, by raising awareness and enforcing waste-reduction policies, health authorities can support sustainability [21, 29, 30]. The main intervention for all pharmacy settings is education regarding the proper disposal of various types of medications [31].

The study's findings highlight significant gaps in PWM practices, particularly in community pharmacies. The results suggest that targeted interventions such as increased training and investment in infrastructure could significantly improve PWM practices, thereby reducing environmental harm. The practical implication is that government bodies and healthcare facilities should focus on regular training programs and infrastructure improvements, such as the use of incinerators and proper disposal sites. These findings can be generalized to other urban areas in Ethiopia and similar developing nations, where PWM practices face comparable challenges.

Limitations of the study

The cross-sectional design of the study made it more difficult for us to determine whether the study variables were causally related. Information bias may have occurred because the results depended on the participants' honesty and accuracy in their responses. A larger sample size is advised to generalize the results across Ethiopian pharmacies, even though the sample size was sufficient to achieve statistical power. The reliance on self-reported data may introduce bias, as participants may provide socially desirable responses or overestimate

their knowledge and practices regarding PWM. Combining self-reported data with objective measures or observations could enhance the validity of the findings. Moreover, including additional variables, such as organizational policies, regulatory frameworks, and community perceptions, could offer a more holistic understanding of the factors influencing waste management practices.

Conclusion

The study revealed that most participants (59.6%) demonstrated good knowledge of PWM, while 40.4% exhibited poor knowledge. In the multiple logistic regression analysis, factors such as professional experience (AOR = 2.86, 95% CI: 1.26, 6.48) and regular PWM training (AOR = 3.60, 95% CI: 1.73, 7.49) were significantly linked to higher levels of knowledge. Similarly, PWM practices were fairly balanced, with 52.9% showing good practices and 47.1% performing poorly. Notably, experience (AOR = 3.33, 95% CI: 1.49, 7.47) and employment in hospitals (AOR = 5.19, 95% CI: 1.95, 13.83) were key factors associated with better PWM practices. Most facilities provided essential infrastructure for PWM, including waste collection containers, clean and color-coded bins for segregation, burial pits, PPE, and access to municipal landfills. However, only 47.6% of the facilities had incinerators and appropriate disposal systems for ash, highlighting an area for improvement in waste management infrastructure.

Recommendations

A practical, environmentally sustainable approach to PWM, with policies and guidelines as well as public awareness campaigns, is necessary to address the problem of safe waste disposal. The national drug regulatory bodies should conduct an environmental risk assessment resulting from the disposal of PW. Pharmacists should facilitate extensive training on sustainable drug use and proper PW disposal at all levels to reduce the risks associated with improper disposal. Reducing PW generation at each step of the drug lifecycle and implementing take-back options, collection at approved sites, and modern technology to treat wastewater are highly recommended to reduce the effects of unwanted pharmaceuticals on human health and the environment. Furthermore, the government should promote the reverse distribution network.

Abbreviations

AOR	Adjusted Odds Ratio
CD	Cytotoxic drug
COR	Crude Odds Ratio
PPE	Personnel Protective Equipment
POP	Persistent Organic Pollutants (POP)
PW	Pharmaceutical Wastes
PWM	Pharmaceutical Waste Management
SPSS	Statistical Package for Social

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Data availability

The dataset is accessible at the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Ethics Review Committee of the School of Pharmacy, College of Medicine and Health Sciences, University of Gondar. The study was subsequently conducted after permission was obtained from each respective pharmacy. The study participants were informed about the purpose of the study, and verbal informed consent was obtained from the study participants. In this study, verbal informed consent was obtained from the Ethics Review Committee of the School of Pharmacy, College of Medicine and Health Sciences, University of Gondar, and the confidentiality of the study participants' data was maintained throughout the study. The study methodology also complied with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Kümmerer K. Pharmaceuticals in the environment: sources, fate, effects and risks. 3rd ed. Berlin: Springer Science & Business Media; 2010.
2. European Parliament. Directive 2004/27/EC of the European Parliament and of the Council. Official J Eur Union. 2004;L136:34.
3. Carvalho R, Reis NM, Nogueira JL. Improper disposal of pharmaceutical waste in developing countries: A systematic review. Waste Manag Res. 2021;39(6):744–54.

4. Ethiopian Food and Drug Authority (EFDA). Pharmaceutical waste management guidelines. Addis Ababa: EFDA; 2021.
5. World Health Organization (WHO). Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies. Geneva: WHO; 1999.
6. United Nations. Agenda 21: Earth Summit - The united nations programme of action from Rio. New York: United Nations; 1992.
7. United Nations. Transforming our world: the 2030 agenda for sustainable development. New York: United Nations; 2015.
8. Paudel E, Choi E, Shrestha N. Pharmaceutical waste management in private pharmacies of Kaski district, Nepal. Int J Innov Sci Res Technol. 2019;4(8):2456–165.
9. Jaseem M, Kumar P, John RM. An overview of waste management in pharmaceutical industry. Pharma Innov. 2017;6(3):158–61.
10. Kadam A, Patil S, Patil S, Tumkur A. Pharmaceutical waste management an overview. Indian J Pharm Sci. 2016;9(1):1–7.
11. Adedeji-Adenola H, Adesina A, Obon M, Onedo T, Okafor GU, Longe M, Oyawole M. Knowledge, perception and practice of pharmaceutical waste disposal among the public in Lagos State, Nigeria. Pan Afr Med J. 2022;42:1–15.
12. Chisholm JM, Zamani R, Negm AM, Said N, Abdel daiem MM, Dibaj M, Akrami M. Sustainable waste management of medical waste in African developing countries: A narrative review. Waste Manag Res. 2021;39(9):1149–63.
13. Mohammed SA, Kahissay MH, Hailu AD. Pharmaceuticals wastage and pharmaceuticals waste management in public health facilities of Dessie town, North East Ethiopia. PLoS ONE. 2021;16(10):1–15.
14. Bound JP, Voulvoulis N. Household disposal of pharmaceuticals as a pathway for aquatic contamination in the united Kingdom. Environ Health Perspect. 2005;113(12):1705–11.
15. Shinde AR, Patil AP, Patil TM, Vakhariya R, Magdum CS. Pharmaceutical waste management: significant for health of nature and future. Int J Pharm Sci Rev Res. 2020;65(2):68–74.
16. Akkajit P, Romin H, Assawadithalerd M. Assessment of knowledge, attitude, and practice in respect of medical waste management among healthcare workers in clinics. J Environ Public Health. 2020;2020:1–12.
17. Huda MN, Hailemariam TG, Hossain SZ, Malo JS, Khan S, Hadisuyatmana S, Ferdous A, Akombi-Inyang B, Islam RM, Renzaho AM. Medical waste management-related factors affecting health and experiences of health risks among medical waste handlers in low and middle-income countries: a systematic review protocol of qualitative studies. BMJ Open. 2022;12(3):1–6.
18. Gudeta T, Assefa D. Assessment of pharmaceuticals waste practices among private drug retail outlets in Ethiopia. J Prim Health Care. 2020;11:1–8.
19. Nyaga MN, Nyagah DM, Njagi A. Pharmaceutical waste: overview, management, and impact of improper disposal. J PeerScientist. 2020;3(20):1–12.
20. Karungamye P, Rugaika A, Mtei K, Machunda R. The pharmaceutical disposal practices and environmental contamination: A review in East African countries. Hydro Res. 2022;5:99–107.
21. Chartier Y, Emmanuel J, Pieper U, Pruss A, Rushbrook, Stringer R, Townend W, Wilburn S, Zghondie R, editors. Safe management of wastes from health-care activities. 2nd ed. Geneva: World Health Organization; 2014.
22. Sreekanth K, Vishal GN, Raghunandan HV, Nitin KU. A review on managing of pharmaceutical waste in industry. Int J Pharmtech Res. 2014;6(3):899–907.
23. Smale EM, Egberts TC, Heerdink ER, van den Bemt BJ, Bekker CL. Waste-minimizing measures to achieve sustainable supply and use of medication. Sustain Chem Pharm. 2021;20:1–7.
24. Jankie S, Stuart AV, Barsatee N, Dookhan V, Sookdeo K, Hernandez S, Mohammed C. Pharmacists knowledge, perception and practice regarding medication disposal. Explor Res Clin Soc Pharm. 2022;8:1–5.
25. Babu SS, Subbaiah S, Paniot S, Ramesh S, Nagasubramanian VR. Impact of practice settings on knowledge, attitude, and practice of disposal of unwanted pharmaceuticals among pharmacists in a selected City of Tamil Nadu. J Appl Pharm Sci. 2021;11(12):151–7.
26. Kharaba Z, Khasawneh LQ, Aloum L, Ghemrawi R, Jirjees F, Al Bataineh N, Al-Azayzih A, Buabeid MA, Al-Abdin SZ, Alfoteih Y. An assessment of the current practice of community pharmacists for the disposal of medication waste in the united Arab Emirates: A deep analysis at a glance. Saudi Pharm J. 2022;30(12):1773–80.
27. Zahid ZR, Khan RA, Fahim S. Evaluation of waste management practices in Burjeel hospital Abu Dhabi, UAE. Phd diss., Bahria University Karachi campus. Ann Commun Med Public Health. 2017;1(1):1–8.
28. Sasu S, Kümmerer K, Kranert M. Assessment of pharmaceutical waste management at selected hospitals and homes in Ghana. Waste Manag Res. 2012;30(6):625–30.
29. Smale EM, Egberts TC, Heerdink ER, van den Bemt BJ, Bekker CL. Waste-minimizing measures to achieve sustainable supply and use of medication. Sustain Chem Pharm. 2021;20:1–8.
30. Komba T. Assessment of municipal solid waste management for better-quality public health and environmental sustainability in the Freetown metropolitan City in Sierra Leone. J Geosci Environ Prot. 2021;9(04):33–49.
31. Afanasjeva J, Gruenberg K. Pharmacists as environmental stewards: strategies for minimizing and managing drug waste. Sustain Chem Pharm. 2019;13:1–5.

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