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Knowledge, perception, and practices of ecopharmacovigilance among government and private medical students in Bangladesh

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Abstract

Given the rapid growth of the pharmaceutical industry and the increasing use of medication, ecopharmacovigilance (EPV) has become an effective approach for managing and reducing the environmental impact of pharmaceuticals. EPV addresses and explains the undesired environmental effects of pharmaceutical use. This study aimed to evaluate the knowledge, perceptions, and practices related to the disposal of unused and expired medications among undergraduate medical students in Bangladesh. A questionnaire-based cross-sectional study was conducted over a period of 3 months, from August to October 2024, at Armed Forces Medical College, Mugda Medical College and Hospital, and Shahabuddin Medical College in Dhaka. A total of 300 3rd- and 4th-year medical students from these medical colleges in Bangladesh completed a self-administered questionnaire. In this study, knowledge of EPV was found to be only 27%. Overall, medical students' perceptions of environmental medication contamination and EPV were encouraging. Among those interviewed, 54.3% "strongly agreed" that leftover medications could have a negative impact on the environment. Despite knowledge of the environmental risks posed by pharmaceuticals, the common practice of storing medications at home until they expire and then discarding them persists. This highlights both a lack of knowledge and the absence of safe disposal procedures. Thus, greater efforts are needed to improve medical students' knowledge of EPV. Respondents also expressed a preference for evidence-based and environmentally friendly methods for disposing of unwanted medications.

Keywords: Ecopharmacovigilance; Medical students; Knowledge; Perception; Environment; Pharmaceuticals

1. Introduction

The modern world is experiencing an unprecedented increase in drug consumption and production due to population growth, increased disease burden, and the rapid advancement of the pharmaceutical industry. As a result, pharmaceuticals have increasingly entered the environment.[1,2] A wide range of medications, including antibiotics, steroid hormones, analgesics, anti-inflammatory drugs, anti-hypertensives, and anti-depressants, have been detected in various environmental compartments, such as soil, sediments, groundwater, surface water, drinking water, and living organisms.[3-6] Pharmaceuticals are commonly referred to as pseudo-persistent pollutants due to their widespread use, continuous release into the environment, and the ineffective clearance of pharmaceutical residues.[7]

These pollutants enter the environment through multiple pathways, including pharmaceutical manufacturing, improper disposal by consumers, hospital waste, pharmacy practices, veterinary use, and other sources.[8-11] Improper disposal of pharmaceuticals leads to the release of harmful chemicals and various pollutants, which can pose risks to human health.[12-14] At present, over 600 pharmaceuticals have been detected in the environment worldwide.[15] Given the widespread use of over-the-counter medications, it is essential to raise public awareness regarding proper disposal procedures.[16] Although pharmaceutical residues are often found in small concentrations, their persistent release into the environment can have a negative impact on the ecosystem, wildlife, and human health.[3,8,11,17] For example, veterinary use of diclofenac has significantly endangered Asian Gyps vulture species,[8] while antibiotic residues contribute to the emergence of antibiotic resistance, which is a serious public health concern.[18-21] In addition, studies have shown that exposure to trace amounts of 17α-ethynylestradiol, an estrogen commonly found in birth control pills, at concentration of 5 – 6 ng/L in lake water can cause feminization and near extinction certain fish species.[22,23] In addition, exposure to animal antimicrobial residues in contaminated food or drinks has been linked to a higher risk of overweight and obesity among school children.[18]

Despite being a major category of emerging pollutants, pharmaceuticals are not regulated under existing laws for detection, notification, or environmental control.[24] Furthermore, the removal of pharmaceuticals using current sewage treatment systems is ineffective.[3,8,15] The environmental effects of drugs have received insufficient attention over time, with few studies examining their impact. Meanwhile, the use of pharmaceuticals in both humans and animals continues to rise. According to one study, by 2030, more than 100,000 tons of veterinary antibiotics will be consumed worldwide.[25] Pharmaceuticals were found in water bodies in previous investigations, most of which came from high-income nations. However, one of the largest studies assessing the prevalence of drugs in 1,052 rivers across104 countries revealed that the most contaminated rivers were located in low- and middle-income nations in South America, South Asia, and sub-Saharan Africa.[26] Despite the growing importance of safe pharmaceutical disposal, both consumers and healthcare professionals remain largely unaware of this issue. In response, ecopharmacovigilance (EPV) has been introduced. EPV is defined as "the science and activities associated with the detection, evaluation, understanding, and prevention of adverse effects of pharmaceuticals in the environment." It aims to address important environmental problems associated with drugs and ensure that they are effectively managed.[11,27,28]

The main goal of EPV is to regulate the causes of pharmaceutical exposure.[8,29] EPV monitors, assesses, and regulates pharmaceutical pollutants, taking into account elements including degradation, wastewater, and the effectiveness of drinking water treatment plants.[30] EPV encourages the reduction of production leftovers, rational utilization, reliability, and the safe disposal of unwanted medications.[31] EPV strategies should focus on drugs known to have negative environmental consequences, with emphasis to areas with elevated risks and significant pollution issues.[32] To minimize the amount of medicinal products in the ecosystem, some EPV strategies have been proposed, including the development and production of green medications, carefully management of pollutants from drug production, the return and disposal of unused medications, and the proper use of medicines. However, EPV has not yet established a formalized implementation model.[3,8,11] Practical application of EPV is already underway. For instance, before a medication can be marketed in the European Union (EU), an environmental risk assessment (ERA) must be completed.[11] According to regulations set by the European Medicines Agency (EMA), every medication intended for human use undergo an ERA before being marketed.[33] In terms of EPV legislations, the United States (US), EU, and Canada lead the world.[17] Pharmaceutical companies like Astra Zeneca have created environmental risk management plans to simplify the monitoring of environmental impacts.[34] According to the Drug Enforcement Administration's 2014 Finalized Rule on the Disposal of Controlled Pharmaceuticals,[35] patients can choose to mail leftover drugs to a registered collector with proper labeling or return them during take-back program. To effectively address the issue of pharmaceutical waste, EPV must be integrated with a medication take-back system, together with additional financial and logistical

involvement from drug manufacturers.[36] The findings of numerous research on how the public and healthcare professionals view EPV have highlighted the need for a clear educational plan on the topic.[28]

According to a Chinese survey, the public expects healthcare professionals, preferably doctors and pharmacists, to educate them about pharmacovigilance.[37] Efforts to include EPV into the education of future medical practitioners are already underway. For example, pharmacy students at the University of Groningen participated in a course titled "To Decrease Pharmaceuticals in Groundwater."[38] Furthermore, a postgraduate degree on pharmaceutical contamination is offered in Spain, and four EU universities have launched a 2-year program named "Sustainable Drug Discovery."[39,40] During manufacturing, use, and disposal, active pharmaceutical ingredients leak into the environment, contributing to an estimated 58,000 neonatal deaths each year from drug-resistant diseases.[41] In the US, approximately 30 billion doses of non-steroidal anti-inflammatory drugs are prescribed annually.[42] Furthermore, leftover pharmaceuticals can lead to poisoning, both accidental and intentional and may encourage self-medication.[43] Irrational prescribing can contribute to pharmaceutical waste; thus, future prescribers should be aware of proper disposal methods and the potential consequences of improper pharmaceutical disposal.[11] According to a study in Nepal, even pharmacists lack sufficient knowledge and awareness of safe pharmaceutical disposal, highlighting the necessity of a safe pharmaceutical take-back program.[44] The pharmaceutical take-back program is a safe and environmentally responsible way to dispose of leftover and expired medications. The drugs are returned to pharmacies or law enforcement agencies and destroyed without causing a threat to the environment.[45] In nations such as Australia and Canada, medicine take-back programs are well-established and authorized by the government. Likewise, nations such as Sweden and the US have effective pharmaceutical waste management system in place.[46] There are several ways to dispose pharmaceutical waste, including chemical, physical, biological, and recycling techniques. According to the World Health Organization (WHO) guidelines on pharmaceutical waste management, healthcare waste should not be burned outdoors, as it may pose environmental hazards.[47] Various modern end-of-pipe technologies, such as photo-assisted processes, biodegradation, ozonation, and extended filtration, have been developed by environmental specialists to improve the removal of pharmaceutical pollutants from environmental matrices. However, factors such as practical stability, cost-effectiveness, and ease of use restrict their implementation in traditional sewage treatment plants.[48,49]

Research conducted in Bangladesh, Nepal, and other regions of the world highlights a lack of knowledge among medical, dental, nursing, and pharmacy students regarding the proper storage and disposal of pharmaceuticals. Approximately 58% of students reported disposing of liquid pharmaceuticals in sinks or toilets, which finally enter wastewater systems. Pharmacies, where students obtain their medications, would be ideal locations for education on this matter. The curricula for medical, dental, nursing, and pharmacy graduates should address safe and appropriate pharmaceutical disposal. In addition, legislative authorities should take these matters into consideration.[50,51] Pharmaceutical consumption in Bangladesh is increasing daily.[52] Bangladesh's annual pharmaceutical consumption is likely among the highest in the world due to its dense population, numerous widely recognized pharmaceutical organizations, and affordable access to almost all sorts of medications. However, many prescribed drugs often go unused for various reasons, including brand name replacements in prescriptions, adverse drug reactions, and patient recovery leading to treatment discontinuation.[53] However, there are still very few regulations governing the regular monitoring, management, and control of pharmaceuticals in the environment as emerging pollutants, which would lead to the continuous discharge of pharmaceuticals into the environment.[17,54] At the 2015 International Conference on Chemicals Management, non-governmental organizations and the pharmaceutical industry recognized the urgent need to protect the environment from "pharmaceutical pollution" due to the widespread presence of pharmaceutical residues and their possible environmental risks.[55,56] The purpose of this research is to evaluate the current understanding of this crucial issue among Bangladeshi medical students. As future healthcare professionals, these students play an important role in both applying EPV principles in their professional practice and educating the public on the subject. Healthcare professionals, particularly prescribers and dispensers, are responsible for promoting rational prescription policies that assure the safe and efficient use of medications, with a focus on the prescriber's role. Given the rapid advancements in the healthcare industry, it is equally necessary for emerging healthcare professionals to mentor and guide their seniors. Since EPV affects both environmental sustainability and public health, its significance cannot be underestimated.

2. Materials and methods

2.1. Study design

This was a questionnaire-based and cross-sectional study.

2.1.1 Ethical approval

The study protocol and final questionnaire were approved by the Ethics Committee of Armed Forces Medical College, Dhaka. Informed consent was obtained from all willing students before they participated in the study. The study adhered to the principles of the Helsinki Declaration on human subjects in medical research.

2.1.2. Study site

The study was conducted at Armed Forces Medical College, Mugda Medical College and Hospital, and Shahabuddin Medical College, Dhaka.

2.1.3. Study duration

The study was conducted over a period of 3 months, from August to October 2024.

2.1.4. Study population

All 3rd-and 4th-year undergraduate medical students were invited to participate in the study. Informed consent was obtained from all interested students before the study began.

2.1.5. Sample size

Approximately400 medical students were initially included in the sampling frame, with 200 students from the 3rd-year and 200 from the 4th-year from each medical college. From this list, 300 medical students were randomly selected to participate in the study, with 160 students from the 3rd year and 140 from the 4th year. Respondents were provided with hard copies of the questionnaire. The first page included an explanatory letter describing the survey's objectives. They were instructed to complete the questionnaire and return it to the researchers within 1 h. Respondents who refused to participate in the study or failed to return the completed questionnaire within the given time frame were excluded.

2.1.6. Sampling method

Enrolment was based on voluntary participation from those willing to participate.

2.2. Data collection

2.2.1. Development of the structured questionnaire

A structured, self-administered questionnaire was developed to address the research question, focusing on several aspects of medical personnel's knowledge, perceptions, and practices regarding the storage of unused pharmaceuticals and the improper disposal of expired and unused medications, which can ultimately affects the ecosystem. To finalize the content, a thorough literature review of published studies on medicine storage and disposal methods, as well as information on EPV, was conducted, along with consultations with subject matter experts.[57-59] The questionnaire was developed in English.

2.2.2. Questionnaire contents

The final questionnaire consisted of several sections and 25 structured questions. The first section included four questions about the respondents' socio-demographic information, such as age, gender, year of study, and whether they had any first-degree relatives in the medical field. Furthermore, four more questions were designed to assess the respondents' understanding of EPV and environmental contamination from drugs, including safe drug disposal procedures, their awareness of EPV, the impact of veterinary diclofenac residues on several Asian Gyps (bird) populations, and the effects of oral contraceptive pill residues on frog sterility and the feminization of male fish in aquatic environment.

The second section of the study consisted of nine questions designed to evaluate medical students' perceptions of EPV. These questions were framed using a 5-pointLikert scale (1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree). This section aimed to assess the students' opinions, attitudes, and beliefs on responsible pharmaceutical management and its ecological implications. Furthermore, the final section of the questionnaire consists of eight questions that evaluate participant's daily behavior and practices related to the management, disposal, and storage of medications. These questions were developed based on a thorough literature review and discussions among the authors.

2.2.3. Validity and reliability of questionnaire

The questionnaire's content was reviewed and verified by two selected experts in the relevant field, both of whom were medical college academicians.[60] Their comments were carefully considered, and necessary revisions were made accordingly. The questionnaire was then forwarded through private email to 30 volunteer faculty members for their comments and answers. Based on their feedback, the questionnaire was further revised to improve clarity and ensure a better understanding of the questions.

2.4. Data analysis

Data analysis was performed using descriptive statistics. Continuous data were expressed as mean ± standard deviation, while nominal data were expressed as percentages. Statistical analysis was carried out using the Statistical Package for the Social Sciences version 26.0 for Windows.

3. Results

The socio-demographic characteristics of the students are shown in Table 1. The mean age of the participants was

22 ± 0.96 years. Among the 300 respondents, females comprised a higher proportion (61.3%) compared to males (38.7%). In addition, one-third of the respondents (33%) had a first-degree relative in the healthcare field. Of the total participants, 160 (53.3%) were 3rd-year students, while 140 (46.7%) were 4th-year students.

Table 1. Socio-demographic characteristics and knowledge of EPV among study subjects (*n*=300)

Participant attribute	Responses	Number (%)
Age (mean±SD)	-	22±0.96
Gender	-	
Male		116 (38.7)
Female		184 (61.3)
Year of study	-	
Third year		160 (53.3)
Fourth year		140 (46.7)
Having any 1st degree relatives in the healthcare field	Yes	99 (33)
	No	201 (67)
Do you have any knowledge about safe drug disposal?	Yes	96 (32)
	No	204 (68)
Do you have any idea about EPV?	Yes	81 (27)
	No	219 (73)
Numerous Asian Gyps (bird) species were eradicated due to environmental animal diclofenac residue	Yes	204 (68)
	No	96 (32)
OCP residues in the water environment cause sterility in frogs and feminization of male fish	Yes	180 (60)
	No	120 (40)

Abbreviations: EPV: Ecopharmacovigilance; SD: Standard deviation; OCP: Oral contraceptive pill.

Table 2 shows that nearly 63.7% of respondents "strongly agreed" and 35.3% "agreed" that the creation and implementation of green manufacturing processes for pharmaceuticals are essential. In addition, 60.7% of respondents "strongly agreed" and 35.3% "agreed" that the potential environmental impacts of a new medicine should be evaluated before it receives authorization. Similarly, 54.3% of respondents "strongly agreed" and 44.3% "agreed" that pharmaceutical residues in the environment could have cause adverse effects on the ecosystem, wildlife species, even human health. Likewise, nearly 45.3% of respondents "strongly agreed" and 53.3% "agreed" that they considered it their professional duty to implement EPV.

Table 3 shows that 73.7% of respondents often checked the expiry date of their medications and 73.3% reported taking their medications according to the advice of a doctor or pharmacist.

Table 4 describes that 20% of private medical students were knowledgeable about safe drug disposal, whereas only 12% of government medical students had this knowledge. The difference was statistically significant ($p \leq 0.05$). The knowledge and perception scores were statistically significant ($p \leq 0.05$) for both government and private medical students, except for the topic of increased microbial resistance to antibiotics due to environmental

Table 2. Perception of EPV among medical students (n=300)

Survey questions	Responses, number (%)				
	Strongly agree	Agree	Disagree	Strongly disagree	Neutral
1. Drugs may be discharged into drainage systems and persist in the environment.	98 (31.3)	128 (42.7)	21 (7)	54 (18)	4 (1.3)
2. Drug compounds in the environment may have harmful consequences on ecosystems, wildlife species, and human health.	163 (54.3)	133 (44.3)	2 (0.7)	2 (0.7)	0
3. EPV is required for managing drug residues and associated adverse effects as part of pharmacovigilance to protect the environment.	129 (43)	167 (55.7)	3 (1)	1 (0.3)	0
4. I have an intense desire in EPV as a future physician.	112 (37.3)	165 (55)	20 (6.7)	3 (1)	0
5. Individuals should be educated on the potential environmental harm caused by pharmaceutical residues, as well as the proper consumption, disposal, and handling of medications.	189 (63)	100 (33.3)	7 (2.3)	1 (0.3)	3 (1)
6. It is essential to plan and implement environmentally friendly techniques pharmaceutical manufacturing processes.	191 (63.7)	106 (35.3)	2 (0.7)	1 (0.3)	0
7. It is necessary to assess the potential environmental risks before approval of a new drug.	182 (60.7)	110 (36.6)	4 (1.3)	1 (0.3)	3 (1)
8. I consider it my professional duty to implement EPV.	136 (45.3)	160 (53.3)	2 (0.7)	2 (0.7)	0
9. If I received proper training, I would be blessed to participate in EPV practices in the coming years.	139 (46.3)	140 (46.6)	9 (3)	3 (1)	9 (3)

Abbreviation: EPV: Ecopharmacovigilance.

Table 3. Practices related to EPV among medical students (*n*=300)

Survey questions	Responses, number (%)
1. How often do you check the expiry date of your medications?	
Often	221 (73.7)
Sometimes	57 (19)
Rarely	20 (6.7)
Never	2 (0.7)
2. How often do you take your medications according to the advice of your doctor or pharmacist?	
Often	220 (73.3)
Sometimes	66 (22)
Rarely	13 (4.3)
Never	1 (0.3)
3. When multiple medications are prescribed to you or your family members, do you use only the prescribed medications?	
Often	157 (52.3)
Sometimes	119 (39.7)
Rarely	18 (6)
Never	6 (2)
4. How often do you practice self-medication for minor illness, such as fever or headaches?	
Often	145 (48.3)
Sometimes	111 (37)
Rarely	13 (10)
Never	14 (4.7)
5. How often do you buy OTC medications that require a valid prescription?	
Often	89 (29.7)
Sometimes	132 (44)
Rarely	68 (22.7)
Never	11 (3.7)
6. What factors limit the use of medications prescribed to your family members?	
Forgetfulness	129 (43)
Medication ineffectiveness	15 (5)
Medications adverse effects	32 (10.7)
Improvement of health condition	124 (41.3)
7. What do you do with any unused medications remaining at your home or hostel?	
Throw away in household garbage	59 (19.7)
Keep at home until it gets expired	218 (72.7)
Burn them along with garbage	1 (0.3)
Return it to pharmacy shop	22 (7.3)
8. Have you ever educated your friends or family members about the safe and proper disposal of medicines?	
Yes	68 (22.7)
No	232 (70.3)

Abbreviations: EPV: Ecopharmacovigilance; OTC: Over-the-counter.

antimicrobial residues. The finding for this aspect was not statistically significant (p=0.674).

4. Discussion

The WHO defines pharmacovigilance as "the science and activities relating to the detection, assessment, understanding, and prevention of adverse effects or any other possible drug-related problems." Due to its importance in reducing the harmful effects associated with pharmaceutical residues, EPV has drawn significant interest from the research community as a significant application of pharmacovigilance in environmental science.[3,8,11] Globally, EPV should be promoted, particularly in developing nations with dense populations and often insufficient sewage treatment systems. The successful adoption of EPV by medical students and their subsequent behavioral changes depends on their comprehensive understanding, knowledge, and positive perception of the issue, which could improve the efficacy of EPV implementation.

To the best of our knowledge, this is the first study in Bangladesh to assess medical students' understanding, perceptions, and practices related to EPV and environmental pharmaceutical contamination. Only 27% of the participants were familiar with EPV, highlighting the urgent need for comprehensive education on the subject for medical students. A separate study conducted in Bangladesh revealed that pharmacy students possessed limited knowledge regarding proper medication disposal methods. Approximately 58% of students disposed of their liquid medications in sinks or toilets, where they ultimately reached the wastewater treatment system.[51] The respondents' knowledge of the ecological hazards posed by drug residues and the increased antibiotic resistance in bacterial communities, potentially caused by antimicrobial residues in the environment. This includes the destruction of many Asian Gyps vultures due to veterinary diclofenac residues, the feminization of male fish, and the sterility of frogs, which may result from hormonal compounds in water. The accuracy rates for these issues were77.7%, 68%, and 60%, respectively. These potential environmental hazards associated with antibacterials and hormonal compounds align with the usual impacts of pharmaceuticals, such as antibiotic-induced bacterial resistance and the endocrine-disrupting effects of hormones. Gyps vulture populations in the Indian subcontinent were largely destroyed due to diclofenac. Approximately 97.3% of participants expressed a desire to learn more about take-back programs, safe disposal techniques, potential environmental pharmaceutical residues, and the handling of unwanted medications, indicating an active interest in environmental protection. The study's most promising result is that 99% of students expressed interest in using eco-friendly methods for disposing of unwanted medications in

Table 4. Comparison of knowledge about EPV between government and private medical students (*n*=300)

Survey questions/Statement	Institution				*p*-value
	Government		Private		
	Yes *n* (%)	No *n* (%)	Yes *n* (%)	No *n* (%)	
Do you have any knowledge about safe drug disposal?	36 (12)	114 (38)	60 (20)	90 (30)	0.007[a]
Have you ever educated your friends or family members about safe medicine disposal?	25 (8.3)	125 (42)	43 (14.3)	107 (36)	0.018[a]
Do you have any knowledge of EPV?	33 (11)	117 (39)	48 (16)	102 (34)	0.000a
Numerous Asian Gyps (bird) species have been eliminated due to environmental residues of veterinary diclofenac.	89 (30)	61 (20)	115 (38)	35 (12)	0.002[a]
Environmental antimicrobial residues may contribute to increased antibiotic resistance in microbial populations.	115 (38)	35 (12)	118 (39)	32 (11)	0.674[a]
OCP residues in the water environment can cause sterility in frogs and feminization of male fish.	70 (23)	80 (26.6)	110 (37)	40 (13.3)	0.000[a]

Abbreviations: EPV: Ecopharmacovigilance; OCP: Oral contraceptive pill.

the future. This high degree of willingness suggests a strong potential for behavior change and collaboration toward environmental sustainability. These findings highlight the importance of providing education and resources to encourage proper medication disposal practices. Although 98.6% of respondents agreed that EPV implementation is necessary, 92.3% indicated interest in engaging with the practice. More significantly, 96% of respondents expressed willingness to use EPV in their future work, which provided that they received appropriate training.

Despite a lack of thorough knowledge of EPV, these findings indicate that most medical students show a positive attitude toward its implementation. However, the study also revealed poor practices, which is consistent with the lack of knowledge regarding EPV. For instance, 73.7% of respondents reported that they "often" checked the expiry dates of medications. In comparison, a study in Chennai, India, found that about 6% of pharmacy and medical students failed to check the expiry dates. In addition, 60% of respondents in that study agreed that medications become harmful after their expiry dates.[61] In this study, about 7.3% of participants returned their unwanted medications to pharmacies. Similarly, a study among dental students in India indicated that 61% believed expired that medications should be returned to the manufacturer.[62] In this study, 72.7% of respondents stored their medications at homes or in their hostels until they expired. A study conducted in Nepal found that 44.7% of medical and dental students also stored medications until they expired.[63] Furthermore, 19.7% of students disposed of unused medications in the trash. A survey in Bangladesh revealed that 47% of both urban and rural residents disposed of unused medications in the same way, and similar practices have been observed globally.[64-66] The reasons for having leftover medication include forgetfulness (43%), medication ineffectiveness (5%), adverse drug effects (10.7%), and perceived improvement in health (41.3%). Similar patterns of keeping extra drugs at home have been observed in other studies.[67] In this study, 68% of respondents were unaware of proper drug disposal methods. A study conducted in the Dhaka Metropolitan area revealed that over 67% of respondents were unaware about the correct way to dispose of drugs.[68] Another study in Nepal found that unwanted and expired medications were not disposed of properly, prompting the authors to recommend the establishment of a government-funded drug take-back program.[69] Although drug storage was common, self-medication was also prevalent. The storage of unused medications at home may contribute to this behavior. In this study, 48.3% of respondents reported self-medicating for common medical conditions, including headaches and fevers. Previous research in Nepal has documented the prevalence of self-medication among both students and public.[61,70-73] Many students consider self-medication acceptable, as they believe they are knowledgeable about medications and medical conditions. When comparing the respondents' knowledge of EPV with that of medical students, those from private institutions scored higher, likely indicating their greater interest and enthusiasm to learn about proper medication disposal. The curricula of these students do not include instruction on proper medication disposal. A significant 97.3% of respondents supported the implementation of a drug take-back program that allows patients to return medications to pharmacies, which would then return them to distributors. In addition, they advocate for education on the potential environmental hazards of pharmaceutical residues and the importance of rational drug use. It is possible to enhance knowledge of EPV during undergraduate studies through educational campaigns, seminars, or workshops targeted

at both students and public, promoting safe medication disposal procedures. The campaigns must emphasize the negative effects of improper medication disposal on the environment, in addition to raising public awareness about safe disposal practices.

This study establishes the basis for further research on EPV. However, the results may not be as globally applicable, as this study involved a small sample size and was limited to one region in Bangladesh. To confirm these findings, future studies with larger sample sizes and participants from other regions of Bangladesh should be carried out.

5. Conclusion

This first study on EPV among medical students in Bangladesh found that while the students had a positive perception of EPV, they lacked sufficient knowledge and experience with EPV. Although medical students were willing to engage in EPV, understanding that pharmaceutical residues in the environment could harm the ecosystem, wildlife, and human health, they still required more relevant information. Their understanding of the concept, goal, significance, and application of EPV was limited. Furthermore, the main barrier to the successful implementation of EPV in Bangladesh was identified as a lack of awareness. To improve medical students' knowledge of EPV, further works are needed.

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Conflict of interest

The authors declare no conflicts of interest.

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Ethics approval and consent to participate

The study protocol and the final questionnaire received approval from the Ethics Committee of Armed Forces Medical College, Dhaka. Informed consent was obtained from all participants before their involvement in the study. The research adhered to the principles outlined in the Helsinki Declaration regarding the ethical treatment of human subjects in medical research.

Consent for publication

Participants consented on the publication of their data.

Availability of data

Data supporting the study's conclusions are not publicly accessible to preserve participants' privacy but are available from the corresponding author on reasonable request.

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