

Medical Students and Ecopharmacology: Understanding Knowledge, Attitudes, and Practices

Kavitha VD¹, Pradnya Deolekar¹, Anant Patil¹, Sonal Signapurkar¹, Azra Naseem¹, Souvik Ghosh²,
Maya Kalyani Srivathsan¹, Akash Sinha¹, Movva Navya, Adwait Malik¹

¹Dept of Pharmacology, D.Y.Patil Medical College and Hospital, Navi Mumbai

²Consultant Intensivist, D.Y.Patil Medical College and Hospital, Navi Mumbai

Corresponding Author

Kavitha VD

Dept of Pharmacology, D.Y.Patil
Medical College and Hospital,
Navi Mumbai.

Mail id:

geminidoc017@gmail.com

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ABSTRACT

Background: Ecopharmacology studies the environmental impact of pharmaceuticals, focusing on their presence in ecosystems through waste and disposal. These substances can harm wildlife and contribute to issues like antibiotic resistance. Addressing this is crucial for public health and sustainability. This study is designed to evaluate the knowledge, attitudes, and practices (KAP) concerning ecopharmacology among medical students at our institute.

Objective: To evaluate eco-pharmacology KAP among students in a tertiary hospital.

Methods: It was a questionnaire based cross-sectional observational study. Study population included second-year healthcare undergraduates. A total of 578 participants who agreed to participate were enrolled and completed a structured KAP questionnaire, and the data were expressed as percentages. The questionnaire consisted of 20 closed-ended questions.

Results: The study revealed that 87.45% of respondents were familiar with the term ecopharmacology, and 91.52% felt a personal responsibility to protect the environment from pharmaceutical waste. While 82.69% expressed concerns about excess medicines at home, 41.69% admitted to disposing of expired drugs in the trash. Only 10.38% followed the recommended practice of returning unused medicines to a pharmacy or hospital. Additionally, 94.11% supported the need for clear disposal guidelines, and 94.80% were willing to participate in awareness campaigns. Participants also proposed solutions such as installing collection boxes in hospitals and pharmacies to improve pharmaceutical waste management.

Conclusions: The study highlights significant gaps in medical students' knowledge, attitudes, and practices regarding ecopharmacology. To foster responsible pharmaceutical disposal and reduce environmental harm, increased education and awareness are essential. Integrating ecopharmacology into medical curricula can play a pivotal role in promoting sustainable practices and ensuring long-term environmental stewardship.

Keywords: Ecopharmacology, Medicine disposal, KAP study.

INTRODUCTION

Over the past few decades, the global concern about the public health impacts of environmental pollution has intensified. The World Health Organization (WHO) estimates that nearly a quarter of the diseases faced by humanity today are a result of prolonged exposure to environmental pollution.¹ Ecopharmacology, also known as environmental pharmacology or ecopharmacostewardship, is the branch of science concerned with the entry of chemicals and drugs into the environment. These substances, when present at various concentrations, disturb the ecological balance of ecosystems.² It is estimated that approximately 88% of pharmaceuticals in the environment stem from patient use. Additionally, drug manufacturing processes and improper disposal of unused medicines contribute to trace levels of pharmaceuticals found in rivers, lakes, soils, and sometimes even drinking water.^{3,4}

The solubility of many drugs in water makes them especially prone to entering the sewage system, adding a new dimension to ecopharmacology.⁶ Pharmaceuticals, whether excreted as parent compounds or metabolites, can make their way into food chains and accumulate, posing risks to both human health and wildlife.⁷ Expired medicines further exacerbate the issue, as they can lead to reduced efficacy, compromised safety, and the formation of harmful by-

products. Improper disposal of these expired medications contributes to the entry of pharmaceutical ingredients into the environment (PIE), worsening contamination.^{8,9}

The "2030 Agenda for Sustainable Development" set by UNESCO emphasizes the importance of identifying and removing pharmaceuticals from the environment. Pharmaceutical residues in ecosystems pose risks such as water contamination, soil degradation, and harm to wildlife. Additionally, they contribute to antibiotic resistance, which threatens global health. Proper disposal and management of pharmaceutical waste are crucial steps in protecting both the environment and public health, aligning with broader sustainability goals for a healthier future.¹⁰

Despite the growing importance of this issue, research on ecopharmacovigilance is still limited. This study was thus planned to assess the Knowledge, Attitude, and Practice (KAP) of eco-pharmacology among undergraduate medical students in tertiary care teaching hospitals. By evaluating the existing KAP, the study aims to enhance awareness and promote solutions. It seeks to foster a deeper understanding of eco-pharmacology and its relevance in modern medical science, while also addressing the environmental impact of pharmaceutical misuse. The results will contribute to better awareness and encourage proactive measures to mitigate the harmful effects of pharmaceutical pollution at various levels.

MATERIALS AND METHODS

Study design:

This was a cross-sectional survey, conducted through prevalidated structured questionnaire. The study was conducted in our institute over a period of two months between August 2024 to September 2024.

Study population

The study population was of either gender, which included MBBS students, dental students, Occupational students, physiotherapy students, allied health students, nursing students and resident's doctors from our institute.

Sampling/sample size

A non-probability sampling technique (convenience method) was employed to reach to the representative population in our institutes. Total of 578 participants were included.

Study instrument:

A structured questionnaire was designed with two sections. Section one focused on collecting personal information from the respondents, such as gender, age, and educational background. Section two contained questions assessing the participants' knowledge, attitude, and practices (KAP) regarding ecopharmacology, consisting of 20 questions in total.

To ensure the validity of the questionnaire, it was reviewed by 20 representatives from the study population. Based on their feedback obtained during the pilot test, necessary revisions were made to improve clarity and accuracy.

After obtaining approval from the Ethics Committee, students were briefed on the purpose of the study. After informing participants about the study objectives and obtaining their consent, a questionnaire was shared via WhatsApp as a Google Form link. Responses were collected from all participants, and the data was entered into Microsoft Excel 2021 for analysis. The results were then evaluated and presented as percentages. A total of 578 participants successfully completed the questionnaire.

Inclusion Criteria

- Second year students from MBBS, dental, nursing, occupational therapy, physiotherapy, allied health sciences and postgraduates willing to participate in the study

Exclusion Criteria

- Faculty members
- Those who were not willing to participate in the study

RESULTS

Out of 602 consenting participants 578 satisfactorily completed the questionnaire with a response rate of 96.01% and were included for evaluation.

Table 1: Demographics

Parameters		Value	Percentage
Total Participants		578	
Mean Age of participants (\pm SD) years		20.52 \pm 1.60	
Age Group in years	20-24	472	81.66
	Above 24	106	18.33
Gender	Male	276	47.75
	Female	302	52.24
Students	Undergraduate	472	81.66
	Postgraduate	106	18.33

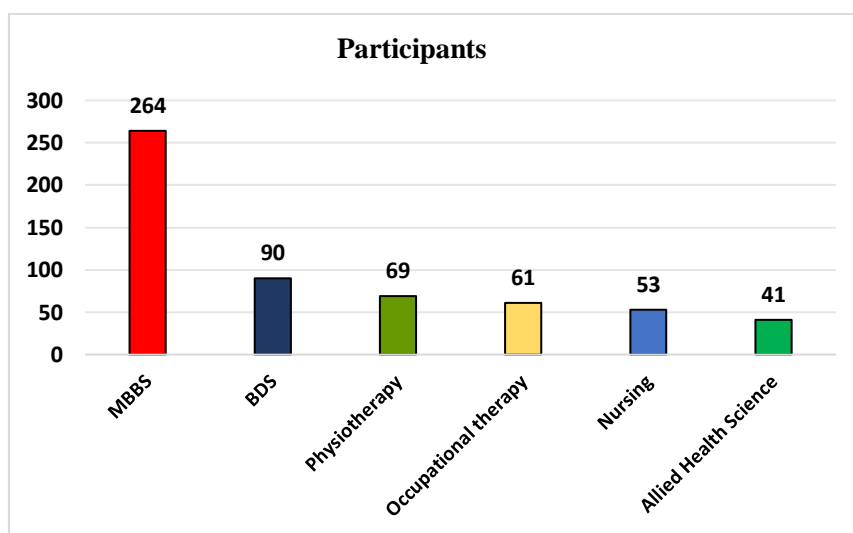


Figure 1. represents the **distribution of participants across different healthcare disciplines.**

MBBS students constituted the largest group (45.67%), followed by BDS (15.57%), Physiotherapy (11.94%), Occupational Therapy (10.55%), Nursing (9.17%), and Allied Health Science (6.99%). This indicates a higher engagement from medical students, while participation from other healthcare fields was comparatively lower, emphasizing the need for broader awareness and active involvement across all disciplines in ecopharmacology education and practice.

Table 1: Knowledge about ecopharmacology amongst participants.

Questions	Yes (n=578) (%)
Are you aware of the term "Ecopharmacology"?	92.21
Do you think drug use can cause environmental pollution?	92.56
Does Environmental pollution contribute to Antibiotic resistance?	81.66
Can expired or unused medicines, if not disposed of properly, be a threat to public safety?	96.86
Which coloured dustbin will you discard medicines in?	81.48
Can pharmaceutical pollution harm human health?	93.25
Have you come across any news reports or articles discussing the environmental impact of pharmaceuticals?	57.30
Are you aware of any laws or regulations in India aimed at reducing the risk of drugs contaminating the environment?	51.82

Table 1 highlights participants' knowledge of ecopharmacology and pharmaceutical pollution. While 92.21% were aware of the term, a higher percentage (92.56%) recognized that drug use can harm the environment. 96.86% acknowledged the risks of improper medicine disposal, and 93.25% agreed that pharmaceutical pollution affects human health. However, awareness of media reports (57.30%) and Indian regulations (51.82%) was lower, indicating the need for better public education on safe medication disposal.

Table 2: Attitude of participants towards ecopharmacology.

Questions	Yes (n=578) (%)
Have you ever had concerns over what to be done with unused medicines?	82.69
There should be clear guidelines for the public on how to dispose of medications in an eco-friendly way.	94.11
How important is it to you that pharmaceutical companies take steps to reduce drug pollution?	89.61
Hospitals and pharmacies should have collection boxes for the safe disposal of leftover, unused, or expired medications.	90.65
Do you believe you have a responsibility to help protect the environment from pharmaceutical waste?	91.52
Would you be willing to change your medication disposal habits if given proper guidance?	94.80

Table 2 highlights the strong need for better pharmaceutical waste management. With 94.11% supporting clear disposal guidelines and 90.65% advocating for collection boxes in hospitals and pharmacies, it is evident that structured disposal systems are necessary. Additionally, 89.61% believe pharmaceutical companies should take responsibility for reducing pollution. Positively, 94.80% are willing to change their habits with proper guidance, emphasizing the need for awareness programs. The high concern (82.69%) over unused medicines and the 91.52% who feel a personal duty to protect the environment further emphasize the urgency for awareness campaigns and policy implementation.

Table 3: The practices of participants about Ecopharmacology.

Questions	Yes (n=578) (%)
Do you read the package inserts/labels containing information on safe disposal of the drugs?	80.96
Do you purchase medications in large quantities for your family?	79.06
Do you discard the expired drugs directly into the dustbin?	41.69
Do you remove medicines from their packaging before throwing them away?	91.17
Have you attended any seminars/workshop/CME (Continue medical education) about ecopharmacology?	53.98
Which method of medication disposal will you prefer?	Refer fig 2

Table 3 highlights the need for better medication disposal practices. While 80.96% read disposal guidelines, a concerning 41.69 % still discard expired drugs in the dustbin, and 91.17% remove medicines from packaging before disposal. Additionally, 79.06% buy medicines in bulk, increasing the risk of waste. Most common medicines left unused at home were paracetamol, antacids and antibiotics. 64.19% of respondents said that unused medicines were in tablet form, 25.10% in syrup form and 10.69 % in ointment form. Fate of unused drugs is shown Figure 1. The lack of participation in seminars/workshops further underscores the need for educational initiatives on safe disposal.

Figure 2: Fate of unused medication:

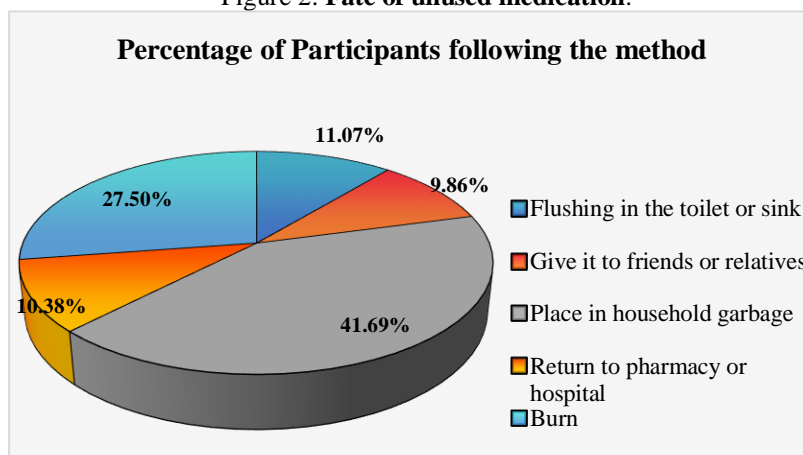


Figure 2 highlights the prevalence of improper medication disposal methods, with most participants discarding medicines in household garbage or burning them. The low percentage (10.38%) of those following the recommended practice of returning medicines to a pharmacy or hospital underscores the urgent need for awareness programs and proper disposal guidelines to prevent environmental contamination.

DISCUSSION

Ecopharmacovigilance emphasizes the need to control pharmaceutical waste at its source to prevent environmental contamination. Improper medication disposal can lead to severe consequences, including pollution, food chain disruption, and harm to diverse life forms, from microorganisms to larger ecosystems.

Knowledge of Participants Regarding Ecopharmacology

Around 535 participants felt that the drugs they consume could cause environmental pollution, this is consistent with the findings of Khanavkar et al.¹¹ study.

The majority of participants (96.56%) were aware of the hazardous environmental and health impact of improper disposal of unused and expired medicines. Studies of drug disposal practices in university students from Kabul have also reported awareness on this issue but lesser than our study.¹²

Furthermore, 533 (92.21%) correctly defined the term 'ecopharmacology,' indicating a solid understanding of the concept among the respondents. This level of awareness is crucial in addressing the environmental impact of pharmaceuticals, particularly given the potential contribution to antibiotic resistance, as recognized by 81.66% of participants. This finding is similar to the studies conducted by Khanavkar et al.¹¹ (80.4%) and lesser as compared with studies done by Advani and Jadhao² and Bhadoriya and Wadagbalkar,¹³ where 86% of participants expressed the belief that environmental pollution caused by drugs could contribute to antibiotic resistance.

The present study also revealed some gaps in knowledge, particularly regarding Indian rules and regulations aimed at minimizing the risk of drug entry into the environment with approximately half of the participants (51.82%) familiar with these concepts.

Attitude of Participants Regarding Ecopharmacology

The majority of participants (82.69 %) expressed concern regarding the disposal of unused or extra medication. The majority (91.52%) of participants agree that it's their responsibility toward environmental protection. However, (94.80%) expressed willingness to engage in proper medication disposal programs. These observations are higher than the findings of a study conducted by Khanavkar¹¹(61%), but similar to finding of Advani²and Gubaeet al.¹⁴

A wide range of antibacterials have been observed in waters and soils and many of these persist for shared their excess medications with other when indicated.¹³

Present study participants were concerned about the disposal of the excess medicines at home but were unaware of safe disposal methods. There are WHO guidelines for 'safe disposal of unwanted pharmaceuticals'. Total 18% of studied participants practiced pouring of liquid medication in the wash basin. Similar practices were reported in studies from Kuwait, UK and USA¹⁵ but in our study 11.07% participants practice.

According to standard guidelines also small quantity liquid medications should be diluted with water and drained. Drugs or their metabolites also find their path to enter the food chain through this route. Therefore, studies have been conducted throughout the world about this issue to find the policy solutions.

Practice of Participants Regarding Ecopharmacology and Drug Disposal

The present study identified areas for improvement in medication management and disposal practices among participants. A significant proportion (79.06%) of participants disclosed buying drugs in bulk for family members, while 91.17% and 92.38% admitted to discarding drugs without containers and pouring leftover syrup/lotion into the wash basin, respectively. These practices have the potential to contribute to improper disposal and environmental contamination. These findings are significantly higher than those reported in the study conducted by Advani and Jadhao.² In the current study, the preferred method for disposing of leftover or unused medicines among the majority of participants (41.69%) preferred throwing of medicines in household garbage. This was followed by flushing it in the toilet or sink (27.50%), giving medicines to friends or relatives (11.07%), burning (10.38%), while returning them to pharmacy or hospital was least preferred method(9.86%). This finding is consistent with the study conducted by Gubaeet al.,¹⁴but in contrast to Khanavkar et al.¹¹ where the preferred method for disposing of leftover or unused medicines among the majority of participants (66.7%) was returning them to a pharmacy or hospital. This was followed by disposing of them by burning (13.7%), throwing them in household garbage (13.7%), and flushing them down the toilet or sink. This difference might be due to garbage bins being more easily available around compounds and lack of awareness about proper disposal practices of medications.

Returning expired and unused medicines to medical stores is community practice in the USA (23%) and UK (22%).^{12,16} According to the current study, most of the methods for disposal of unused and expired medicines followed by the respondents are not recommended methods, though they are commonly used in many places. Nevertheless, the recommended method for disposal of most pharmaceuticals is high temperature incineration, which requires some initial organized method of collecting and sorting. Nowadays, in many developed countries, drug-take-back systems are established for collection of unused and expired medicines. One type of drug-take-back program that has been suggested by “Nebraska Medication Education for Disposal Strategies (MEDS)” is to put tamper-resistant boxes in pharmacies that will allow consumers to bring medicines back to knowledgeable pharmacists. For example, in Sweden and Korea, more people return unused medicines to a pharmacy for correct disposal, as they have realized the environmental concerns posed by expired medicines.^{17,18} Indian government also needs to be proactive to launch feasible expired pharmaceutical collection programs, such as Francisco’s Safe Medicine Disposal program, Dispose a Med program, Chemical Control Program, Sharps Waste Disposal Program Expired medications drop-off operation in California USA.¹⁹ Medications Return Program or Take-back programs in Canada and Meds Disposal in Europe.^{20,21,22}

In Taiwan, an educational pharmacist intervention booklet has been designed to teach their customers in how to use and store the medications properly.²

Limitations:

Certain limitations must be acknowledged. The reliance on self-reported data may introduce response bias, as participants’ perceptions and recollections could lead to overestimation or underestimation due to social desirability or recall bias. Additionally, the study’s single-center focus and cross-sectional design provide only a snapshot of ecopharmacology-related knowledge and practices at a specific time, limiting generalizability and the ability to track changes over time. Future multi-institutional and longitudinal studies are needed to evaluate the long-term effectiveness of interventions in enhancing ecopharmacology awareness and practice.

CONCLUSION

This study highlights the need for ongoing education and structured interventions to improve ecopharmacology awareness and practices among healthcare students. While awareness of pharmaceutical pollution is high, gaps in regulatory knowledge and improper disposal practices remain. Collaborative efforts between institutions, regulatory bodies, and pharmaceutical companies are essential to promoting sustainable medication management and reducing environmental risks.

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