

Literacy and Attitudes toward Eco-pharmacology among Medical and Nursing Students: A Quasi-experimental Study

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ABSTRACT

Background

Medical and nursing students have the potential to protect Nepal's delicate ecosystems and enhance public health outcomes by making informed decisions about pharmaceutical waste management which demand updating existing curricula and zeal for teaching and learning the principles of eco-pharmacology.

Objective

To assess the knowledge, perception and attitude of medical and nursing students on eco-pharmacology before and after short educational intervention.

Method

The quasi-experimental study (quantitative with embedded qualitative elements) was carried out among students of Bachelor of Science in Nursing (BSc Nursing), Bachelor of Nursing Science (BNS), and Bachelor of Medicine and Bachelor of Surgery (MBBS) in a medical college from April 2022 to March 2023 after getting approval from Institutional Review Committee (Reference number: 468). The predefined validated questionnaire was administered before and after two weeks of the short educational intervention in the form of lecture with interactive session. The data were analyzed using descriptive statistics.

Result

This study of 131 students (59 MBBS, 39 BSc Nursing, 33 BNS) demonstrated that educational intervention on eco-pharmacology significantly improved knowledge scores for MBBS ($p < 0.0001$) and BSc Nursing students ($p < 0.0001$), while BNS students showed no statistically significant improvement ($p = 0.637$) despite having good baseline knowledge. Post-intervention, MBBS students reached 100% positive perception, BNS students improved from negative to 57% positive and BSc Nursing students increased to 86%.

Conclusion

This study shows that even a short educational intervention can have a positive impact on students' comprehension of drug-related environmental health hazards.

KEY WORDS

Environment, Medical students, Nursing students, Pharmaceutical waste

INTRODUCTION

Eco-pharmacology is an evolving discipline which deals with the fate, effects and risks of pharmaceutical compounds and their metabolites in ecosystems.¹ The views of medical and nursing students on eco-pharmacology are crucial as healthcare professionals contribute significantly to the production and management of pharmaceutical waste.¹⁻³ To narrow down the knowledge gap and facilitate the effective disposal of pharmaceutical waste, healthcare professionals, particularly physicians and nurses, are expected to take the lead in teaching the public about environmental issues and public health.⁴

Good understanding of eco-pharmacology is required for medical and nursing professionals to understand the effects of pharmaceutical waste on the environment and make an advance towards sustainable healthcare practices. Through the promotion of knowledge and perception towards eco-pharmacology, medical and nursing students have the potential to preserve Nepal's fragile ecosystems and improve public health outcomes by making well-informed decisions regarding pharmaceutical waste management.⁵

There has been limited study on knowledge, perception and attitude on eco-pharmacology. The median knowledge score on eco-pharmacovigilance among medical and dental students of one of the medical colleges of Nepal was found to be eight out of ten and above 70% of students of medical colleges of India were aware of the term eco-pharmacology.³⁻⁵ Therefore, this study was planned to assess the knowledge, perception and attitude on eco-pharmacology among medical and nursing students before and after a short educational intervention.

METHODS

This quasi-experimental study (quantitative with embedded qualitative elements) was conducted from April 2022 to March 2023 in Nepalese Army Institute of Health Sciences (NAIHS) after getting ethical approval from IRC NAIHS (Reg 468 dated Dec 2021). The study was conducted among third year students of Bachelor of Medicine and Bachelor of Surgery (MBBS) from the College of Medicine, and third (final) year Bachelor in Nursing Science (BNS) and fourth (final) year Bachelor of Science in Nursing (BSc Nursing) from College of Nursing. The total students in MBBS 3rd year were 100 and final year of BSc Nursing and BNS were 40 each. The census sampling method was used for the study. The questionnaire was administered to those students who provided informed written consent.

The questionnaire was developed following discussions with two subject matter experts and consulting published literature.³⁻⁵ Three content experts (one pharmacologist, one registered nurse with expertise on pharmaceutical waste management and one hygiene and sanitation consultant) were given the questionnaire and the materials

for educational intervention in order to perform content validation on the initial draft. The questionnaire was administered to 20 students 10 medical students and 10 nursing students in order to verify its face validity. The recommendations made by the students were taken into account for improved legibility and comprehension of the statements, and the appropriate adjustments were made accordingly. After analyzing the responses of the 20 students, Cronbach's alpha for questions based on knowledge and perception was found to be 0.76.

Self-administered questionnaire included four parts. Part one contained questions regarding socio-demographic information like age, gender, place of stay, etc. Part two had ten statements (K1-K10) regarding knowledge on eco-pharmacology with 'true' or 'false' options. Part three consisted seven statements (P1-P7) in five-point likert scale (1 = strongly agree, 2 = agree, 3 = undecided, 4 = disagree and 5 = strongly disagree) for assessing perception and part four consisted four multiple options questions and one yes/no question regarding practice on eco-pharmacology (attached as supplementary file). Correct responses received one score, while incorrect answers received zero score for statements regarding knowledge. Bloom's cut-off criteria were used to categorize knowledge levels into good (80-100% correct response; score 6-7), moderate (60-79% correct response; score 4-5), and poor (< 60% correct response; score < 4) knowledge towards eco-pharmacology.⁶ The maximum score was 10 and minimum was 0. Perception/attitude scores were categorized as positive, neutral and negative based on score of 4-5, 3 and less than 3 respectively.^{6,7} The questionnaire covered topics such as awareness about environmental impacts of drugs, pharmaceutical waste management practices, and the role of healthcare professionals in promoting environmentally sustainable practices. A pre-test was conducted, followed by an educational intervention and a post-test, two weeks after the educational intervention session. Time allotted for pre-test and post-test was 45 minutes each. After the completion of pre-test, the structured educational intervention on eco-pharmacology was conducted by three pharmacologists and a nurse with experience in pharmaceutical waste management. The modality of intervention was didactic cum interactive session on eco-pharmacology of four hours duration for three groups of study participants (B.Sc., BNS and MBBS students) in a single day. The contents of the session included introduction and scope of eco-pharmacology, its impact on environment and public health, drug disposal at home and health facility, challenges and practices of eco-pharmacovigilance and feedback session.

Data were entered in MS Excel 2010 (version 14.0) by using the validation method and double-checking. Data processing and analysis were done using a statistical package for social science (IBM SPSS version 21) software. The quantitative information was recorded in terms of the Likert scale and mean score was determined. Qualitative

information was gathered from closed ended and open-ended questions and categorized thematically wherever possible. The data were analyzed with descriptive statistical techniques (frequency, percentage, mean and standard deviation), presented in the form of tables, diagrams and texts and paired t-test was applied to determine whether the level of changes after intervention were significant or not. The p -value < 0.05 was considered statistically significant.

RESULTS

Among 180 eligible participants, 131 (72.77%) only participated in the study as they gave consent and were present during the time of questionnaire administration.

Socio-demographic characteristics of the respondents

Out of 131 respondents, there were 59 MBBS students, 39 BSc nursing and 33 BNS students. The mean ($\pm$ SD) age of the respondents was 21.48 ± 2.21 years with mean age of MBBS students being 21.48 ± 0.62 years, BSc Nursing students being 22.05 ± 0.97 years, and BNS students being 25.57 ± 2.15 years (Table 1).

Students' knowledge regarding eco-pharmacology

MBBS students had good knowledge about the source of drugs and entry of their metabolites into environment prior to the intervention. BSc nursing students had good knowledge on reproductive and developmental abnormalities in aquatics caused by drugs and they

Table 1. Socio-demographics of medical and nursing students

Socio-demographic parameters		MBBS	BSc Nursing	BNS
Age in years		21	22.28	25.57
Gender (n)	Male	27	0	0
	Female	32	39	33
Native place (n)	Rural municipality (Gaunpalika)	12	18	17
	Municipality (Nagar-palika)	35	21	16
	Sub-metropolitan city (Upamahanagar-palika)	4	0	0
Current stay (n)	Metropolitan city (Mahanagarpalika)	8	0	0
	College hostel	59	5	3
	Private hostel	0	7	4
	Home	0	17	14
	A rented house with family	0	1	2
	A rented house without family	0	9	10

also knew about the need of drug take back schemes by pharmaceuticals. However, BNS students had good knowledge of eco-pharmacology prior to the educational intervention. Out of 131 students, overall mean change in percentages as well as mean score regarding knowledge on eco-pharmacology are increased in all students in post-test, which was only statistically significant for MBBS (p

Table 2. Student's pre-test and post-test correct response on statement regarding knowledge on eco-pharmacology

Statement	MBBS			BSc Nursing			BNS		
K1	71.19	100	28.81	64.1	100	35.9	60.61	84.85	24.24
K2	81.36	98.31	16.95	64.1	92.31	28.21	93.94	100	6.06
K3	77.97	98.31	20.34	87.18	94.87	7.69	93.94	100	6.06
K4	62.71	93.22	30.51	74.36	92.31	17.95	87.88	60.61	-27.27
K5	64.41	84.75	20.34	84.62	100	15.38	90.91	96.97	6.06
K6	79.66	88.14	8.48	56.41	82.05	25.64	78.79	84.85	6.06
K7	74.58	98.31	23.73	66.67	87.18	20.51	93.94	96.97	3.03
K8	83.05	100	16.95	69.23	92.31	23.08	87.88	78.79	-9.09
K9	91.53	98.31	6.78	61.54	94.87	33.33	90.91	93.94	3.03
K10	76.27	98.31	22.04	76.92	97.44	20.52	81.82	87.88	6.06

Notes: [True was correct response for positive statements (K1 to K7) and false was correct response for negative statements (K8 to K10).]

K1: Eco-pharmacology is concerned about entry of drugs into the environment through any route and at any concentration disturbing the balance of ecology as a consequence.

K2: Drugs and their metabolites can enter into the environment during use, excretion, and the improper disposal of drugs.

K3: An increasing presence of drugs in sewage, sludge and soils has been linked with reproductive and developmental abnormalities in various types of fish and other aquatic species.

K4: Chemotherapeutic drugs used for cancer treatment are found in a range of concentrations in the environment which might have adverse effects to human.

K5: Drug manufacturers and pharmacies should have drug take back schemes.

K6: Any chemical ingested by humans or animals has the potential to be excreted in sweat.

K7: Inappropriate disposal practices are often a significant contributor of drugs present in wastewater and other environmental media.

K8: Industrial wastes of the pharmaceutical companies do not contribute towards the entry of drugs into the environment.

K9: Improper disposal of leftover drug does not contaminate the environment to a great extent.

K10: Environmental pollution by drugs does not have impact on antibiotic resistance and cumulative toxicity.

< 0.0001) and BSc Nursing ($p < 0.0001$) students but not significant with BNS students ($p = 0.637$). The response on individual statements are shown in table 2.

Table 3. Mean ($\pm$ SD) score of knowledge before and after educational intervention

	Mean Score $\pm$ SD		P-value, (95% C.I)
	Pre-test	Post-test	
MBBS	7.63 $\pm$ 1.36	9.57 $\pm$ 0.62	<0.0001, (-2.3282 to -1.5518)
BNS	8.66 $\pm$ 0.64	8.84 $\pm$ 0.93	0.3631, (-0.5726 to 0.2126)
BSc	8.38 $\pm$ 0.98	9.33 $\pm$ 0.89	<0.0001, (-1.3722 to -0.5278)

Table 4. Percentage distribution of knowledge levels among student groups before and after educational intervention

Student group		Good knowledge (%)	Moderate knowledge (%)	Poor knowledge (%)
MBBS	Pre-test	15.30	30.59	54.20
	Post-test	64.40	20.30	15.30
BNS	Pre-test	86.00	10.00	4.00
	Post-test	87.88	9.09	3.03
BSc Nursing	Pre-test	20.51	53.84	25.65
	Post-test	92.30	0.00	7.70

Table 5. Comparison of mean score of responses (5-point likert scale) on perception (P) on eco-pharmacology pre and post intervention

Statements	MBBS			BSc Nursing			BNS		
	(Mean score $\pm$ SD)			(Mean score $\pm$ SD)			(Mean score $\pm$ SD)		
	Pre-test	Post-test	P-value	Pre-test	Post-test	P-value	Pre-test	Post-test	P-value
P1	4.32 $\pm$ 1.06	4.88 $\pm$ 1.24	0.0095	2.95 $\pm$ 0.87	4.10 $\pm$ 1.22	0.0001	2.55 $\pm$ 0.80	4.09 $\pm$ 1.32	0.0001
P2	3.72 $\pm$ 0.91	4.66 $\pm$ 1.16	0.0001	3.23 $\pm$ 0.94	4.36 $\pm$ 1.30	0.0001	2.36 $\pm$ 0.74	4.03 $\pm$ 1.30	0.0001
P3	3.88 $\pm$ 0.95	4.79 $\pm$ 1.21	0.0001	3.49 $\pm$ 1.04	4.08 $\pm$ 1.20	0.023	2.00 $\pm$ 0.64	3.33 $\pm$ 1.05	0.0001
P4	3.86 $\pm$ 0.92	4.46 $\pm$ 1.09	0.0018	2.74 $\pm$ 0.80	4.03 $\pm$ 1.20	0.0001	2.24 $\pm$ 0.72	3.33 $\pm$ 1.05	0.0001
P5	3.96 $\pm$ 0.95	4.54 $\pm$ 1.11	0.0028	2.64 $\pm$ 0.77	4.10 $\pm$ 1.21	0.0001	2.45 $\pm$ 0.80	4.24 $\pm$ 1.37	0.0001
P6	3.37 $\pm$ 0.8	4.58 $\pm$ 1.15	0.0001	2.59 $\pm$ 0.76	3.92 $\pm$ 1.15	0.0001	2.03 $\pm$ 0.66	4.09 $\pm$ 1.32	0.0001
P7	3.32 $\pm$ 0.78	4.54 $\pm$ 1.11	0.0001	3.00 $\pm$ 0.87	4.21 $\pm$ 1.25	0.0001	2.42 $\pm$ 0.79	3.39 $\pm$ 1.07	0.0001

Notes:

P1: The unsafe disposal of drugs can pose a hazard to public safety (animal/humans) and to the environment.

P2: Residues of various types of medicinal products have been detected in various environmental compartments, such as surface water, groundwater, soil, air, and biota.

P3: Several active drugs and their metabolites are dispersed in the environment mainly due to discharge of large amounts of products through sewage systems by consumers.

P4: Humans are unintentionally exposed to very low concentrations of medicinal products via daily intakes of drinking water, leaf crops, root crops, fishes, dairy products, and meat.

P5: The indirect environmental exposure of antimicrobials and medicinal products may create antimicrobial resistance in human gut flora.

P6: There is a serious need for more comprehensive studies and programs to educate the mass on proper methods of drug disposal.

P7: Eco-pharmacology should be introduced to syllabus of medicine and nursing at the undergraduate level.

Table 6. Percentage distribution of students' perception on eco-pharmacology before and after educational intervention

Student group	Pre-test perception (%)			Post-test perception (%)		
	Positive	Neutral	Negative	Positive	Neutral	Negative
MBBS	64.40	11.90	23.70	100	0.0	0.00
BNS	0.00	0.00	100	57.00	43.00	0.00
BSc Nursing	57.00	43.00	0.00	86.00	14.00	0.00

Students' perception regarding eco-pharmacology

Majority of MBBS and nursing students had positive perception towards necessity of teaching learning of eco-pharmacology for medical and nursing students (Table 5).

There was improvement in level of perception across all three group of students (Table 6). The most significant changes occurred in MBBS students who achieved 100% positive perception and BNS students who improved from 100% negative to 57% positive perception.

Student's practice of eco-pharmacology

The responses in this section were mutually inclusive with one or more than one response given by the respondents (Table 7). Majority of MBBS students 42 (71.19%) and BSc Nursing students 22 (56.41%) had drugs for gastritis followed by antibiotics as common drugs at home whereas 18 (54.55%) BNS students had antibiotics at their home followed by drugs for gastritis.

DISCUSSIONS

This study explored the impact of educational intervention regarding eco-pharmacology across medical and nursing students.

Table 7. Comparison of percentage of responses on practice on Eco-pharmacology

Statements	Responses	MBBS (n=59)		BSc Nursing (n=39)		BNS (n=33)	
		Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)
What are the common drugs that are at your home?	Drugs used for acid peptic diseases (gastritis)	71.19	47.46	56.41	66.67	39.39	51.52
	Antibiotics	49.15	52.54	41.03	56.41	54.55	63.64
	Drugs used in chronic diseases like hypertension, diabetes mellitus, etc.	28.81	28.81	35.90	41.03	30.30	24.24
	Drugs used for cold and cough	25.42	30.51	20.51	33.33	15.15	9.09
	Paracetamol	20.34	25.42	33.33	23.08	45.45	48.48
	Other analgesics	5.08	11.86	2.56	7.69	21.21	33.33
What do you do with leftover/unused drugs?	Store till expiry date	37.29	44.07	46.15	58.97	51.52	57.58
	Store for future use	20.34	25.42	41.03	48.72	30.30	21.21
	Give to needy patients	6.78	11.86	30.77	43.59	33.33	27.27
	Return to pharmacy	0.00	3.39	15.38	23.08	12.12	3.03
What do you do with expired drugs?	Throw in dustbin	96.61	100.00	69.23	94.87	81.82	96.97
	Flush down toilet	3.39	0.00	7.69	0.00	0.00	0.00
	Return to pharmacy	0.00	0.00	23.08	5.13	15.15	3.03
Do you remove the drug from its container before throwing it in the garbage?	Yes	18.64	57.63	43.59	76.92	57.58	93.94
	No	81.36	42.37	56.41	23.08	42.42	6.06
What sources will you search for information about eco-pharmacology?	Books	91.53	94.92	46.15	66.67	84.85	96.97
	Internet/Websites	54.24	62.71	38.46	43.59	63.64	33.33
	Social media	32.20	37.29	28.21	35.90	45.45	54.55

Knowledge outcomes

There were variations in the three groups' initial levels of knowledge. Change in the category of knowledge was not statistically significant for BNS students but MBBS and BSc Nursing students showed significant improvements. MBBS and BSc Nursing students' notable improvement is consistent with earlier studies showing how educational interventions can raise students' knowledge levels in the field of eco-pharmacology. Several studies have shown that how educational interventions, like seminars, lectures, and simulation-based learning, improve medical and nursing students' knowledge and abilities.^{5,8,9} However, the lack of statistically significant improvement among BNS students contrasts with the results of previously published studies.^{8,9} This contrast might be due to the differences in curricula, and prior exposure of BNS students to drugs as they joined course after few years of work experience. In addition, teaching methods might also influence how successful educational interventions are for various student populations.⁸

Perception outcomes

The results showed significant increment in the students' perception score of the risks connected to improper drug disposal and the existence of pharmaceutical residues in the environment. The MBBS students' strong agreement which increased from 84.75% to 100% on the risks associated with improper pharmaceutical disposal is consistent with

earlier research emphasizing the value of teaching medical students about environmental health concerns.^{10,11} Parallel to this, the significant rise in awareness among BSc nursing students from 23.08% to 87.18% highlights how well-targeted educational interventions can improve students' environmental health literacy in nursing programme. This finding aligns with research emphasizing the importance of integrating environmental health content into nursing education to prepare nurses for addressing emerging medicine-related public health challenges.^{10,12} Furthermore, the marked rise in student agreement for the identification of pharmaceutical residues in different environmental compartments is in accordance with the expanding corpus of research demonstrating the pervasive presence of pharmaceuticals in environmental matrices.^{8,10}

There has been a notable rise in student awareness about the unintentional exposure of humans to drugs through food and drink and relationship between indirect environmental exposure to antimicrobial and the emergence of antimicrobial resistance. This shows that it is crucial to teach future medical professionals on the origin and spread of drug contamination in order to reduce any possible threats to public health. Education on antimicrobial resistance and eco-pharmacology can be incorporated into medical and nursing curricula to enable upcoming medical professionals to tackle this urgent problem. Though this study demonstrated that students understand the importance of safe drug disposal

procedures and the integration of eco-pharmacology in undergraduate courses, there are several barriers and challenges to it.^{14,15} This study identified limited emphasis on eco-pharmacology in the healthscience curricula as a common barrier. Additionally, time constraints, workload pressures, and competing priorities within the healthcare system can pose challenges in implementing environmentally sustainable practices.^{4,9,14,15}

Practice outcomes

Drugs for acid peptic disorders were most frequently reported followed by antibiotics and analgesics as common household drugs in all categories, though in different proportions. Because digestive problems were common, proton pump inhibitors and antacids were seen as necessary drugs in the medical cabinet in many houses which is consistent with the tendency of self-medication for symptoms related to acid peptic disorders.¹⁶⁻¹⁸ The use of analgesics like paracetamol varies slightly which may be explained by person's unique pain threshold, knowledge of alternate pain relief techniques, and cultural preferences for particular analgesics.¹⁹ Across all groups, going back to the drugstore to return leftover drugs is infrequent. Consistent with data from published literature, all groups had the tendency of saving drugs till their expiry date for future usage.^{5,9,20} This widespread practice demonstrated that people of all demographic backgrounds were generally aware of the possible risks of expired prescription drugs.²¹⁻²³ Providing drugs to patients in need, was more common among nursing students and this aligns with studies that highlighted the charitable character of healthcare workers and their professional ethics and ideals with strong commitment to patient care and drug administration.²³⁻²⁵ However, general pattern of not returning unused drugs to the pharmacy, as shown in various studies, was also depicted in our study across all three categories (MBBS, BSc, and BNS).^{23,25} The results showed that most respondents disposed the expired drugs in the trash can, which is in line with suggestions made by published literature on drug disposal procedures.²² Studies continuously recommends against flushing drugs down the toilet because of possible health and environmental risks, such as contaminating water sources and aquatic ecosystems.^{4,11,22,23} Even though most students knew how to dispose off drugs properly, some BNS and BSc Nursing students admitted flushing their drugs down the toilet. The need of education and awareness initiatives aimed at healthcare professionals, who are crucial in supporting safe drug management practices, is highlighted by this mismatch.

All respondents indicated that books were the most preferred source of information regarding eco-pharmacology which is similar to findings from published literature highlighting the importance of traditional educational materials in healthcare education.^{5,23,25} Books

provide thorough and more reliable information that is frequently referred by experts and students, giving them a strong basis in comprehending difficult subjects like eco-pharmacology.²⁶

This study found that MBBS and BNS students in particular were common users of the web-resources, which is indicative of the growing trend of digitalization in medical education. This result is in lieu with studies showing how internet platforms are being increasingly used for learning and disseminating medical knowledge.²⁷⁻²⁹ Social media sites such as Facebook was widely used, particularly by BNS and BSc nursing students, indicating their preference for informal means of getting knowledge. Social media use in healthcare education may give rise to questions over the veracity and authenticity of the material supplied, even while it might promote networking and knowledge sharing.^{29,30} The need of adapting instructional materials to differing learning styles and preferences was highlighted by the differences in choices for information sources among various student groups.

This study was limited to one particular institution, small sample size might have an effect on how well the results apply to a larger population. Even if post-test was done after two weeks, it might still be too little time to assess participants' long-term changes in knowledge, attitudes, perception and practice. Self-administered questionnaire has limited value in assessing the practice as there are many types of biases. Though direct observation of practice is required for better conclusion, this study focused on closed-ended and open-ended questions. The particular contextual elements of the colleges such as implemented curriculum, institutional culture, and regional environmental health concerns, might have an impact on our conclusions.

CONCLUSION

Educational interventions focusing on eco-pharmacology showed promising improvements in student's knowledge, attitude and perception. There are significant curricular gaps that need addressing the better prepared healthcare professionals for environmental health responsibilities related to pharmaceutical waste management.

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