

Research

A Cross-Sectional Study to Assess the Knowledge of Pharmacy Students About Drug Pollution in Spain

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ABSTRACT

The presence of pharmaceuticals in the environment is an issue of growing concern. The European Commission adopted the “European Union Strategic Approach to Pharmaceuticals in the Environment”, which focuses on actions to reduce the risk of pharmaceuticals in the environment, including how environmental aspects can become part of medical training programs.

Objective: Obtain data from pharmacy students about pharmaceutical pollution to provide information about the training needs that may help develop new actions related to the training and dissemination of this issue.

Methods: A total of 1614 pharmacy students from 5 Schools of Pharmacy in Spain completed a self-administered questionnaire consisting of 24 questions: 13 about knowledge, 8 related to attitude, and 3 to opinion.

Results: Around 75% of students reported that they did not know “One Health” or “emerging pollutant” concepts and around 88% declared that they did not know that diclofenac caused a catastrophic vulture decline in Asia. The importance of this topic and their attitude to acquiring new knowledge was evaluated higher than 8 points out of 10, while received training during their studies was a score of 2.8 points out of 10.

Conclusion: The knowledge about key concepts was relatively poor. In fact, they judged training about pharmaceuticals in the environment during their pharmacy studies was very scarce. However, students consider drug pollution to be a very important issue and have a very good attitude toward acquiring knowledge about it.

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1. Introduction

Pharmaceuticals have significantly contributed to improving the life expectancy and quality of life of people through their use in the prevention and treatment of diseases. However, in recent decades, there has been growing concern about the harmful effects they can exert on the ecosystems.^{1–5} Indeed, pharmaceuticals are considered contaminants of emerging concern.^{6,7}

The consumption of human and veterinary medicines has increased significantly in recent years.^{5,8} The latter, together with waste from pharmaceutical manufacturing laboratories, self-excretion by consumers due to the inability of sewage treatment plants to completely eliminate drugs,^{7,9} inadequate disposal practices of expired/unused medicines¹⁰ and the leakage of veterinary medicines used in animal husbandry, including pets, into solid media,¹¹ have contributed to an increase in the amount of pharmaceutical residues reaching the environment. To date, almost 1000 different drugs have been detected in a wide range of environmental matrixes.¹²

Drugs can be found in aquatic environments (surface water, wastewater, groundwater, drinking water, etc.) and in solid environments such as biota, soil, and sediments in rivers and streams.^{13,14} Depending on the concentrations found, a variety of negative environmental and biological effects can occur including the feminization of fish with subsequent population collapse due to chronic exposure to the drug¹⁵ and alteration of their behavior; and the well-known and documented example as the first case of an ecological disaster caused by drug contamination: the decline in the population of the Indian vulture caused by the feeding of these birds on the carcasses of cattle treated with the drug diclofenac.¹⁶ The presence of antimicrobial residues in the environment is also being recognized as a potential source of antimicrobial resistance.¹⁷

Since pharmaceuticals are one of the most worrying emerging pollutants, their study is one of the priority research areas of the main bodies responsible for protecting public health and the environment, such as the World Health Organization, the Environmental Protection Agency, and the European Commission. These bodies, along with others such as the Strategic Approach to International Chemicals Management and the Organization for Economic Co-operation and Development (OECD), have collaborated in the development of policies on this emerging issue. In 2019, the European Commission introduced the European Green Deal as an integral part of its strategy to implement the 2030 Agenda and the United Nations Sustainable Development Goals. The Deal included the ambition of a toxic-free environment and the promotion of clean air, clean water, healthy soil, and biodiversity. In particular, the Biodiversity and Farm-to-Fork strategies defined in the Deal set out actions and objectives aimed at restoring a sense of coherence between environment and health policies, contributing to a more integrated approach to the "One Health" concept.¹⁸

In March 2019, the European Commission adopted the "European Union Strategic Approach on Pharmaceuticals in the Environment". Action areas include reducing waste, improving waste management, and filling knowledge gaps. In June 2019, the Council of the European Union stated the importance of accelerating concrete and ambitious actions to reduce the risk from pharmaceuticals and their residues to the environment,¹⁹ noting that the most effective measures include legislative actions.²⁰

The OECD report on Pharmaceutical Residues in Freshwater,² led the European Parliament to consider that current policy approaches to pharmaceutical waste management were insufficient to protect water quality and freshwater ecosystems.²¹ Accordingly, the European Commission encouraged additional measures to address environmental risks. Measures include proposing revisions of regulations, and pharmaceutical legislation,²² and exploring how environmental aspects can become part of medical training and professional development programs.¹⁹

The Basque Sustainable Pharmacy project started in 2019 with the ambitious aim of understanding the problem of the global presence of

medicines in the environment from the perspective of the pharmacists,⁸ integrating the "One Health" global health framework. Some of the objectives of this initiative include monitoring the presence of pharmaceuticals, analyzing their impact on the environment, developing technological solutions, and stimulating training and education. For this reason, a pilot study was developed to assess the knowledge and attitudes of students at the School of Pharmacy in Vitoria-Gasteiz, northern Spain.²³ This study revealed a lack of knowledge among Pharmacy Degree students about pharmaceuticals in the environment. However, the attitude of the pharmacy students was quite positive, since the majority of the participants considered drug pollution to be a relevant issue in general and in pharmacy practice.

The aim of the present study is to investigate the level of knowledge and attitude toward the problem of pharmaceuticals in the environment from a wider perspective, including students from 5 Schools of Pharmacy in Spain, to obtain more representative and robust results. The completion of these questionnaires on pharmaceutical pollution by Pharmacy Degree students provides updated information on the knowledge and attitude toward this topic, which will help to develop further actions related to social dissemination and educational training on this emerging topic.

2. Methods

A self-administered questionnaire, previously implemented in a recent study, was employed to evaluate the knowledge and attitudes on drug pollution of Pharmacy Degree students in Spain. This questionnaire was designed with a validated attitude scale and was approved by the Ethics Committee for Research Involving Human Subjects of the University of the Basque Country/Euskal Herriko Unibertsitatea (CEISH-UPV/EHU) (detailed information available at Domingo-Echaburu and colleagues).²³

This questionnaire was completed between October 2021 and May 2023, using a combination of indirect (email, online survey) and direct recruitment (applied in person), for all academic years of 5 of the 22 (23%) Schools of Pharmacy located in different regions of Spain. Included in this study were the School of Pharmacy of La Laguna (Tenerife-Canary Islands), the School of Pharmacy of Santiago de Compostela (Galicia), the School of Pharmacy of Seville (Andalusia), the School of Pharmacy of Valencia (Valencian Community), and the School of Pharmacy of the Basque Country (UPV/EHU).

The responses to the knowledge questions were based on a 5-point Likert-scale format from totally disagree (0) to totally agree (5) or "yes/no", while the items for the attitude and opinion questions ranged from 0 = "totally disagree" to 10 = "totally agree."

Qualitative variables were presented as frequencies and percentages. Normality tests (Kolmogorov-Smirnov) were conducted on all quantitative variables to evaluate their distribution. These were presented using the mean and SD if they follow a normal distribution, and the median and percentiles if they do not follow a normal distribution.

Appropriate statistical tests were used to examine possible relationships between the different variables in the study. For continuous variables, *t* test (or Mann-Whitney U test if normality assumptions were not met) was used, one-way ANOVA (or its non-parametric equivalent Kruskal-Wallis) was used to assess significant differences in the means of multiple groups, and the Bonferroni correction was used for post hoc comparisons. For categorical variables, the chi-squared test (or Fisher's approximation when the number of expected events per level was small) was used. For the answers to the knowledge questions, which had a large number of possible answers, the chi-square test was used, grouping the answers into 2 categories: answers with a value equal to or less than 3 and answers with a value greater than 3, in order to obtain a *p* value due to the convergence of the test.

Statistical analyses were performed using SPSS software (SPSS Statistics for Windows, Version 29.0. Armonk, NY: IBM Corp) for data analysis.

Table 1
Demographic Characteristics of Participants (N = 1614).

		Responders no. (%)						p value
		Total	La Laguna n = 405	S. Compostela n = 235	Seville n = 132	UPV/EHU n = 487	Valencia n = 355	
Gender	Male	376 (23%)	117 (29%)	66 (28%)	23 (17%)	91 (19%)	79 (22%)	.015
	Female	1206 (75%)	278 (69%)	166 (71%)	106 (80%)	385 (79%)	271 (76%)	
	Others ^a	32 (2%)	10 (2.5%)	3 (1.3%)	3 (2.3%)	11 (2.3%)	5 (1.4%)	
Academic yr	1	383 (24%)	97 (24%)	86 (37%)	2 (1.5%)	132 (27%)	66 (19%)	< .001
	2	327 (20%)	78 (19%)	51 (22%)	7 (5.3%)	107 (22%)	84 (24%)	
	3	283 (18%)	59 (15%)	47 (20%)	5 (3.8%)	78 (16%)	94 (27%)	
	4	361 (22%)	62 (15%)	49 (21%)	98 (75%)	75 (15%)	77 (22%)	
	5	256 (16%)	109 (27%)	2 (0.9%)	19 (15%)	95 (20%)	31 (8.8%)	
Other post/ graduate	Yes	100 (6%)	7 (1.7%)	7 (3.0%)	15 (11%)	32 (6.6%)	39 (11%)	< .001
Age in yrs	Mean (SD)	20.96 (3.78)	21.65 (4.53)	20.15 (2.58)	22.01 (2.52)	20.03 (2.14)	21.61 (5.07)	< .001

Abbreviation: SD, standard deviation.
^a Others: Non-binary, I prefer not to tell, No response.

Table 2
Pharmacy Students' Knowledge of Drug Pollution in 5 Schools of Pharmacy in Spain (N = 1614).

Survey question (Q) no.	Responders no. (%)		
	Yes	No	UK/NR
Q1. I know the term “contaminants of emerging concern”.	389 (24.1%)	1220 (75.6%)	5 (0.3%)
Q2. I know the term “ecopharmacovigilance”.	631 (39.1%)	978 (60.6%)	5 (0.3%)
Q5. I agree with the following statement: “At the beginning of this century, there was a very important decrease in the population of some species of vultures in Asia, as a consequence of the veterinary use of ivermectin.	168 (10.4%)	28 (1.7%)	1418 (87.9%)
Q10. I know the “Environmental Risk Assessments” (ERA) evaluation of the European Medicines Agency (EMA).	171 (10.6%)	1439 (89.2%)	4 (0.3%)
Q12. I know “SIGRE” (Spanish medicines take-back program).	901 (55.8%)	709 (43.9%)	4 (0.3%)
Q13. I know the “One Health” concept.	397 (24.6%)	1213 (75.2%)	4 (0.3%)

Abbreviation: UK/NR, unknown/no response.

A significance level of 0.05 was used for all statistical tests.

3.2. Knowledge Results

3. Results

3.1. Descriptive

A total of 1614 Pharmacy Degree students from 5 different Schools of Pharmacy in Spain completed the questionnaire. Briefly, 487 participants (30%) were studying at the School of Pharmacy of Vitoria-Gasteiz (UPV/EHU), 405 participants (25%) at the School of Pharmacy of La Laguna, 355 (22%) at the School of Pharmacy of Valencia, 235 (15%) at the School of Pharmacy of Santiago de Compostela and 132 (8%) at the School of Pharmacy of Seville. The highest response rate was obtained in Vitoria-Gasteiz (65.8%), followed by La Laguna (57.1%), Santiago de Compostela (23.8%), Valencia (9.9%) and Seville (8.3%).

Around 75% of the students were women, which is in line with the proportion of female pharmacists in Spain.²⁴ The average age of the participants was 21 years and only 6% had or were studying another degree or postgraduate academic year (38% Dietetics and Nutrition degree, 18% Nutrition, 17% Optics and Optometry). The demographic characteristics of the students are shown in Table 1.

The lack of knowledge about basic concepts related to drug pollution is high among pharmacy students, as can be seen in Table 2, 3, 4 About 75% of the students declared that they were unaware of concepts such as "emerging pollutants" (Q1) or "One Health" (Q13), with UPV/EHU students being the most unaware (86%). Furthermore, 89% of the students reported that they did not know the “Environmental Risk Assessment” (ERA)” concept (evaluation of the European Medicines Agency [EMA])(Q10). In the case of the SIGRE concept (Spanish medicines take-back program) (Q12), 33% of the students from Seville were not aware of it, compared to 44% of the average (Supplementary Table S1). Interestingly, the data obtained from these last questions (Q10, Q12, and Q13) were statistically significantly different ($p < .001$) between Schools.

Regarding the ecological disaster caused by exposure to diclofenac by some species of vultures in Asia (Q5), 88% of the students answered that they did not know the answer to this question. A total of 54% of the students totally agreed with the statement that drugs have a harmful effect on the environment (Q3); however, approximately 29% of respondents did not know that wastewater treatment plants are not able to eliminate the majority of drugs that enter through contaminated water (Q6), nor that drugs can be found in our tap water (Q7) (48%).

Table 3Pharmacy Students' Knowledge of Drug Pollution in 5 Schools of Pharmacy in Spain ($N = 1614$).

Survey Question(Q) no.	Responders no. (%)						UK/NR
	0 (Totally disagree)	1	2	3	4	5 (Totally agree)	
Q3. Drugs can have harmful effects on the environment.	4 (0.3 %)	9 (0.6 %)	51 (3.2 %)	226 (14.0 %)	441 (27.3 %)	869 (53.8 %)	14 (0.9 %)
Q4. The presence of antibiotics in the environment can contribute to the generation of antibiotic resistance.	7 (0.4 %)	18 (1.1 %)	32 (2.0 %)	153 (9.5 %)	376 (23.3 %)	922 (57.1 %)	106 (6.6 %)
Q6. Wastewater treatment plants are capable of eliminating most of the drugs that reach them.	46 (2.9 %)	97 (6.0 %)	290 (18.0 %)	456 (28.3 %)	208 (12.9 %)	42 (2.6 %)	475 (29.4 %)
Q7. Drug residues have been found in tap water. In concrete, in Spain, more than 40 different drugs have been identified.	13 (0.8 %)	33 (2.0 %)	74 (4.6 %)	283 (17.5 %)	305 (18.9 %)	126 (7.8 %)	780 (48.3 %)
Q8. Some drugs present in the environment can bioaccumulate throughout the food web.	1 (0.1 %)	3 (0.2 %)	32 (2.0 %)	237 (14.7 %)	488 (30.2 %)	578 (35.8 %)	274 (17.0 %)
Q9. Drug pollution can affect the achievement of the sustainable development goals proposed by the United Nations Organization in 2015.	4 (0.3 %)	8 (0.5 %)	35 (2.2 %)	194 (12.0 %)	463 (28.7 %)	524 (32.5 %)	386 (23.9 %)

Table 4Pharmacy Students' Knowledge of Drug Pollution in 5 Schools of Pharmacy in Spain ($N = 1614$).

Survey Question(Q) no.	Responders no. (%)					UK/NR
	A. All drugs	B. Only for human drugs	C. Only for veterinary drugs	D. Only for cytostatic drugs	E. It is not mandatory	
Q11. Currently, an Environmental Risk Assessment (ERA) is mandatory for the authorization of new medicines in Europe.	807 (50.0 %)	61 (3.8 %)	13 (0.8 %)	23 (1.4 %)	39 (2.4 %)	671 (41.6 %)

Percentile 10% Percentile 50% Percentile 90%

Regarding this last question, students from Valencia were less aware or did not answer it (34%, 14 points less than the general) ([Supplementary Table S1](#)). The results obtained from different universities showed a statistically significant difference ($p \leq .05$) for Q3, Q6, and Q7.

The data on individual knowledge for each of the Schools of Pharmacy are available as [supplementary information](#) in [Supplementary Table S1](#).

3.3. Attitudes Results

The students' mean attitudes toward drug pollution are shown in [Fig. 1](#). The evaluation of the respondents' mean attitudes toward the problem of drug pollution from all universities was 8.6 points out of 10. All means obtained from different universities showed a statistically significant difference ($p \leq .05$) except Q17 and Q21 ([Supplementary Table S2](#)).

Overall, Q16 (Acquiring knowledge about drug pollution will help me in the future as a pharmacist) had the higher score (9.0) while Q21 (Drug pollution is an important part of Pharmacy) was the lowest rated (8.1), with the lowest scores for Sevilla and Valencia (7.9 out of 10).

The highest average score for Q15 (The environmental impact of medicines is an important issue because it can negatively affect human health) was obtained by the University of Seville (9.3). Moreover, the

students from La Laguna had the highest proportion of responses of "completely agree" to Q24 (the acquisition of knowledge about drug pollution is very positive for me) ([Supplementary Fig. S6](#)).

The data on attitude for each university are available as [supplementary information](#) in [Supplementary Fig. S4](#).

3.4. Opinion Results

The students' opinion about drug pollution is shown in [Fig. 2](#). All means obtained from different universities showed a statistically significant difference ($p < .001$). In Q22 (The training received so far in the "Degree in Pharmacy" on the presence of drugs in the environment and their potential ecotoxicological effects) the average of the UPV/EHU (2.4) was the lowest whereas at Valencia School of Pharmacy (3.3) was the highest, respectively, compared to the overall average (2.8). Something similar happened with Q23 (I think that my knowledge about drug pollution–environmental impact of medicines is adequate). This is not the case for Q24 (I would like to expand my training on drug pollution–environmental impact of medicines), where the average rose significantly to 7.8, and where Valencia School of Pharmacy had the lowest average (7.2).

Approximately 54% of all students evaluated received training about pharmaceuticals in the environment to be poor, giving a score of

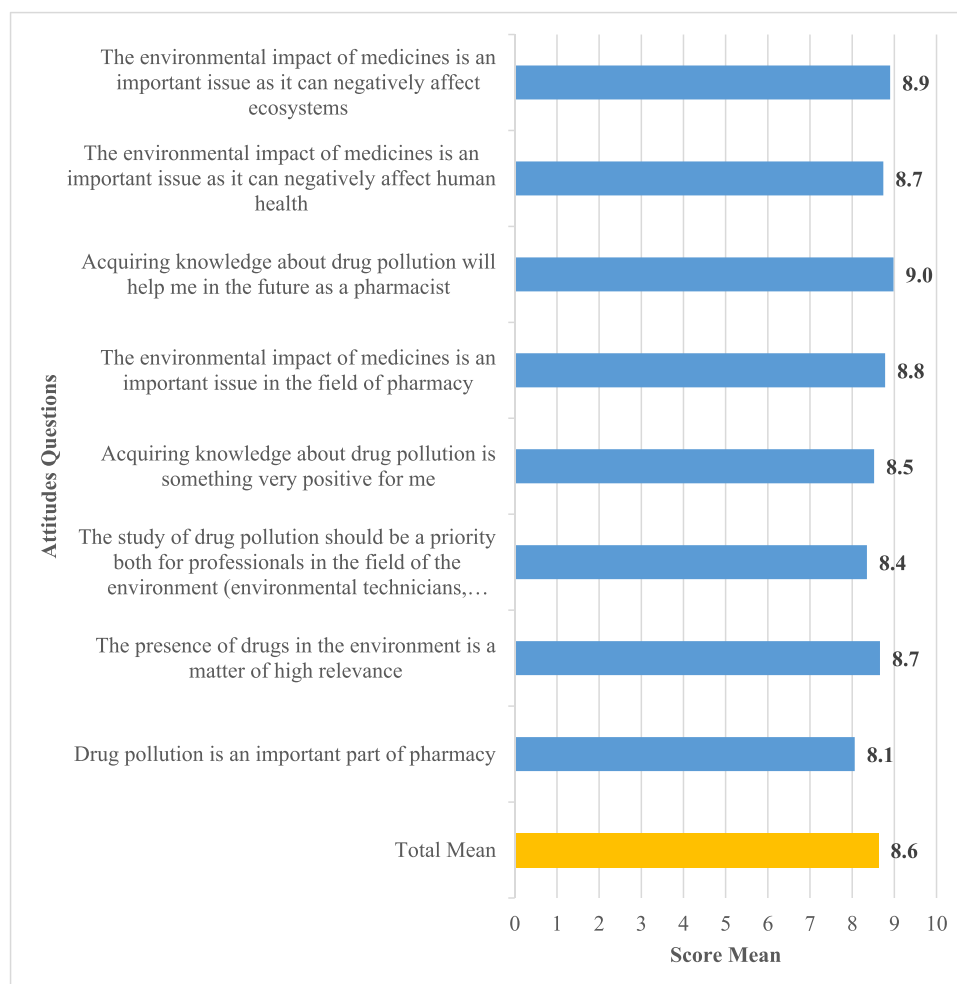


Fig. 1. Pharmacy Students' Mean Attitudes Per Question of Drug Pollution in 5 Schools of Pharmacy in Spain.

2 out of 10 or less in Q22. In concrete, 30% of participants gave a score of 0 points, and 12% a score of 2 points. The School of Pharmacy of UPV/EHU stands out with almost 40% of its students giving this score, followed by the School of Pharmacy of La Laguna with 30% (Supplementary Fig. S5).

In contrast, the students strongly agreed (8 of 10) that they would like to expand their training on drug pollution–environmental impact of medicines (Q24). More than 34% of the respondents from all the universities gave the maximum response to this question, which is the highest score for the School of Pharmacy of La Laguna with 50% of the students (Supplementary Fig. S6).

4. Discussion

The aim of the present study was to investigate the level of knowledge and attitude toward the problem of pharmaceuticals in the environment among Pharmacy Degree students from 5 Schools of Pharmacy in Spain. This study has shown that Pharmacy Degree students in Spain, surveyed in this particular research, have reported inadequate knowledge of drug pollution. A significant number of students were unfamiliar with basic concepts such as “emerging contaminants”, “One Health” and EMA ERA reports, as well as the catastrophic vulture population decline in Asia due to diclofenac. However, we acknowledge that some of the questions, such as Q4, (the presence of antibiotics in the environment contributing to antibiotic resistance) represent complex topics, where there is no “right answer” to indicate knowledge. Some participants may have some knowledge of the subject, but this is not reflected in the way the answer is given (yes/no).

Studies surveying Pharmacy Degree students about this matter are scarce. For example, according to research conducted in Ethiopia,²⁵ approximately 54% of respondents totally agreed that pharmaceuticals have a negative impact on the environment. However, 48% of the students surveyed were unaware of their presence in drinking water, and 29% were unaware of their presence in wastewater treatment plants, despite the fact that many drugs still persist after treatment.

It should be noted that the response rate varied considerably between the different universities. Response rates were much higher when a direct recruitment method was applied (Vitoria and La Laguna) than in Seville and Valencia. Regarding the basic concepts of drug pollution, 86% of the UPV/EHU students (11 points above the average) did not know them. This result may be related to the fact that this university is the one with the highest number of first-year pharmacy students surveyed ($N = 132$; 34%), which suggests that there may be a greater acquisition of knowledge in this area as one progresses through the degree. This hypothesis would be in line with the study carried out on the training of medical and pharmacy students at Swedish universities, a pioneering country in the development of the environmental impact of pharmaceutical policies of interest to other countries,²⁶ where it was reported that in the case of pharmacy training, the highest number of academic years on this subject are offered in the fourth year.²⁷

In 2001, Farmaindustria,²⁸ the National Trade Association of the Spanish-based pharmaceutical industry, in collaboration with pharmacies and distributors, launched SIGRE with the aim of complying with Law 11/1997 on Packaging and Packaging Waste.²⁹ This law required manufacturers or marketers of packaged products to manage the collection and environmental treatment of these containers. Later, the Law

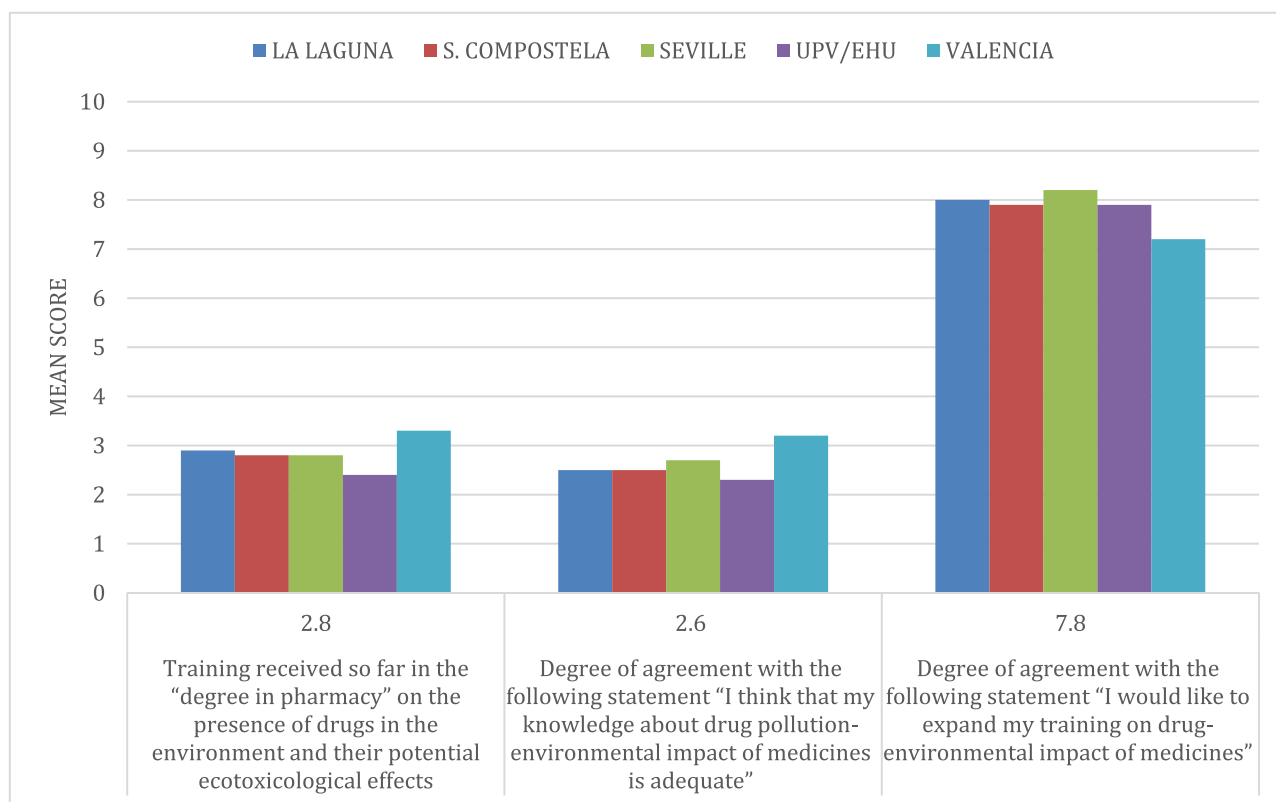


Fig. 2. Pharmacy Students' Mean Opinion Per School of Pharmacy of Drug Pollution in 5 Schools of Pharmacy in Spain.

29/2006 on Guarantees and Rational Use of Medicines and Healthcare Products³⁰ recognizes the need to create and participate in systems that ensure the collection of medication waste generated in households. According to our study, 44% of students are not aware of the "SIGRE" concept (Spanish medicines take-back program) as the appropriate system established in Spain for the collection of unused or expired medicines. We consider this percentage to be worrying, especially considering that this aspect is closely related to the community pharmacy, one of the main places where the majority of the respondents will probably carry out their professional activity. However, if we compare the data with those obtained from American university students from different programs, including Environment and Sustainability and Health and Medicine, only 24% were aware of drug take-back programs.³¹

The average value obtained by the students of these 5 Schools of Pharmacy in Spain was lower than the percentage described in the SIGRE 2022 Sustainability Report,³² where 86% of the general population includes the recycling of household medicines among their good environmental habits. Therefore, we believe that pharmacy students' knowledge on this specific topic has room for improvement.

The average recycling rate of pharmaceutical waste in Spain (86%) exceeds that of some other European countries. For example, around 62% of Portuguese and 54% of Dutch inhabitants return unused or expired medicines containers to pharmacies or other collection centers.³³ All these countries have high recycling rates for pharmaceutical waste thanks to the environmental policy of Extended Producer Responsibility, where this commitment extends to the post-consumer phase of the drug cycle.^{33,34} Although the percentages for lack of awareness of pharmaceutical waste management systems in countries such as Bangladesh (67%), Ethiopia (67%)⁹ or Lebanon (63%)³⁵ are higher than those obtained in European countries, the practices for proper disposal of household pharmaceutical waste have considerable room for improvement in all countries, regardless of income.⁹

The average attitude of Pharmacy Degree students toward gaining knowledge about pharmaceutical pollution is very positive, with a score of 8.6 out of 10. Similar results are observed in the Chinese study carried out among university students of science and technology ($n = 392$), where the mean value obtained for the question "Pharmaceutical residues in the environment could have adverse effects on the ecosystem, wildlife species and even human beings" is 4/5, whereas in our study the mean value obtained for the questions Q14 "The environmental impact of medicines is an important issue because it can negatively affect ecosystems" and Q15 "The environmental impact of medicines is an important issue because it can negatively affect human health" is 9/10.³

Interestingly, it seems that the attitudes and opinions of Pharmacy Degree students toward this subject increase during their university studies. For example, the highest average score for Q15 (The environmental impact of medicines is an important issue because it can negatively affect human health) was obtained by the University of Seville (9.3). Moreover, the students from La Laguna had the highest proportion of responses of "completely agree" to Q24 (the acquisition of knowledge about drug pollution is very positive for me). (Supplementary Fig. S6). These faculties are the ones with the highest proportion of final year students of all the universities studied, (Seville with 88% of 4th/5th year students and La Laguna with 42% of 5th year students) (Supplementary Tables S4 and S6).

In the Swedish university study mentioned above, just under half of the respondents were fairly or very interested in starting or expanding their training on the topic of pharmaceuticals in the environment. In our study, this percentage is considerably higher, around 80%. Considering that the population of the Swedish study are academic year organizers of pharmacy, medicine, or prescription programs at Swedish universities and the population of our study are students at pharmacy faculties, it may be suggested that students have a greater interest than staff teachers. Factors such as lack of time during the academic year,

lack of information about what is included in other academic years, or lack of adequate skills/knowledge about the topic, are the most commonly identified barriers to integration of this topic into university curricula.²⁷

The study's results support the necessity of enhancing teaching on sustainability issues in Schools of Pharmacy; indeed, these issues are becoming increasingly important in academia. For example, in 2023, the University of Helsinki announced the world's first professorship of Sustainable Pharmacy, which will help provide pharmacy and medicine professionals with the knowledge to change practices in the sector to make them more environmentally friendly, in line with the medical education and professional development programs promoted by the European Union.¹⁹ Incorporating aspects of drug pollution in standards for accreditation might be helpful in the future.

5. Limitations

Response rates varied largely among universities and academic years, so not all faculties or academic years were equally represented, curtailing the generalizability of our results. Another important aspect is that the results indicate self-reported knowledge rather than actual knowledge. Moreover, some of the questions represent complex topics, where there might be no "right answer" indicating knowledge. In addition, as some knowledge questions are (yes/no) answers, students may be somehow familiar with the term but not fully know what it means.

6. Conclusions

Most of the Pharmacy Degree students surveyed reported not being aware of key concepts related to drug pollution, although they knew that medicines in the environment may exert a negative impact on it.

Moreover, students had a very good attitude toward acquiring knowledge related to this area, especially judging training about pharmaceuticals in the environment during a Pharmacy Degree is very scarce.

Future steps, based on the results obtained, should be aimed at promoting education and research on pharmaceuticals in the environment, as well as the dissemination and transfer of the acquired knowledge to the general public. How this topic might be included as a standard for accreditation might be helpful in the future too.

Ethical Approval

This study was approved by the Ethics Committee for Research involving Human Subjects of the University of the Basque Country/Euskal Herriko Unibertsitatea (CEISH-UPV/EHU). The informed consent to participate is not applicable.

Author Contributions

Conception and design: All authors. **Material preparation:** Z.A., U.L., G.O., S.D.-E. **Data collection:** Z.A., A.R., S.D.-E., C.E., J.P., C.A.-L. **Data analysis:** Z.A., J.A. The first draft of the manuscript was written by Z. A. and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.ajpe.2024.101254](https://doi.org/10.1016/j.ajpe.2024.101254).

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