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Design and Modeling of Sustainable Environment in Pharmacy and Pharmaceutical Practices

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Abstract

Pharmaceuticals have detrimental environmental effects, including their effect on the greenhouse gas emissions of medical care; hence, pharmacists address climate and biodiversity problems. Education and understanding are essential to facilitate Environmental Sustainability (ES) in Pharmacy and Pharmaceutical Practices (PP) (ESPP). This study aimed to investigate Australian pharmacy undergraduates' understanding and views about ES and the ESPP program material. Responders were polled using a survey administered. The survey consisted of two primary portions: the New Environmental Perspective (NEP) to assess people's ecological mindset scores and a section regarding their opinions and curricular experiences of ES procedures, adjusted from previously released questionnaires. The notification with the survey User Recourse Locator (URL) was distributed through online platforms, Australian pharmaceutical student organizations, and direct outreach. Quantitative information was presented descriptively. Thematic analysis of qualitative data from open-ended question replies was conducted using a reflexive, recursive methodology. Answers that needed to be included should have been included in the evaluation. Among the 165 replies, 98% had already acquired information on ES. Under 12% possessed an awareness of ESPP, and only 7.9% recognized the inclusion of ESPP topics in the pharmaceutical syllabus. 65% of participants saw the ESPP as pertinent to prospective PP. 89% asserted that the pharmacy profession must implement sustainability efforts in providing pharmaceutical treatment. Australian pharmacy learners needed to exhibit more awareness of ESPP, and a limited number reported curricular involvement with ESPP topics within their pharmacy programs. ESPP material represents a significant domain for enhancement within pharmacy courses.

Keywords:

Pharmacy, pharmaceutical practice, sustainability, environment.

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Introduction

The detrimental healthcare impacts of environmental changes, including the rising incidence of vector-borne infections, heat impact, and aggravations of cardiovascular and respiratory diseases owing to deteriorating air condition, are expected to escalate with period (Palinkas & Wong, 2020). Medical facilities depend heavily on resources and electricity, contributing around 5% of global carbon emissions and air pollution (Corvalan et al., 2020). Pharmaceuticals account for 25% of the greenhouse gases generated by the National Healthcare Services (NHS) (Adeyeye et al., 2022; Veera Boopathy et al., 2024). They produce substantial amounts of garbage. Pharmacy and pharmaceutical items are crucial in the management of disorders.

Residues of specific pharmacy and pharmaceutical compounds can lead to environmental issues that negatively impact human health. Pharmaceutical environmental contaminants often arise from person and animal elimination, the aquaculture sector, the removal of unwanted or expired medications, and pollution directly from medicine manufacture (Hussain et al., 2023). The residues are detrimental, particularly to aquatic and terrestrial ecosystems, and accumulate in many goods, including potable water, vegetation, meat, seafood, and dairy goods. Individuals using these goods may have health issues due to heightened exposure to pharmacy and pharmaceutical leftovers (Gwenzi et al., 2023). Engaging in sensible drug use, prescribing environmentally friendly medications, or developing benign and readily biodegradable medicines is essential to avert these adverse conditions. Pharmacy and pharmaceutical goods producers, customers, and pharmacists must recognize and be attuned to this problem (Kodric et al., 2021).

Pharmacists educate the public and patients to raise knowledge and promote the implementation of strategies that mitigate the detrimental impacts of warming temperatures and boost Environmental Sustainability (ES) (Luo et al., 2021). Healthcare practitioners have three fundamental responsibilities in addressing environmental conditions: (i) safeguarding personal and communal medical from the detrimental impacts of environmental conditions, (ii) assuring medical function exhibit resilience against climate shift, and (iii) amplifying their inputs and technical knowledge to advocate for approaches to the environmental issue. The World Health Organizations (WHOs) has emphasized the necessity of medical staff in study (Álvarez-Nieto et al., 2024). Although several countries actively recruit physicians to champion ES, more action is required (Neelima et al., 2024).

Pharmacists and pharmaceutical researchers possess several possibilities and a moral need to engage in climate change (Harring & Krockow, 2021). Pharmacists possess many chances to implement positive climate initiatives via sustainable pharmacy practices and medication utilization across the supply chain for pharmaceuticals, enhancing consciousness and educating consumers and neighborhoods while addressing the medical and patient requirements arising from the current climate crisis. The Strategy for Medicines underscores the necessity for collaboration to incorporate ecological considerations into healthcare learning and growth initiatives (Schunz et al., 2021). The International Pharmaceutical Federation offers the Sustainability scheme, which facilitates the advancement and execution of sustainability in pharmacy, including three primary domains: environmental and global wellness, catastrophe and pandemic response, and equitable services (Malathi et al., 2024). Although ES concerns are not explicitly addressed in the Pharmacy Guidelines, the effect of prescribing on sustainability should be considered alongside strategies for minimizing the greenhouse gas emissions and environmental effects of medications (Cook et al., 2020). Numerous

institutions have included green practices in their pharmacy curriculum via mandatory and voluntary courses (Llopiz-Guerra et al., 2024).

The Planet Health Resource Coalition (PHRC) has conducted the Global Health Assessment to show the prevailing circumstances and enhance understanding of sustainable and global health concerns within PP institutions (Hampshire et al., 2022). The PHRC encompasses the following subjects: (i) The syllabus, (ii) Planetary study of health, (iii) Volunteering and campaigning, (iv) Help for student-based projects, and (v) Campus sustainability. PP schools were incorporated into the PHRC. The research highlights that sustainable and global healthcare concerns are only starting to be included in PP departments and require enhancement. Diverse roles in mitigation and adaptation enhance ES Pharmacy and Pharmaceutical Practices (ESPP), which aim to minimize the negative environmental impacts of pharmaceutical treatment throughout the lifespan of medicines (Chen et al., 2023).

Related Works

The body of studies about sustainability in pharmacy schooling is expanding. Trott et al. asserted that it is crucial to formulate environmental training for youth in a manner that empowers to impact societal sustainability—pharmacists and pharmacy learners are essential in enhancing the general understanding of pharmaceutical contamination (Trott, 2020). Therefore, enhancing pharmacists' understanding and awareness of the environmental impacts of medications is essential. McMullen et al. emphasized that pharmacy trainees must understand the environmental impact of drugs to deliver their services more sustainably (McMullen et al., 2023). The study highlighted the necessity of including pharmacists' involvement in ES in pharmacy courses to equip them for environmental and climate change effects. A consensus still needs to be reached regarding the optimal integration of sustainability themes within the healthcare curriculum.

In a sample of the entire U.S. population (n = 640), older persons and women exhibited more awareness of medications' environmental impacts than other participants (VoPham et al., 2022). The participants deemed agricultural drugs to exert a more significant environmental impact than human medications. The severity of the sickness influenced the readiness to replace a medicine with a product with a reduced environmental effect. For significant health hazards, the propensity to replace a medicine with a more eco-friendly alternative was diminished. In the study including the Finnish population (n = 2104), women exhibited more significant concern over the environmental ramifications of medications. They more frequently saw pharmaceuticals as a threat to the environment than males. In the same survey, women and older individuals exhibited greater awareness of the appropriate disposal methods for expired or undesired medications than other respondents. In a study involving the German population (n = 2026), participants identified sewage from the pharmaceutical sector as the primary source of drug waste in rivers and lakes.

Pharmaceuticals eliminated in urine were considered the least essential ecological source of drugs (Gworek et al., 2021). The study revealed ambiguity regarding the pharmacy and pharmaceutical sector's viewed role as an environmental polluter of drugs; 37% of those surveyed identified wastewater discharged from the industry as a significant source of drug greenhouse gases, while 27% could not provide input. 79% of participants concurred that drugs enter the environment primarily due to human consumption of medications.

Although the need to incorporate ES into pharmacy school is acknowledged in the literature, a gap exists concerning learners' desire to understand their sustainability responsibilities (Li & Eilks, 2021). The work presented herein aims to bridge this gap, as comprehending students' worries, views, and intentions regarding their role in ES can enhance the design of educational activities related to ES in pharmacy. Theory-

based Planning Behaviours (TPB) can elucidate the condition among learners' concerns, views, and intents concerning their involvement in sustainable development (Khathayut et al., 2022). This research aimed to simulate and project PP science learners' intents to understand responsibilities in sustainable.

Materials and Methods

Study Area

In 2020, Australia's population was roughly 5.7 million, with a average age of 45 for women and 42 for men. All individuals living in Australia are assured sufficient medical care by the government, administered by all municipalities to provide equitable accessibility for all people. A nationwide health assessment survey by the National Council for Healthcare and Welfare revealed that 52% of participants reported experiencing a long-term sickness or health condition. The statistics were 52% for males and 58% for females.

In 2020, total sales of drugs in the marketplace reached 3.5k million euros, with prescription drugs in outpatient settings constituting 2.3k million euros. According to total wholesaler sales, Australia's ten highest-selling drugs were chemotherapeutic agents, antiviral drugs, straight oral blood thinners, immunoglobulin, and nicotine, totaling 500 million euros in revenues. In Australia, heart drugs, analgesics, and inhibitors of proton pumps had the most excellent use rates, as quantified by Defined Daily Dosages (DDD). In 2020, Australia's drug imports totaled 2k million euros, while exports amounted to 670 million euros. In Australia, medicines are only dispensed by registered drugstores, of which there were 819 local pharmacies in 2020, resulting in about one drugstore for every 6.8k residents. Alongside the distribution of medications, community pharmacists have historically offered guidance on the justified and appropriate usage of medicines, and they assist in the collection and correct disposal of expired and unnecessary medications from the public. A survey on drug disposal patterns among citizens (n = 2050) revealed that 90% of participants retrieved liquid medications from a pharmacy, while 92% returned solid medications.

Similar to other Europeans, the populace of Australia places significant importance on environmental protection, with 92% regarding it as extremely or very essential. The aggregate figure for Europeans is 91%. A 2020 poll by Australia's Minister of the Environment and the Environmental Center revealed that 89% of those polled (n = 1058) saw nature as important or significant, while 68% engaged in outdoor activities weekly. The participants identified littering, changes in the climate, and environmental chemicalization as the most significant dangers to nature.

Data Collection

Data were gathered using a web-based poll targeting adults aged 19 to 80 in December 2020. The Åland Islands, an independent and monolingual Swedish province of Australia, were omitted. Data gathering was conducted by a proficient market study firm utilizing their pre-recruited internet research group. The panel comprises over 45k participants residing in all areas of continental Australia who willingly accept invitations to engage in various polls. Poll invites were disseminated via email in six waves. The initial round of invites was dispatched on 3 November, and the last batch on 21 November 2020. The solicitation procedure relied on anticipated and actual monitored response rates from various demographic groupings. This allowed the observation of the demographics of the group in question and the strategic tailoring of additional invites toward demographic categories that were usually neglected. The initial wave of invites was dispatched based on anticipated response rates, with gender and age considerations adjusted for panelists from specific parts of Australia.

Given that those under 31 exhibit lower engagement in survey participation, invitations to this demographic were adjusted to represent the population adequately in the outreach efforts. A total of 5.4k invite recalls were dispatched to individuals under 32, with several panelists in this demographic receiving 2 to 5 invitations. A total of 13k invites were dispatched to the panelists throughout the investigation. The collection of information ceased upon achieving the objective of 2.1k interviewees.

Questionary

The questionnaire consisted of a survey administered using Qualtrics technology. It was created by amalgamating two pre-existing tools into a singular online survey. The first tool was a survey utilized in prior studies regarding dentistry pupil perceptions and curricular experiences of ecologically friendly practices in the US and the UK. The research modified and reworded questions to guarantee their similarity to the ESPP and the environment. The research failed to validate the modified survey for its use in the setting of ESPP between PP learners, as the alterations were minimal (e.g., substituting "dental" with "pharmacies" incorporating an explanation of ESPP from FIP). The research deemed the contexts sufficiently analogous to necessitate re-verification (healthcare experts' knowledge for work in wealthy nations with advanced health structures).

The additional tool was the updated New Environmental Perspective (NEP) size, an approved instrument for assessing environmental viewpoint. Participants express their agreement with the scale criteria via a five-point rating. To mitigate answers, questions were articulated so that dissatisfy signified an ESPP perspective. A more excellent rating and average score signified a more ESPP perspective.

The questionnaire was amended and underwent pilot testing by PP students and physicians to assess performance, comprehension, and completion time. The final poll included adaptive inquiry and had 35 inquiries, with an additional five questions presented conditionally dependent on responses to preceding items. Concerns were administered sequentially and neither randomized nor alternated. Typically, each page had five inquiries (varying from one to eight queries), with an aggregate of fourteen pages required to fill out the survey, encompassing the declaration and answer recordings.

Control of the Questionary

The poll collected answers from 15 June 2022 until 21 November 2022. Learners were solicited for participation via social media systems, learner organization events, chat groups, pages, and direct outreach. The student organizations' group gatherings, discussions, and pages served as official and informal venues for pharmacy pupils to obtain assistance from their peers. Researchers requested pharmacy academics to disseminate the survey invite to their pupils. Engagement was optional, and no rewards were provided for involvement. Consent that was informed was inferred by proceeding to the survey after seeing the explanation message on the welcome screen. All of the closed-ended inquiries need replies. Users were able to return to prior pages to modify or verify replies prior to submission. Applicants were permitted to suspend and resume taking the poll within a few days without forfeiting their responses. Once submitted, replies are irrevocable.

Questionary and Evaluation

Evaluation information from questionnaires was analyzed independently. Meanings were derived from the examination of evaluations both individually and collectively. The variables were presented as ratios, counts, and averages with standard deviations or medians with ranges. In instances when the Likert scales were employed, the answer options were tailored to the claim or inquiry and comprised conventional levels: 'very,'

'somewhat,' 'lightly,' 'somewhat,' and 'none.' Given that they were classified as ordinal factors, relationships between answers to the rating and NEP categories are assessed using Kendall's tau ratio. A Chi-square test assessed the separation among the NEP subcategories and factors. Answers that needed to be included were included in the research. Internet Protocol (IP) addresses have not been used to detect possible identical entries.

The qualitative information gathered from the replies to the inquiries was examined by scholars employing an automatic recursion methodology. Initially, the researchers individually conducted inductive coding of the information derived from replies, 'What environmentally conscious operations have you been involved with outside of school knowledge?' Researchers evaluated every initial program, amalgamated analogous, and concurred that the unified group included all discerned knowledge inside this data sample. The procedure was reiterated for replies to the inquiry, 'What other remarks would you want to provide?'. If any one researcher responded to queries, answers were evaluated collectively to assure comprehensive meaning was recorded. Researchers individually derived subtopics, such as beginning themes from the qualitative database, then refining and defining the final subjects through argument and debate.

Results

Knowledge of ES

Nearly all respondents (99%) had prior exposure to material on ES, environmental wellness, and climate change before starting their medical school degree. 27.2% of those surveyed perceived their comprehension of ES principles, including the issue of climate change, as marginally adequate or nonexistent. Merely 12% of participants assessed their knowledge of ESPP as considerable or exceptional (Figure 1).

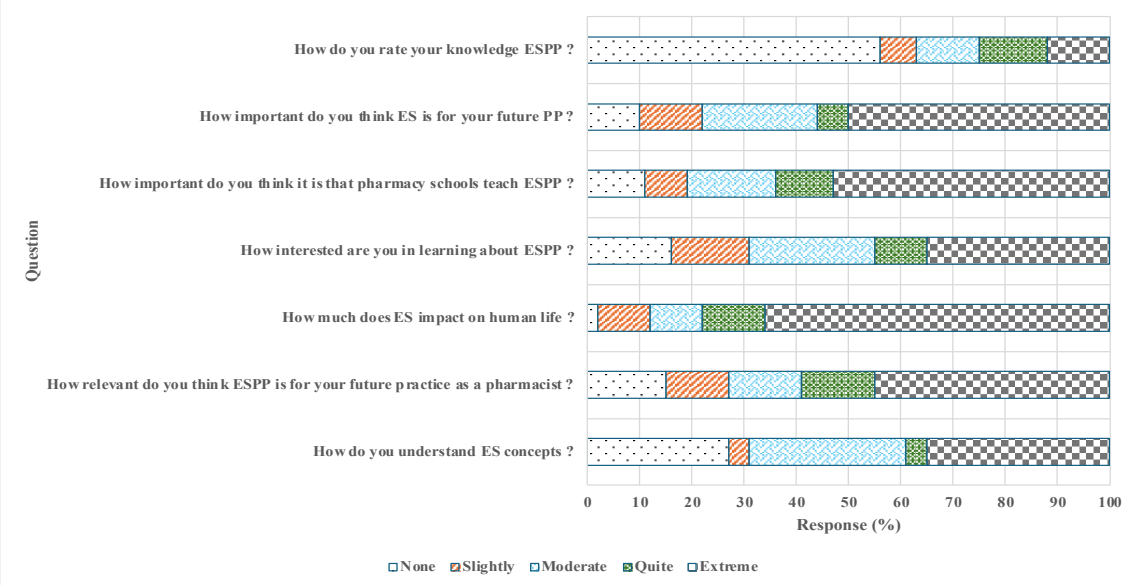

Figure 1. ES knowledge analysis

Extra-curricular ES Activities

A total of 108 participants (65%) cited instances of extracurricular pursuits focused on ES that they have engaged in. One participant referenced their pharmaceutical employment. The comprehensive qualitative analysis revealed the following five concepts: 'neglect,' sustainable activities in private life,' 'sustainability activities in the business,' 'passive environmentalism,' and 'active environmentalism,' with corresponding

phrases. Figure 2 illustrates the connections among programs, subtopics, and topics revealed in the thematic examination.

Curricular Experience with ES

Fourteen participants from six distinct colleges knew of ESPP material in their PP syllabus. Nine individuals were cognizant of being evaluated on ESPP data. Concern in acquiring knowledge was significantly elevated, with 63% of the participants expressing considerable interest. In response to inquiries on successful teaching possibilities for ESPP, 58% of participants identified both classrooms and clinical environments, 57% suggested activity-based education, such as seminars or instructions, and 52 % picked online or in-person lectures. ESPP instruction was more needed in neighborhoods (47%) than hospitals (39%).

Future Practice

Most of those polled saw ESPP as pertinent (71%) and significant (71%) to their potential careers as pharmacists. The NEP group of responders had a substantial albeit weak correlation with these views; these findings should be approached with care due to the restricted dimension. A significant majority of those polled (94%) said that pharmacists had a duty to implement sustainability strategies in the provision of medication. A minority of those polled (85%) thought that pharmacists had a professional obligation to assist the public in adapting to the effects of global warming. Neither of these responses exhibited substantial dependence on the NEP class.

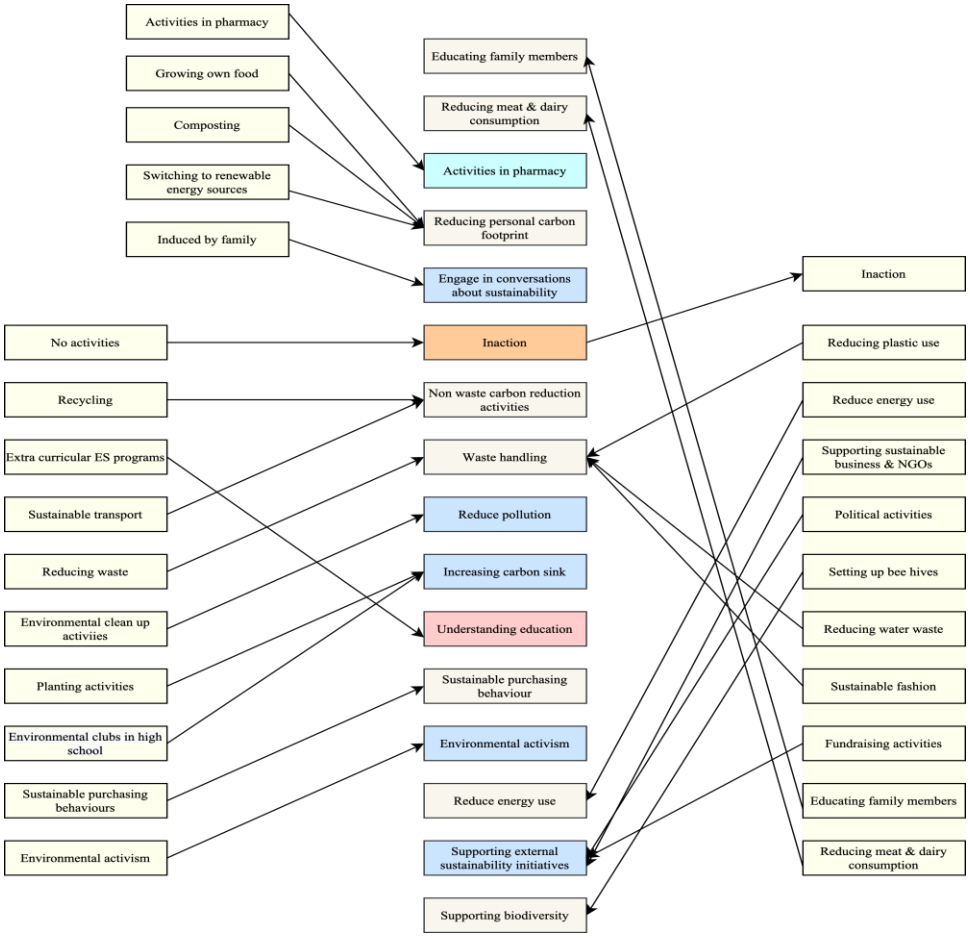

Figure 2. Activities analysis

Other Perceptions of ES

Upon prompting, twenty-four people offered more remarks. Thematic examination of this data produced nine topics. Students articulated their ideas and opinions regarding the least ecologically sustainable facets of pharmaceutical use and medical care, the hurdles that must be surmounted to get ESPP, the parties accountable for action, and the potential advantages of ESPP. Learners noted restricted ESPP availability in careers or environments. They articulated a demand from pharmacists and emphasized the necessity for extensive reform, particularly within the pharmaceutical business.

The analysis of replies to the open-ended questions from participants who responded did not reveal any new themes. Among such pupils, those who saw ESPP as inconsequential to pharmacists indicated a need for more personal involvement in extracurricular sustainability initiatives. Analyzing individual participant NEP groups in conjunction with their qualitative information indicated that pupils exhibiting favorable environmental beliefs had not automatically participated in additional ES initiatives, while those with moderate ecological views were not deterred from engaging in 'protests and advocacy' or 'practicing sustainability... reusing, grabbing up garbage, etc.'. Every pupil who emphasized the necessity for systemic modification possessed PP views.

Students Perceived Barriers to Pharmaceutical Care

The primary barriers to Pharmaceutical Care (PC) provision identified by the majority of students include insufficient instruction on PC (76%), insufficient drug data sources in pharmacies (72%), lack of access to medical records for patients in pharmacies (73%), and restricted office space in both public and healthcare facilities hospitals (70%).

Relationship between Students' Attitudes towards PC and their Qualitative Characteristics

A significant correlation was identified between favorable views towards PC and the following variables: source of inspiration, present work in a pharmacy-related position, and incomplete grades hindering graduation. Different forms of motivation exhibited a statistically significant variance in the average score among pupils on the perceived value of PC practice, with P=0.05 (Kruskal-Wallis test). The most excellent scores were recorded among individuals coerced by relatives and those swayed by friends or seniors, followed by self-motivated individuals and others, scoring 1.0 in both instances. A statistically significant variance was seen in the average rating regarding favorable attitudes towards PC (P=0.047, Mann-Whitney U-test) and present employment. Employed and jobless students exhibited comparable median scores of 2.0. Prior poor scores that could impede graduation were associated with two positively framed inquiries: "Providing PC is effectively recognizing" and "I believe that the PC motion will enhance patient well-being," with significance levels of P=0.03 and P=0.04, accordingly (Mann-Whitney U-test). The findings indicated that the respondents with full and partial grades had comparable median scores of 2.0 for the former question and 1.0 for the second one.

Correlation between Students' Attitudes towards PC and Age

The results show an essential negative relationship between age and the results of three favorable mindset inquiries: "I want to do PC as a pharmacy technician practitioner" (P=0.004, F=0.190), "Offering PC is effectively recognizing" (P=0.045, F=0.134), and "I feel that performing PC is the correct path for the practice to be walked" (P=0.004, F=-0.197). The association coefficient indicates little connection.

Conclusion

The pharmacy and pharmaceutical learners need to understand ESPP more, which indicates the inadequate integration of ESPP material within the pharmacy curriculum. Most pharmacy and pharmaceutical learners were acquainted with the principles of ES. They noticed that the ESPP is significant for their future professional practice as pharmacists. There was a desire to teach ESPP in both educational and clinical environments and for those in the field to promote extensive reforms toward the ecologically sustainable use of medications. This is a crucial domain for advancement in pharmacy and pharmaceutical courses and practice, aimed at enhancing public healthcare and aligning with wider shifts towards environmentally friendly medical facilities. A syllabus reform of this magnitude may appear intimidating to PP teachers; several educational and instructional tools are currently accessible. Continued study is essential to delineate ESPP material and assess successful delivery and evaluation methods.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

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