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Postgraduate Pharmacy Education: A Scoping Review of Curricula, Competency Development, and Assessment Practices in MSc and PhD Programs

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Abstract

This study seeks to systematically examine and evaluate the existing landscape of postgraduate pharmacy education to: a) identify current evidence, best practices, challenges, recommendations, and potential solutions; and b) construct a framework to enhance the effectiveness of postgraduate pharmacy programs. A scoping review was performed in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). Multiple electronic databases were searched, including PubMed, Scopus, EMBASE, ProQuest, Web of Science, and Google Scholar, covering publications from January 2011 to September 2023. Data extraction and charting followed the Arksey and O'Malley framework, utilizing a pre-structured data collection instrument. Studies were then synthesized and categorized according to shared themes.

From 5542 identified articles, 36 met inclusion criteria, focusing on postgraduate pharmacy education (PhD and MSc). These were grouped under three major themes: 1) courses and curriculum, 2) training and skills development, and 3) assessment and mentorship strategies. Research methods reported included descriptive analyses, surveys, questionnaires, trials, and focus groups/interviews. The findings highlighted the importance of competency-based curricula with continuous evaluation, structured career planning, and varied course offerings. Core competencies identified comprised soft skills, communication, research abilities, leadership and management, and critical thinking. Comprehensive evaluation techniques and peer review approaches were also emphasized. Key challenges included balancing academic objectives with practical experience, training limitations, scarce resources, time restrictions, and faculty workload. Evidence-based recommendations for enhancing postgraduate pharmacy education include practice-oriented courses, tailored and comprehensive assessments, emphasis on real-world competencies, advanced teaching strategies, and mentorship programs. The proposed framework offers guidance for holistic program improvement across the three identified themes.

Keywords: Postgraduate, Pharmacy, Education, Curriculum, Courses, Skills

Introduction

Pharmacy is a rapidly evolving scientific field, with an increasing number of students pursuing postgraduate studies [1]. Postgraduate education plays a critical role in shaping advanced pharmacy practice, bridging gaps in knowledge, and improving patient care and population health outcomes. Programs must deliver teaching across a wide array of specialized domains, including professional education, drug discovery, medicinal chemistry, pharmaceutics, biotechnology, biochemistry, pharmacogenetics, pharmacokinetics, pharmacognosy, pharmacology, pharmacotherapy, pharmacoepidemiology, pharmacoeconomics, and pharmacoinformatics. Additionally, postgraduate programs should enhance healthcare systems, pharmacy legislation and ethics, and proficiency in advanced analytical techniques [2, 3], all contributing to patient safety and population health.

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Postgraduate pharmacy education faces multiple challenges: an oversupply of graduates in traditional fields versus emerging job opportunities, curricula misaligned with professional practice requirements, reliance on outdated teaching methods, and the need to keep pace with technological advancements and global practice standards [4–6]. Particularly in low- and middle-income countries, gaps exist in educational quality, systemic support, and practice preparedness. Teaching approaches vary across institutions [7–10], and it remains unclear whether current programs effectively meet student needs while aligning with industry and healthcare demands [3]. Institutions must continuously assess and improve curricula to satisfy graduate expectations and employer requirements [4].

Currently, no universal guidance exists for universities to navigate the evolving challenges of postgraduate pharmacy education. Accreditation processes largely focus on undergraduate programs, neglecting postgraduate-specific issues. Moreover, global differences in educational needs further complicate standardization. This raises the research question: what insights, perspectives, challenges, and recommendations can inform the optimization of postgraduate (PhD and MSc) pharmacy programs worldwide? Addressing this question requires a scoping review to systematically map existing evidence and provide a comprehensive understanding of the state of postgraduate pharmacy education. Our objectives are: a) to identify insights, challenges, and recommendations that can help programs address gaps and enhance curricula and teaching methods; and b) to develop a framework for optimizing postgraduate pharmacy programs.

Materials and Methods

Study design

We performed a scoping review to map the existing literature and identify a framework for enhancing postgraduate pharmacy education programs. Scoping reviews are suitable for broad research questions and are commonly used to highlight gaps in current evidence [11]. The review adhered to the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews), which includes 22 reporting items [12].

The study protocol was prepared following the PRISMA-P (Preferred Reporting Items for Systematic Reviews and Meta-analysis Protocols) checklist [13].

Inclusion and exclusion criteria

Studies were considered for inclusion if they:

i) were published in peer-reviewed journals;

ii) focused primarily on curriculum design and educational development within MSc and PhD pharmacy programs;

iii) addressed topics such as competencies, assessment approaches, or course content;

iv) were published in English between January 2011 and September 2023;

v) used qualitative, quantitative, or mixed-methods designs to examine aspects of postgraduate pharmacy education.

Studies were excluded if they:

i) focused on PharmD, public health, diploma, or practice-oriented master programs without a research/thesis component;

ii) addressed research initiatives unrelated to postgraduate programs;

iii) involved dual-degree programs such as PharmD/MPH due to their interdisciplinary focus;

iv) focused on genetic counseling, which does not directly pertain to research-based pharmacy education;

v) were non-pharmacy related;

vi) examined university infrastructure rather than curriculum content; or

vii) were commentaries or review articles, to emphasize primary research findings.

Information sources and search strategy

We searched PubMed, EMBASE, Scopus, ProQuest, Web of Science, and Google Scholar for relevant studies published from January 2011 to September 2023. Keywords included “postgraduate,” “higher education,” “graduate,” “PhD,” “MSc,” “masters,” “education,” “curriculum,” “courses,” “syllabus,” “skills,” “competencies,” “assessment,” “evaluation,” “pharmacy,” and “pharmaceutical sciences.” Searches were limited to titles and abstracts and restricted to English-language publications.

Three reviewers independently screened titles and abstracts to determine eligibility, resolving discrepancies through discussion. Targeted journals were also examined, including American Journal of Pharmaceutical Education, Journal of Medical Education and Curricular Development, Currents in Pharmacy Teaching and Learning, Pharmacy Education, European Journal of Education, Journal of Pharmacy Practice and Research, and Health Education Journal. Duplicate

records, title/abstract screening, and full-text assessments were performed using Rayyan software [14].

Study selection and data extraction

Three reviewers independently assessed full-text articles and confirmed their inclusion. A standardized Excel-based data extraction form was used to record key information, including author, year, study objectives, focus, country, identified challenges, recommendations, and conclusions. Any disagreements were resolved through discussion.

Data charting and synthesis followed the framework of Arksey and O'Malley [11]. Studies were categorized according to three overarching themes: i) courses, curriculum, and syllabus; ii) training, competencies, and skill development; iii) assessment, evaluation, and mentorship strategies, as shown in **Table 1**.

Table 1. Operational definitions of the three core themes used in this review.

Theme	Definition
Courses, curriculum, and syllabus	Overall, the reviewed studies address one or more of the following concepts in education: a) Courses refer to distinct modules within a degree program that target particular domains of knowledge and skills b) Curriculum denotes the complete set of studies needed to obtain a given degree, including all courses, educational activities, and evaluation components c) Syllabus represents a comprehensive outline for an individual course, detailing the intended learning outcomes, key topics, evaluation methods, and additional relevant details
Training, competencies, and skills development	Overall, the reviewed studies address one or more of the following concepts: a) Training involves organized educational activities delivered via diverse formal and informal programs to acquire the essential knowledge, skills, and attitudes for effective professional practice b) Competencies describe observable, demonstrable, and assessable capabilities or skills needed to execute specific tasks and integrate knowledge in practical and real-life scenarios c) Skills development refers to the ongoing process of obtaining and improving practical abilities through different educational approaches required for proficient professional practice and related responsibilities
Assessment, evaluation, and mentorship methods	Studies that examine the organized procedures, diverse techniques, various instruments, and assessment approaches employed to gauge students' knowledge, skills, competencies, attitudes, and overall progress during the program

Development of the conceptual model

To formulate a comprehensive framework for designing and enhancing postgraduate pharmacy programs (MSc/PhD), we conducted an extensive review of the literature, examining reported challenges, suggested recommendations, influential factors, and successfulinterventions. The Arksey and O'Malley framework was applied for data extraction and synthesis. The model development proceeded through the following steps:

1. *Extraction of core themes:*

Analysis of the literature highlighted three primary domains essential for structuring postgraduate pharmacy education:

- Program structure, curriculum, and course content
- Development of competencies and practical skills
- Approaches to assessment, evaluation, and mentorship

2. *Framework development:*

A conceptual model was created around these domains, incorporating the following elements:

- Structured curriculum planning, covering both mandatory and elective components
- Integration of competency-based design principles
- Alignment of training and skill-building with student needs, program goals, and workforce expectations
- Utilization of varied assessment and evaluation methods to monitor program effectiveness, student learning outcomes, and career readiness
- Incorporation of successful strategies and lessons from international experiences

3. *Enhancement and expansion:*

To ensure the model's robustness, additional elements and emerging trends were incorporated based on study team consensus. For example, within the "program structure and curriculum" domain, components such as needs assessment, periodic evaluation, and iterative program refinement were included to promote

sustainability. Emerging technologies, including artificial intelligence, were also considered for enhancing assessment, evaluation, and mentorship practices, drawing from evidence reported in the reviewed studies. By combining literature evidence and practical examples, this approach resulted in a detailed conceptual framework designed to guide the development, evaluation, and continual improvement of postgraduate pharmacy programs.

Results and Discussion

Literature identification:

Following duplicate removal, 5542 records were retrieved from the databases **(Figure 1)**. After title and abstract screening, 5461 articles were excluded according to the pre-established criteria, leaving 81 full-text articles for detailed assessment.

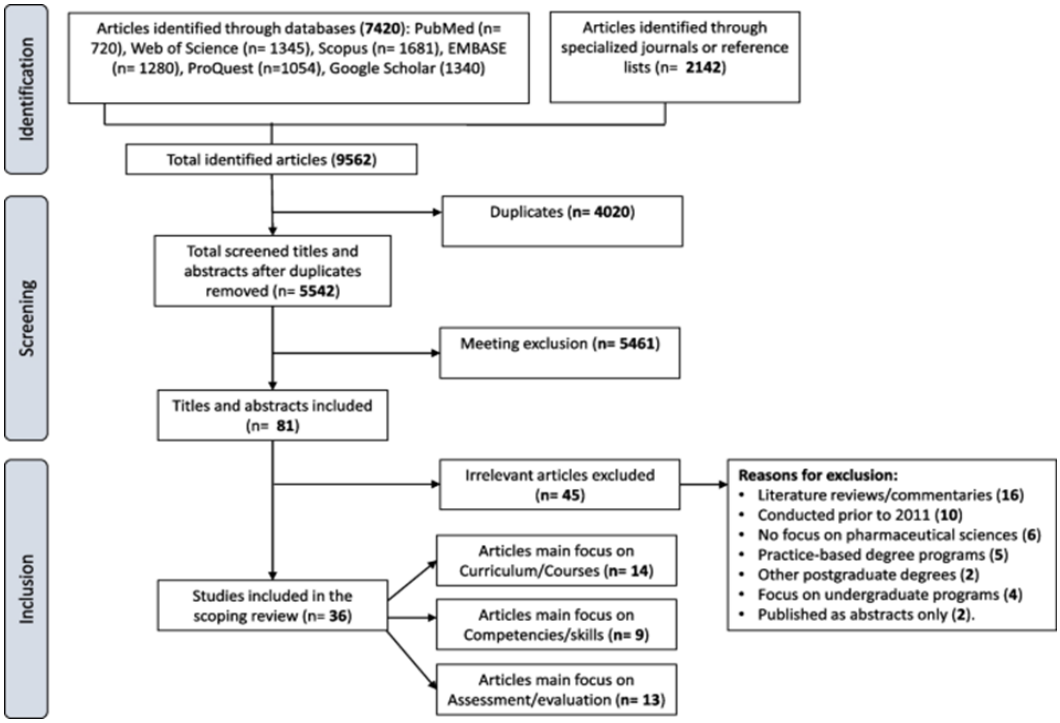


Figure 1. PRISMA flowchart illustrating study selection.

Characteristics of included studies

Studies were organized into three overarching themes, as defined in **Table 1**. **Table 2** presents detailed study characteristics, including authors, publication year, objectives, geographical location, study design, and main findings. Among the included studies, 14 addressed curriculum and course-related issues, 9 focused on competency and skills development, and 13 explored assessment, evaluation, and mentorship approaches **(Figure 2)**. The studies employed quantitative, qualitative, and mixed-method designs **(Figure 2)**.

Table 2. Summary of study characteristics and results by thematic area.

Authors	Year	Journal	Focus	Objective(s)	Country	Design	Results/conclusion
Theme 1: Courses, Curriculum, and Syllabus							
a. Courses							
Medina M, *et al*. [15]	2015	Curr Pharm Teach Learn	PhD	To assess the number and type of partnerships, the content contributed by mentors, and the current career outcomes of graduates from the Preparing Future Faculty (PFF) course	Oklahoma, USA	Descriptive	The majority of PFF graduates obtained faculty positions. The PFF course was regarded as a sustainable and beneficial offering for students aiming for academic careers

Freitas M, *et al*. [16]	2016	Biochem Mol Biol Edu	MSc	To provide students with authentic laboratory exposure through the development of the Non-Stop Lab Week (NSLW) module within the MSc curriculum	Portugal	Cross-sectional survey	Students largely viewed the intensity of the NSLW as appropriate and career-relevant, mirroring experiences in their present professional roles
Nikravanfard N, *et al*. [17]	2017	Dev World Bioeth	MSc, PhD	To investigate the extent and quality of research ethics training courses in postgraduate medical sciences programs in Iran	Iran	Descriptive	Research ethics education was deficient in most postgraduate medical programs in Iran
Zainal N, *et al*. [18]	2017	Ther Innov Regul Sci	MSc	To examine the need for pharmacoinformatics courses in BSc and MSc pharmacy programs	Malaysia	Cross-sectional survey	MSc programs were reported to have greater expectations than BSc programs, indicating the requirement for more advanced pharmacoinformatics curriculum content
Ahmed W, *et al*. [19]	2021	PLoS One	MSc	To assess research ethics education in MSc pharmacy programs in Jordan and benchmark it against international standards	Jordan	Descriptive	Research ethics training in pharmacy graduate programs was deemed insufficient both in Jordan and globally
				b. Curriculum format			
Fuhrmann C, *et al*. [20]	2011	CBE Life Sci. Educ	PhD	To propose a broader doctoral curriculum that prepares students for varied science-related career trajectories	California, USA	Cross-sectional survey	Students expressed interest in diverse career options (both research-oriented and non-research)
Eddington N, *et al*. [21]	2016	Am J Pharm Educ	MSc/PhD	To create an evidence-based report outlining a competency-based and practical framework for graduate and postgraduate education	USA	Cross-sectional focus group and survey	Key recommendations included emphasizing career guidance, external peer review, and preparation for academic positions
Barrett J, *et al*. [22]	2016	Pharmacol. Res	MSc	To describe an existing MSc program in Drug Discovery and Development and explain its design rationale	Pennsylvania, USA	Descriptive	The program experienced increased enrollment and near-complete successful placement of graduates in relevant industry and research positions
Lypson M, *et al*. [23]	2016	BMC medical education	MSc/PhD	To identify and implement improvements in the operations of the institutional program review committee	Michigan, USA	Cross-sectional focus group and interviews	A committee leveraging dedicated faculty expertise and prior resident input offered significant advantages over alternative evaluation structures
Allen G, *et al*. [24]	2018	Ther Innov Regul Sci	MSc	To determine necessary program updates to address future students' educational requirements	Australia	Survey/Questionnaire	The program was updated according to feedback, including reduction to two years of part-time study, full online delivery, and real-world-oriented assessment tasks to support career goals

Keller F, *et al*. [25]	2018	J Med Educ Curric Dev	PhD	To outline the rationale, 10 core components, and structure of the resulting PhD program	Switzerland	Descriptive	The program provided a conceptualized PhD framework aligned with European standards, potentially serving as a model for interdisciplinary health sciences doctoral programs
Chisholm O. [26]	2019	Front Pharmacology	MSc	To restructure and assess the program to align with contemporary academic standards and local industry demands	Sydney, Australia	Descriptive	The program shifted from a hybrid instructional model to a fully online interactive format
Koster A, *et al*. [27]	2020	Pharmacy (Basel)	MSc	To detail the structure of three programs designed for community or hospital pharmacists	Netherlands	Descriptive	The curriculum design was considered supportive of professional identity formation and expertise development
Gu J, *et al*. [28]	2021	Journal of Chinese Pharmaceutical Sciences	MSc	To analyze the current state and future trends in professional Master of Pharmacy education in China	China	Surveys (E-mail, telephone, literature)	Professional master's programs in pharmacy in China were insufficient to meet demand. Pursuing a professional doctorate was suggested to tackle complex issues in drug production and regulation
Theme 2: Training, Competencies, and Skills Development							
a. Research competencies							
Poloyac S, *et al*. [29]	2011	Am J Pharm Educ	PhD	To identify and apply core competencies for students in the clinical pharmaceutical sciences PhD program	Pittsburgh, USA	Descriptive + Retrospective evaluation	Core competencies were established. Students achieved above-satisfactory results in 78.6% of evaluation metrics (mean score > 3.8 on a 5-point scale)
b. Curriculum development training							
Newton G, *et al*. [30]	2011	Am J Pharm Educ	MSc, PhD	To introduce and assess a seminar on curriculum development	Indiana, USA	Cross-sectional focus group	Faculty-led simulation of curriculum development proved effective in equipping students for related duties
c. Communication skills							
Garces H, *et al*. [31]	2015	Curr Pharm Teach Learn	PhD	To train students in presenting research to non-scientific audiences and assess outcomes	Kentucky, USA	Cross-sectional Survey	Event feedback indicated enhanced confidence in public speaking among participants and mentors. Judges highlighted the importance of structured training in soft skills for career advancement
Ponzio N, *et al*. [32]	2018	J Microbiol Biol Educ	PhD	To assist students in articulating research findings to varied audiences more effectively	New Jersey, USA	Descriptive	Post-course, students demonstrated significantly greater confidence and

							clarity in research communication
d. Health administration and leadership training							
Colmenares E, *et al*. [33]	2021	Am J Health Syst Pharm	MSc	To outline the design, outcomes, and stakeholder feedback for a combined MSc and residency program in health-system pharmacy administration and leadership	North Carolina, USA	Descriptive + cross-sectional survey	Participants reported attainment of primary objectives and competencies. Employers expressed strong preference for hiring graduates from this program for leadership roles
e. Industrial training							
McLaughlin J, *et al*. [34]	2019	Plos One	PhD	To identify employer expectations for PhD graduates to better tailor academic training to industry requirements	North Carolina, USA	Interviews of experts from various pharmacy disciplines	Key themes included breadth/depth of knowledge, communication, adaptability, collaboration, experiential learning, research productivity, and motivation
Lebovitz L, *et al*. [35]	2020	Am J Pharm Educ	PhD	To review characteristics of PhD students and graduates in a full-time program and evaluate their preparedness for careers	Maryland, USA	Descriptive	Most graduate programs offered limited preparation for industry skills, suggesting the need for targeted experiences to support non-academic career paths
f. Critical-thinking and problem-solving							
Panczyk M, *et al*. [36]	2019	Acta Pol Pharm	PhD	To assess Evidence-Based Practice competencies among doctoral pharmacy students at the Medical University of Warsaw	Poland	Descriptive + Cross-sectional Surveys	Deficiencies were observed in critical appraisal and problem-solving related to evidence-based pharmacy. Hybrid learning (classroom combined with online modules) was shown to improve outcomes
Gajbhiye S, *et al*. [37]	2021	Perspect Clin Res	PhD	To gauge perceptions of critical appraisal tools among students and faculty, and assess student performance	India	cross-sectional questionnaire-based evaluation	Participants affirmed the importance of journal article critique in postgraduate training. Involvement in journal club activities improved critical evaluation skills
Theme 3: Assessment, Evaluation, and Mentorship Methods							
a. Performance assessment							
Robinson G, *et al*. [38]	2015	CTSJOURNAL	MSc	To enable individualized midpoint feedback	Pittsburgh, USA	Descriptive	The CCR process was resource-intensive for students and faculty but considered valuable in terms of time, cost, and effort
Leak R, *et al*. [39]	2015	Am J Pharm Educ	MSc, PhD	To enhance grant writing skills through an active-learning approach	Pittsburgh, USA	Descriptive + Cross-sectional survey	Resubmitted grants showed substantial grade improvements. Survey participants reported greater

							confidence in grant preparation
Bloom T, *et al*. [40]	2016	Am J Pharm Educ	MSc	To establish a program-wide assessment system for an MSc in pharmaceutical sciences	North Carolina, USA	Descriptive	An iterative program-level assessment process was created involving data gathering, peer review, and discussions
Abu Farha R, *et al*. [41]	2020	J. Acad. Ethics	MSc, PhD	To investigate postgraduate students' knowledge, attitudes, and practices regarding plagiarism	Jordan	A cross-sectional survey	Students exhibited strong conceptual understanding of plagiarism, yet plagiarism rates remained elevated
Sweden S, *et al*. [42]	2020	Heliyon	MSc, PhD	To assess adherence of graduate students in Jordanian universities to ethical practices in informed consent and confidentiality	Jordan	A cross-sectional questionnaire	Postgraduate students showed inadequate compliance with data confidentiality and informed consent standards in human subject research
Alcorn S, *et al*. [43]	2022	Currents in Pharmacy Teaching and Learning	MSc	To redesign and assess a technology-assisted VIVA exam (TaVIVA) for reduced faculty effort, student acceptability, lower anxiety, and maintained validity	Australia	Post-activity survey	Students reported high satisfaction with TaVIVA, noting fairness and reduced stress. Further refinement was recommended, though traditional in-person VIVA was viewed as more authentic
b. Tools/methods for delivering lectures							
Richardson A, *et al*. [44]	2013	Am J Pharm Educ	MSc	To compare the effectiveness of 3D technology versus traditional 2D graphics in teaching drug-target interactions	United Kingdom	Randomized controlled trial	3D presentations significantly improved student comprehension of drug-receptor interactions over 2D methods
Swanson H, *et al*. [45]	2014	J Med Educ Curric Dev	MSc, PhD	To pilot the use of Lecture Tools as an active learning platform in Pharmacokinetics and Pharmacodynamics teaching	Kentucky, USA	Descriptive and a Cross-sectional survey	Findings suggested Lecture Tools could be effectively applied in medical education
Jalgaonkar S, *et al*. [46]	2019	Indian J Pharmacol	MSc/PhD	To compare postgraduate pharmacology students' views on computer-simulated methods (CSM) versus traditional live animal experiments (LAE) in bioassays	India	A questionnaire-based survey	CSM enhanced experimental results and student confidence when used prior to LAE
Volodymyrovych T, *et al*. [47]	2022	International Journal of Computer Science and Network Security	MSc	To examine the application of peer-to-peer platforms and immersive technologies (especially virtual reality) in training future pharmacy masters	Ukraine	Pre-post quiz and cross-sectional questionnaire	Significant knowledge gains were observed (pre-test average 26%, post-test 74%) with peer-to-peer and VR tools. Overall satisfaction reached 86.73% for these technologies in MSc pharmacy training
c. Mentoring							
Soucy K, *et al*. [48]	2016	CellPress	PhD	To propose a novel dual-mentorship model in	Maryland, USA	Descriptive	Dual mentorship shortened time to degree completion

				collaboration with partner laboratories			without compromising graduate outcomes or productivity
Raffing R, *et al*. [49]	2017	BioMed Central	PhD	To explore PhD supervisors' reported needs and preferences based on their supervision experiences in medical fields	Denmark	A semi-structured interview	PhD supervisors expressed a desire for targeted competency development, particularly in clinical supervision contexts
Yue J, *et al*. [50]	2019	Stud. Educ. Evaluation	MSc	To inform mentor development by examining mentors' and graduates' views on the importance of mentor competencies	China	A questionnaire-based survey	Recommendations included supportive policies and dedicated time for mentor growth, systematic evaluation of mentoring skills, and voluntary adoption of all competencies by mentors

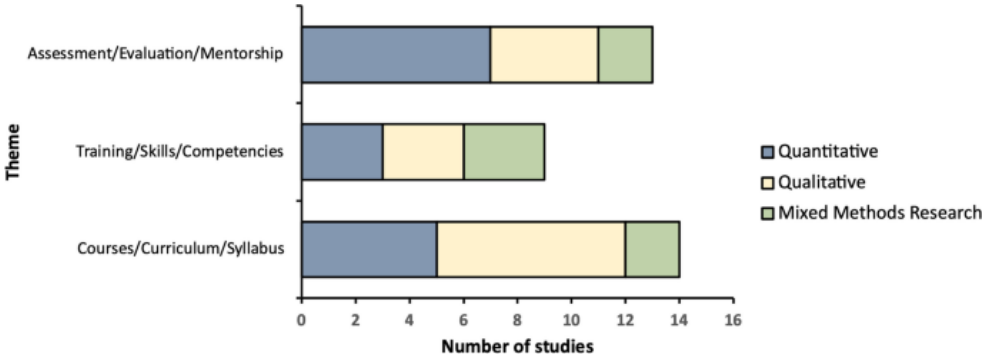


Figure 2. Distribution of research methodologies by theme.

The studies covering MSc, PhD, or combined programs were further categorized by thematic focus **(Figure 3)**. A majority of the research targeted master's programs, highlighting a greater scholarly focus on this program type **(Figure 3)**. Within master's studies, most attention was given to curriculum and course design, whereas PhD-focused research emphasized competencies and skills development, reflecting the specialized training needs of doctoral candidates **(Figure 3)**. Country-wise distribution of the included studies is presented in **Figure 4a**.

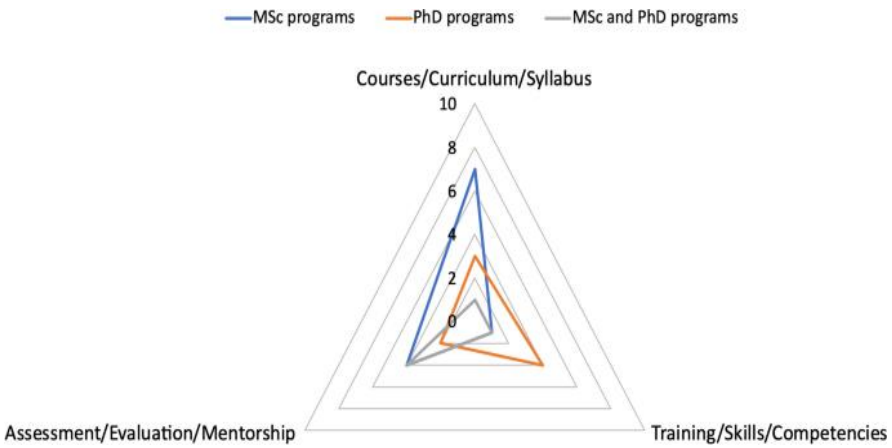
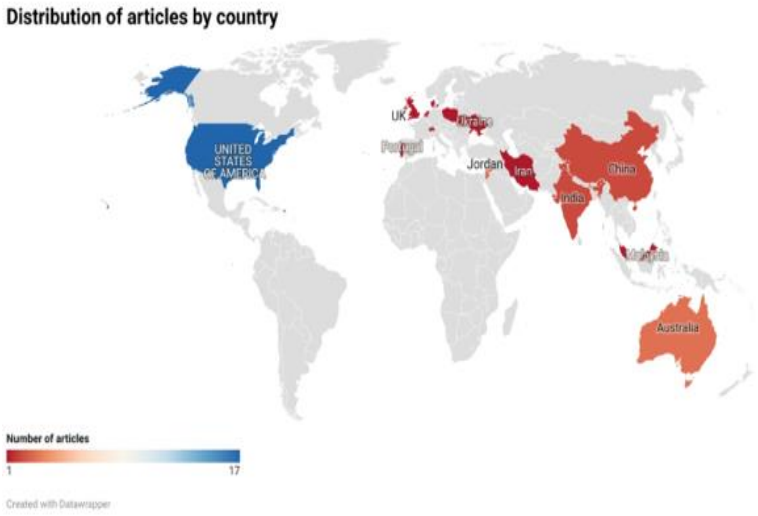
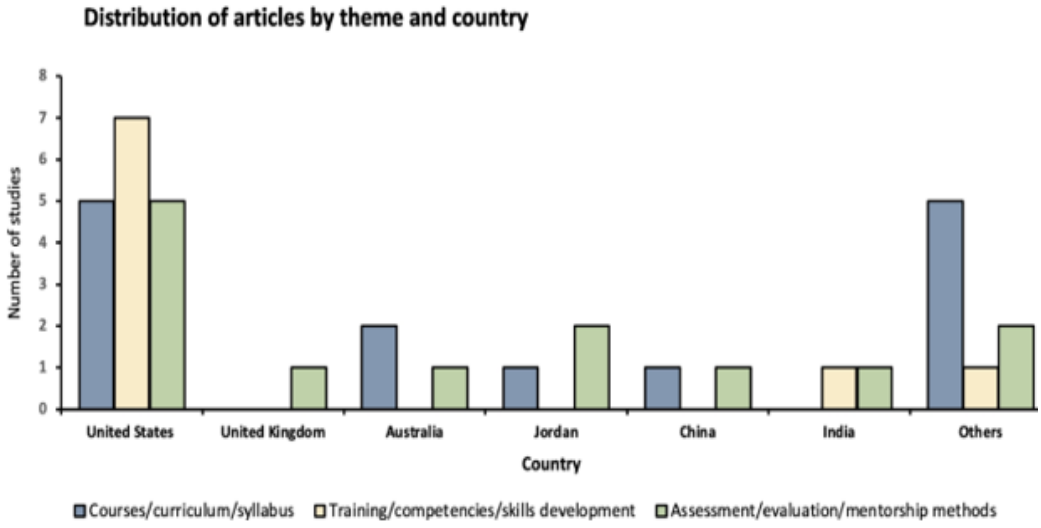


Figure 3. Distribution of studies according to program type and thematic focus.



a)



b)

Figure 4. Distribution of the reviewed studies: (a) total of 36 studies by country; (b) studies organized by country and thematic focus

Courses, curriculum, and syllabus

Fourteen studies specifically examined enhancements to courses and curricula for specialized MSc and PhD pharmacy programs **(Figure 2)**. These studies were conducted in nine countries, with the USA contributing the highest number (n = 5, 35.71%), followed by Australia (n = 2, 14.29%) **(Figure 4b)**. Other countries represented included Jordan, Iran, Portugal, Malaysia, the Netherlands, Switzerland, and China **(Table 2)**.

Five publications highlighted the significance of offering targeted courses to strengthen postgraduate training, covering areas such as research ethics, academic career preparation, pharmacoinformatics, and laboratory-based experiences [15–19]. Additionally, nine studies addressed program design, curriculum review, and restructuring to align educational content with both current and anticipated student needs [20–28]. These studies applied various methods, including descriptive analyses, surveys, questionnaires, and qualitative techniques like focus groups and interviews **(Table 2)**.

Training, competencies, and skills development

Nine studies evaluated the integration of specific competencies into postgraduate programs **(Figure 2)**.

Most originated from the USA (n = 7, 77.7%), with India and Poland each contributing one study **(Figure 4a)**. The majority (n = 8, 88.9%) focused on PhD students, whereas two studies included MSc students **(Figure 3)**. The results emphasized the importance of developing research expertise, curriculum design skills, communication abilities, leadership and health administration skills, industrial training experience, as well as critical thinking and problem-solving capabilities **(Table 2)**. Study designs varied, incorporating mixed-methods, cross-sectional surveys, retrospective analyses, interviews, and descriptive research approaches **(Table 2)**.

Assessment, evaluation, and mentorship

Thirteen studies explored strategies for evaluating students, delivering lectures effectively, and implementing mentorship programs **(Table 2)**. The USA accounted for the largest share of studies (n = 5, 38.46%), followed by Jordan (n = 2, 15.38%) **(Figure 4)**. Other studies originated from the UK, India, Denmark, China, Australia, and Ukraine.

Six studies concentrated on assessment approaches, underscoring comprehensive evaluation and peer review practices **(Table 2)** [38–43]. Two studies highlighted the need to assess performance beyond theoretical knowledge [41, 42] **(Table 2)**. Four studies recommended employing artificial intelligence and digital tools to enhance lecture delivery and facilitate understanding of life sciences concepts [44–47] **(Table 2)**. Additionally, three studies examined mentorship frameworks, demonstrating that dual-mentor models positively influence postgraduate training outcomes [48–50] **(Table 2)**.

Conceptual model

To integrate the themes and highlight their interconnections, a conceptual framework was developed **(Figure 5)**. This model represents the essential elements distilled from the literature for designing high-quality, collective MSc and PhD pharmacy programs. To our knowledge, this is the first conceptual framework specifically targeting postgraduate pharmacy education. It synthesizes insights, perspectives, challenges, and recommendations to inform the design and optimization of programs globally, organized around the following key themes:

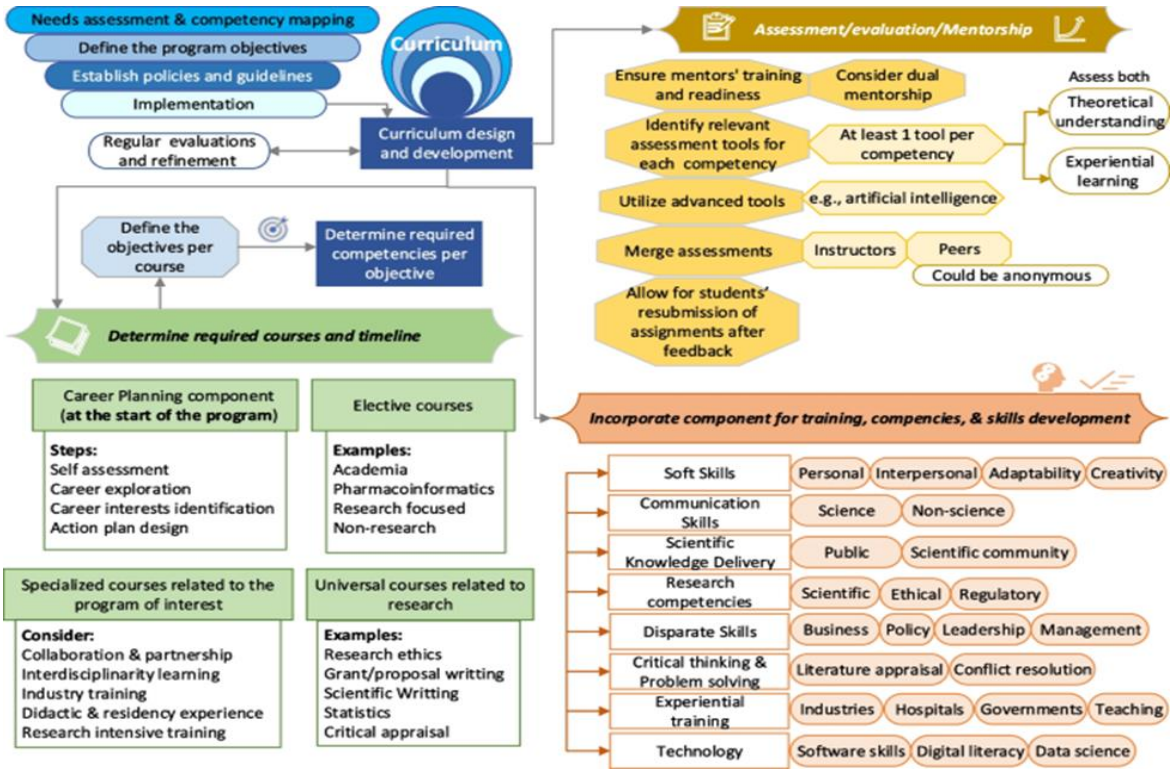


Figure 5. Conceptual framework for structuring a high-quality MSc/PhD pharmacy program, based on evidence and recommendations from the literature.

Courses, curriculum, and syllabus

This theme emphasizes the creation and structuring of curricula. Studies stress the importance of linking program content with competency-based education, labor market expectations, career planning, research opportunities, collaboration, and specialized areas of pharmacy practice. The findings indicate that comprehensive program design is critical to equip graduates with the knowledge and skills required for professional success and workforce readiness.

Training, competencies, and skills development

This theme highlights the key areas postgraduate programs can target to enhance students' knowledge, practical skills, attitudes, and competencies required in professional practice. Studies emphasized that non-discipline-specific skills—such as leadership, management, data literacy, and communication abilities—are increasingly critical in today's job market. Moreover, providing opportunities for training in non-academic career skills was found to significantly improve students' overall competencies and positively influence program outcomes, producing graduates better prepared to meet employer expectations.

Assessment, evaluation, and mentorship methods

This theme focuses on the significance of structured assessment and mentorship in promoting student success and effective program development. Reported strategies included mentorship programs, advanced assessment instruments, combined assessment approaches, and peer evaluation. Evidence from the literature suggests that these methods not only enhance the evaluation of student learning but also contribute to assessing program effectiveness, supporting successful implementation and continuous improvement of postgraduate pharmacy programs.

Principal findings

This scoping review systematically mapped the available evidence on postgraduate pharmacy education. A total of 36 primary studies were included, addressing curriculum design, skills development, and assessment strategies for MSc and PhD pharmacy programs internationally. These studies were organized into three major themes for discussion: i) courses, curriculum, and syllabus; ii) training, competencies, and skills development; and iii) assessment, evaluation, and mentorship methods.

Courses, curriculum, and syllabus

Several studies examined the role of both universal and specialized courses in shaping postgraduate pharmacy curricula.

Research ethics (RE): Research ethics emerged as a critical topic, equipping students with skills to uphold ethical standards in clinical and biomedical research [51, 52]. Findings indicate that ethics education remains insufficient in postgraduate pharmacy programs, particularly in developing countries such as Jordan and Iran [17, 19, 42]. Ahmed *et al*. reported that only 10% of research-based master's programs globally offered standalone research ethics courses, while 40% included discussions within other courses [19]. Integrating comprehensive ethics training into curricula is therefore strongly recommended, especially in developing countries, with further investigation warranted in developed nations.

Teaching skills and academic preparation: While many postgraduate students pursue higher education to enter academia, programs often emphasize research skills over teaching experience [53]. Teaching assistantships can provide practical teaching exposure [54], but access may be limited. Embedded courses, such as the Preparing Future Faculty (PFF) program, offer graduate students and postdoctoral fellows supervised teaching experiences [15]. Graduates of PFF frequently secured faculty positions, and the program was deemed sustainable and valuable [15]. Similar elective courses could be integrated into PhD programs to prepare students interested in academic careers [55].

Pharmacoinformatics: Fox *et al*. highlighted the growing importance of pharmacoinformatics in master's programs [18]. Careers in this field require both theoretical knowledge and hands-on training [56]. Suggested topics include drug formulary management, advanced pharmacy and medical informatics, supply chain management, evidence-based medicine, and health policy [18]. MSc students demonstrated higher expectations for pharmacoinformatics competence compared to BSc students, underscoring the need for dedicated postgraduate pharmacoinformatics courses [18].

Laboratory experience: Practical laboratory exposure is another essential curricular component. For instance, the

Non-Stop Lab Week (NSLW) at the University of Aveiro, Portugal, allowed master's students to independently conduct molecular assay projects over one week, simulating a real laboratory environment [16]. Students found the experience intense but highly valuable for their careers, and it closely reflected the conditions they encountered in their professional roles post-graduation [16]. Many postgraduate programs risk limiting students to the specialized skills of their thesis supervisors, potentially leaving gaps in broader competencies. Initiatives like NSLW help bridge this gap by exposing students to diverse real-world laboratory tasks. Similarly, programs may consider early-semester modules allowing students to explore multiple research projects, broadening scientific knowledge while connecting with potential thesis supervisors and future career opportunities.

Focusing on only a few courses is insufficient, and developing a full, well-rounded curriculum presents a significant challenge [57]. Modern postgraduate and undergraduate pharmacy and medical education increasingly emphasize Competency-Based Education (CBE) because of its proven effectiveness [58–60]. In CBE, curricula are designed to integrate structured learning activities, including instructional systems, both theoretical and experiential courses, and assessments that demonstrate mastery of the intended skills and knowledge [60]. Several studies have recommended the inclusion of CBE when designing postgraduate pharmacy curricula [21, 25–27].

Keller *et al*. proposed essential curricular elements for postgraduate pharmacy programs, highlighting decisions regarding core competencies, foundational knowledge, lecture content, syllabus organization, thematic training modules, research seminars, research integrity, supervision, student feedback, evaluation, assessment, stipends, financial support, and alumni networking [25]. They also outlined competencies for PhD health sciences programs across three domains [25]:

1. *Scientific knowledge:* Information literacy, research methodology, scientific writing, ethics and integrity, and professional conduct.
2. *Management and organization:* Self-management, project management, teaching.
3. *Leadership and personal skills:* Leadership abilities and communication skills.

Pharmacy education continues to evolve to meet the demands of diverse career pathways. Initiatives have aimed at developing curriculum recommendations to prepare graduates for these varied careers. One such initiative is the American Association of Colleges of Pharmacy (AACP) Research and Graduate Affairs Committee report [20]. Drawing on data from multiple U.S. universities [21], this report emphasized foundational skills applicable across pharmacy disciplines, organized into five areas [21]:

1. Foundational knowledge
2. Research
3. Scientific communication
4. Education
5. Leadership and management
6. Personal and professional development

The report further highlighted three key recommendations: providing career guidance, implementing external peer review, and preparing students for academic roles [21].

Koster *et al*. described three tailored pharmacy master's programs for community and hospital pharmacists [27], designed using the CanMEDS framework**,** which defines essential physician competencies to meet societal health needs [27]. They stressed that workplace-based experiential learning is vital and should complement traditional on-campus education, exposing students to both environments [27].

Career planning and professional development: These are critical curriculum components, particularly since many postgraduates pursue postdoctoral training, even without plans for research-focused careers [61]. Unfortunately, career guidance typically occurs late in programs [20]. Early mentoring and career discussions—ideally at program start—can help students make more informed decisions. While a PhD was traditionally linked to academic careers, this perception has shifted over the past decade, necessitating broader curricular content to prepare graduates for diverse roles [20].

The current workforce presents a "supply–demand" mismatch: limited academic positions and an increasing number of graduates. Therefore, curricula should diversify beyond traditional academic tracks. For instance, Fuhrmann *et al*. reported that biomedical PhD students were exploring both research and non-research career options, highlighting the need for a more comprehensive doctoral curriculum [20]. Programs can support students by helping them develop career plans and providing professional skills training in consultation with program mentors. Flexible mandatory electives can

also allow students to tailor courses according to their career objectives.

Curriculum updates: Regular curriculum revision is essential to maintain relevance with evolving industry standards. Allen *et al*. illustrated this by updating a pharmaceutical medicine curriculum at an Australian university based on a cross-sectional survey, resulting in a two-year, part-time, fully online program with interactive assessments to support career goals [24]. Barrett *et al*. qualitatively described a Master's program in drug discovery and development that evolved from a single course to a full program in response to student and industry needs [22]. The curriculum included epidemiology, nanotechnology, pharmacogenomics, and project management courses, with most graduates entering the pharmaceutical industry, demonstrating the importance of continuous program evaluation [22]. Lypson *et al*. also outlined a structured program evaluation process at the University of Michigan Health System, incorporating dedicated faculty, standardized meetings, expert input, electronic documentation, and a focus on ongoing improvement [23].

To ensure program quality, supervisors must guarantee that students meet requirements and graduate efficiently. Blended learning, which integrates online and in-person instruction, has been suggested as an effective approach [62, 63]. Additionally, dual degree options or hybrid programs can allow students, including working professionals, to attain advanced qualifications in shorter timeframes while maintaining high educational standards.

Training, skills, and competencies development

Preparing students for postgraduate pharmacy education requires more than theoretical coursework; it should include practical skill-building and the development of critical thinking abilities. Graduates must gain competencies that allow them to excel in diverse professional roles. While some skills are specific to a student's area of specialization, others are broadly applicable across medical and pharmaceutical programs. Moreover, the modern workforce requires more than traditional scientific research expertise. Graduates are increasingly expected to demonstrate competencies in areas such as business management, policy implementation, and emerging technologies. Therefore, postgraduate curricula should integrate content that addresses these multifaceted demands. Competencies are commonly defined as meaningful, profession-specific combinations of skills, knowledge, attitudes, and abilities necessary for competent performance [60]. Key competencies identified in the literature for pharmacy postgraduate education include research proficiency, curriculum development skills, communication, health administration and leadership, industrial training, and critical thinking/problem-solving abilities.

Poloyac *et al*. developed core research competencies for a clinical pharmaceutical sciences PhD program [29]. They identified eight major competencies required to integrate preclinical and clinical knowledge effectively in research [29]:

1. Literature review and critical evaluation
2. Hypothesis formulation
3. Research methodology and study design
4. Statistical methods and data interpretation
5. Grant writing and management
6. Oral and written scientific communication
7. Ethical research conduct
8. Leadership, management, and interdisciplinary teamwork

Each competency included subcategories and rubrics for evaluating student performance [29]. These competencies provide a flexible framework that can be adapted to other research-focused postgraduate programs.

For students pursuing academic careers, acquiring curriculum development skills is essential. Newton *et al*. demonstrated the benefits of a faculty-led curriculum development simulation for MSc and PhD pharmacy students, which provided hands-on preparation for future academic responsibilities [30].

Effective communication is another critical requirement in research and professional pharmacy practice. Training in presentation, negotiation, and conflict resolution enhances graduates' capabilities, as employers increasingly value diverse soft skills [64]. Studies indicate that doctoral pharmacy students who received targeted communication training improved their confidence, public speaking, and ability to discuss research findings [31, 32]. Incorporating communication-focused lectures and courses within postgraduate programs is therefore vital to strengthen both personal and interpersonal skills.

Specialized programs may also necessitate specific competencies. For instance, the Health-System Pharmacy Administration and Leadership (HSPAL) master's program at the University of North Carolina at

Chapel Hill combined coursework with a practical residency [33]. The curriculum balanced leadership, management, clinical, administrative, and didactic courses to prepare graduates for pharmacy leadership roles [33]. Outcomes indicated that students achieved core competencies, and graduates were more likely to be hired for administrative positions [33].

Laboratory experience remains an important component of many pharmacy programs, particularly for those pursuing careers in the pharmaceutical industry. However, most graduate programs inadequately address industry-specific skills [35]. McLaughlin *et al*. conducted a qualitative study on employer expectations for pharmaceutical sciences PhD graduates and identified desired attributes, including depth and breadth of knowledge, collaboration, communication, adaptability, experiential training, research productivity, and motivation [34]. Embedding practical laboratory experience, including placements in local and international pharmaceutical companies, can provide essential preparation for non-academic careers.

Critical thinking and problem-solving are highly valued skills for pharmacy postgraduates, crucial for conducting research and evaluating scientific literature. Barriers to developing these skills include students' perceptions, limited metacognitive strategies, biases, and the challenges of engaging in effortful thinking [65]. Nevertheless, these skills can be cultivated in supportive educational environments. Studies from India and Poland have explored approaches to enhance these abilities [36, 37]. In India, research examined student and instructor perceptions of using critical appraisal tools, finding that journal club activities significantly improved critical appraisal skills [37]. In Poland, graduates showed limited knowledge and attitudes toward evidence-based pharmacy, particularly in evaluating scientific literature and applying problem-solving strategies [36]. The study recommended blended learning, combining in-person and online modules, to improve these competencies [36]. Further research across different countries is needed to assess critical thinking and problem-solving training in postgraduate pharmacy programs and inform curriculum development.

Assessment, evaluation, and mentorship

Competency-based education is most effective when students' abilities are continuously monitored throughout their postgraduate program [66, 67]. A well-structured course syllabus should clearly present timelines, assessment strategies, deadlines, submission requirements, and emphasize feedback and constructive critique [66, 67]. Instructors are responsible for defining course objectives and selecting appropriate embedded assessment tools to meet these goals [40]. For example, an MSc in Pharmaceutical Sciences implemented a program-level assessment strategy using iterative data collection, peer review, and group discussions [40]. This assessment framework targeted **cognitive** (knowledge-based), affective (emotion-based), and psychomotor (action-based) domains [68]. Bloom's taxonomy guided the development of these assessments, allowing course goals to be defined by complexity and specificity [40, 68]. Program effectiveness can be evaluated through student feedback on course content, delivery, assessment strategies, and improvement suggestions [40, 68].

Several studies have examined postgraduate pharmacy student assessments. Robinson *et al*. described a descriptive study in which students submitted evidence for each competency, with instructors approving satisfactory submissions or requesting revisions to ensure competency mastery [38]. Based on individual performance, faculty could recommend elective courses during the second half of the program [38]. Similarly, an NIH Grant Application Writing Assessment for pharmacology postgraduates demonstrated significant improvements in grades upon resubmission, with surveys showing increased student confidence in grant writing [39]. These findings highlight the value of midpoint evaluations to assess competencies. Although time-intensive, this process is considered worthwhile given the benefits in skill development and program quality.

Evaluating theoretical understanding alone is insufficient; practical application must also be assessed. A study in Jordan revealed that while students demonstrated strong theoretical knowledge of plagiarism, practical assignments showed high instances of plagiarism [41]. Institutions should therefore teach paraphrasing methods and provide tools for plagiarism checking. Another study in the same country found inadequate adherence to ethical standards regarding data confidentiality and informed consent among postgraduate students [42]. Assessing students on practical application ensures competence in real-world contexts.

Advancements in technology, including artificial intelligence, play an increasingly important role in lecture delivery. 3D virtual simulation has been shown to enhance learning in postgraduate programs [44, 46]. For

example, a randomized controlled study found that 3D visualization of drug-receptor interactions improved comprehension and performance compared to traditional 2D models [44]. Similarly, computer simulations for experimental animal modeling in pharmacology enhanced confidence and outcomes before live tissue experiments [46]. A pilot study using Lecture Tools, a cloud-based interactive system for pharmacokinetics and pharmacodynamics instruction, showed positive student experiences [45]. Students could respond to questions, participate interactively, and annotate slides using smart devices [45]. Limitations included faculty preparedness, lecture preparation time, and restricted session duration [45]. Other effective platforms for interactive postgraduate and undergraduate education include Coursera, EdX, Socrative, Yammer, and Lecture Capture Systems [69–71].

Effective supervision and mentorship are critical for postgraduate success. Swedish PhD students reported that inadequate supervision delayed thesis completion [49]. Postgraduate students must have access to qualified mentors capable of guiding research and academic development. Supervisors themselves noted the need for training in providing proper guidance and clarifying their mentorship roles [49]. Yue *et al*. highlighted that mentor competence can be enhanced through supportive policies, dedicated time, and structured programs, with competency assessments and voluntary endorsement of responsibilities [50].

The dual-mentorship model has been identified as a promising approach. Soucy *et al*. reported that PhD students supervised by two expert mentors from separate organizations achieved superior outcomes, graduating two years earlier than those in traditional programs without compromising quality [48].

After analyzing each theme, a visual summary **(Figure 6)** was created to highlight the key challenges in postgraduate pharmacy education. This overview can help educators understand barriers and guide continuous program improvement.

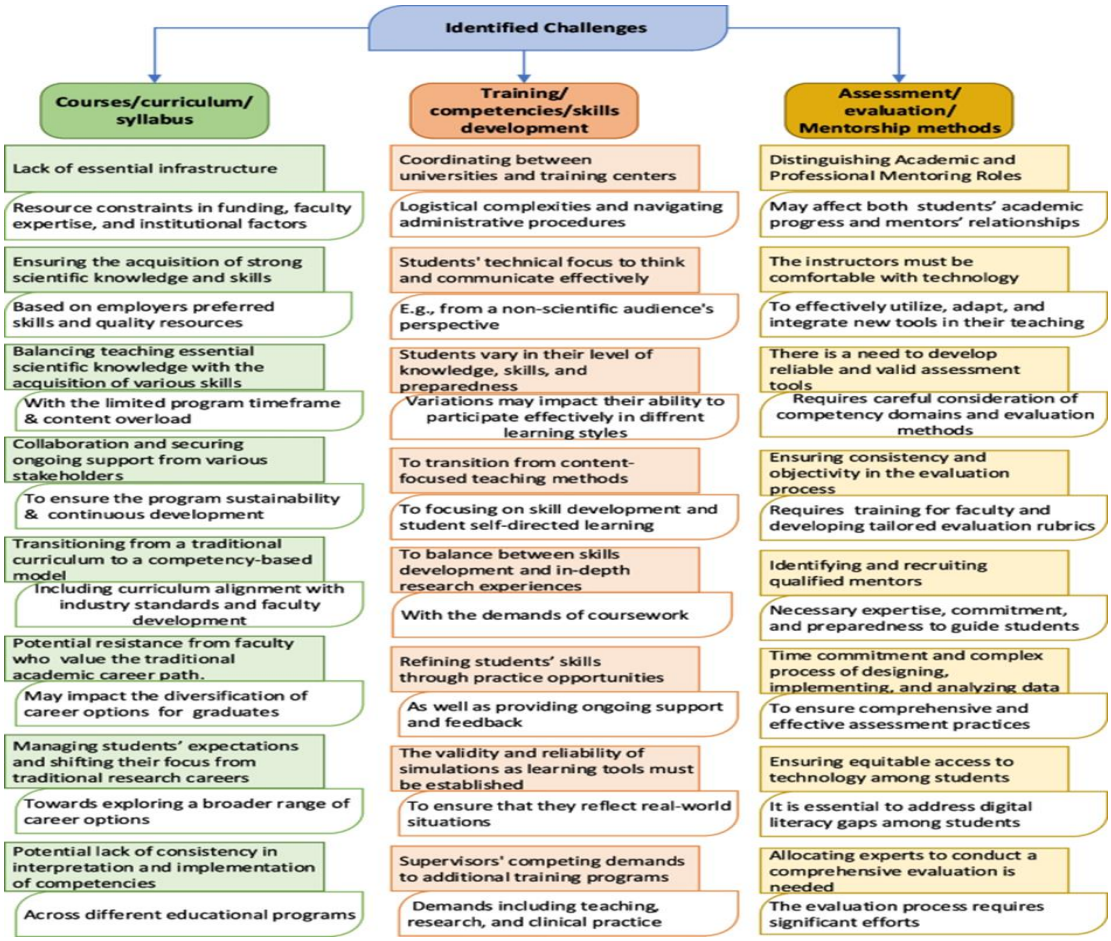


Figure 6. Overview of the primary challenges identified within the three themes

Study recommendations

Drawing from this scoping review, we developed a conceptual framework delineating an optimal structure for postgraduate pharmacy programs **(Figure 5)**. This framework presents evidence-informed recommendations to assist universities in enhancing student learning experiences and refining pharmacy MSc and PhD programs. Implementation should be adapted to each program's specific context, capacity, and objectives. The framework can serve multiple stakeholders. Researchers may focus on a specific theme or subcategory to design and evaluate interventions. Postgraduate students can use the model to identify essential knowledge, skills, and competencies required to meet the evolving demands of the job market. Educators, program administrators, and management teams can apply the model to guide continuous curriculum improvement and program development.

This review also identifies opportunities for future research. First, most included studies were observational and descriptive; only a single randomized controlled trial (RCT) and a few mixed-method studies were reported. Future research should prioritize well-designed RCTs and mixed-method studies evaluating postgraduate programs within the three identified themes. RCTs would provide high-quality evidence for research and practice, while mixed-method studies would capture quantitative and qualitative insights from specific program contexts. Second, research should examine programs from initial needs assessment and objective setting through final evaluation, using established frameworks to ensure a systematic, comprehensive approach. Third, few publications focused on assessment and evaluation methods; investigating this area can yield critical insights into program effectiveness and guide further program development. Fourth, findings indicate that MSc-focused research emphasizes courses, curricula, and syllabi, while less attention is given to training, competencies, and skills development. Investigating these aspects would enhance the preparation of competent graduates. Conversely, PhD programs have been less examined regarding course and curriculum development; future studies should explore the design and evaluation of PhD-specific curricula, particularly with competency-based education approaches. Finally, expanding research internationally, across both developing and developed countries, is needed to advance postgraduate pharmacy education globally.

Study strengths and limitations

Strengths:

This scoping review represents, to our knowledge, the first systematic synthesis and mapping of evidence on pharmacy postgraduate education (MSc and PhD). Several methodological strengths are noteworthy:

- Detailed examination of program implementation offered insight into successful strategies and identified areas for improvement across different program stages.
- Inclusion of studies using diverse research designs provided a comprehensive overview of the literature landscape on postgraduate pharmacy programs.
- Development of an evidence-based conceptual framework to guide enhancement of pharmacy postgraduate education, incorporating curriculum, competency development, and assessment practices.
- Use of clearly defined themes facilitated structured analysis and presentation of findings.
- Application of standard methodology, including PRISMA-ScR, and the Arksey and O'Malley framework for data synthesis and charting.
- Implementation of a documented, transparent, and replicable search strategy covering major databases and relevant journals in pharmacy education.

Despite these strengths, certain limitations are acknowledged:

1. As a scoping review, a formal quality assessment of included studies was not performed, necessitating cautious interpretation and additional research before applying interventions or recommendations. To mitigate this, only peer-reviewed journal articles were included.
2. Most studies were descriptive and observational, with a single RCT; hence, well-designed RCTs are recommended for future evaluation of postgraduate pharmacy programs.
3. The review included only English-language publications between 2011 and 2023, which may exclude relevant studies published in other languages or before 2011.

Limitations of the conceptual model

While this conceptual model offers a valuable foundation for designing high-quality, collective pharmacy postgraduate programs, several limitations should be acknowledged prior to its application or interpretation:

First, regarding methodological robustness, the model would benefit from a more structured approach, such as the Delphi method, to further strengthen its reliability. Nevertheless, the current model was developed based on a comprehensive literature review and synthesis. It draws from a diverse dataset derived from primary studies employing a variety of research methods, including surveys, qualitative interviews, and mixed-methods approaches. The diversity of methodologies, the range and quality of the data, and the varied experiences of multiple postgraduate programs collectively enhanced the depth and quality of the model.

Second, contextual adaptability represents a potential limitation. Implementing or tailoring this model in developing countries may pose challenges due to high costs and limited access to required resources. Certain model components may necessitate expensive infrastructure or technology that is not readily available in low-income settings. As such, educational institutions in these contexts are encouraged to adapt the model in a cost-sensitive manner, leveraging the resources they have.

Finally, stakeholder engagement is essential. The perspectives and input of various stakeholders—including educators, program administrators, and employers—should be actively considered to evaluate the model's applicability. Some elements of the model may not fully align with the priorities, capacities, or interests of all stakeholders. Additionally, stakeholders may identify additional factors or considerations not explicitly addressed in the model that are important for their context.

Conclusion

Postgraduate pharmacy education plays a critical role in bridging undergraduate learning with specialized, practice-oriented knowledge, equipping graduates to deliver high-quality service across diverse pharmacy domains, settings, and roles. Consequently, higher education institutions must continually evaluate and update their programs to ensure relevance and effectiveness.

This scoping review has compiled extensive evidence-based insights, highlighting recommendations, gaps, opportunities for improvement, and conclusions across several key areas:

a) Practice-oriented courses, curricula, and modules.
b) Competency- and performance-based assessment strategies.
c) Real-world skills, applied competencies, and training initiatives.
d) Innovative tools and teaching methods for enhanced learning experiences.
e) Programs emphasizing the importance of mentorship and student support.

From these findings, a conceptual framework was developed to guide the enhancement and advancement of pharmacy postgraduate programs. Furthermore, this review identified several avenues for future research to address ongoing challenges and fill gaps in pharmacy postgraduate education.

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