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Curriculum, competency development, and assessment methods of MSc and PhD pharmacy programs: a scoping review

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Abstract

Background/objectives We aim to systematically review and evaluate the current landscape of postgraduate pharmacy education to a) identify current evidence, best practices, challenges, recommendations, and solutions; and b) develop a framework to optimize postgraduate pharmacy programs.

Methods A scoping review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). Electronic databases, including PubMed, Scopus, EMBASE, ProQuest, Web of Science, and Google Scholar were utilized. The search covered studies published from January 2011 to September 2023. Following the principles of Arksey and O'Malley's framework, data charting and extraction were performed using a pre-designed data collection tool, followed by the synthesis and grouping of studies based on common themes.

Results Of the 5542 articles found, the review included 36 eligible ones focusing on pharmacy postgraduate education (PhD and MSc), grouped into three themes: 1) courses and curriculum; 2) training and skills development; 3) assessment and mentorship methods. Utilized methodologies included descriptive analyses, questionnaires, surveys, trials, and focus groups/interviews. The studies underscored the need for competency-based curricula with regular evaluations, career planning, and diverse course offerings. Identified key skills and competencies in the studies included soft skills, communication, research, desperate skills (e.g., leadership and management), and critical thinking. The studies also emphasized the value of comprehensive evaluation and peer review methods. Challenges included balancing academic and real-world requirements, training, limited resources, time constraints, and faculty workload.

Conclusion Evidence-based suggestions to improve postgraduate pharmacy education include the implementation of practice-oriented courses, value of tailored/or comprehensive assessments, focus on real-world skills, effectiveness of advanced teaching methods, and mentorship role. The proposed framework can guide program enhancement and highlight the need to improve programs holistically, entailing the three themes.

Keywords Postgraduate, Pharmacy, Education, Curriculum, Courses, Skills, Training, Competency, Evaluation, Mentor

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Background

Pharmacy is a dynamic discipline of science, rapidly expanding with a rising number of students pursuing postgraduate studies in the field [1]. Postgraduate education is pivotal in shaping and advancing pharmacy practice across diverse settings, effectively addressing significant challenges and bridging crucial gaps. Such a specialized knowledge would ultimately contribute to improved patient care and population health outcomes. Further, postgraduate education programs must ensure the provision of teaching across diverse specialized domains. These include, but are not limited to, professional education, drug discovery, medicinal chemistry, pharmaceutics, biotechnology, biochemistry, pharmacogenetics, pharmacokinetics, pharmacognosy, pharmacology, pharmacotherapy, pharmacoepidemiology, pharmacoeconomics, and pharmacoinformatics. Additionally, these programs should aim to contribute to advancing and improving healthcare systems, pharmacy laws and ethics, and proficiency in working with advanced machines and analytical techniques [2, 3], all of which have positive impacts for the quality and safety of patient care and the overall health of populations.

Postgraduate pharmacy education faces a range of challenges. These include the surplus of postgraduates in traditional disciplines as compared to available emerging jobs in the market, curricula that fail to align with the demands of pharmaceutical practice settings, maintaining traditional teaching methods despite the dynamic change in the pharmaceutical industry, and advanced global practice and technology [4–6]. Notably, pharmacy postgraduate education in low- and middle-income nations confronts numerous challenges and gaps related to education, systems, and practice. Further, teaching methods at different universities are diverse [7–10]. As a result, it is unclear whether these universities are effectively optimizing and tailoring their educational strategies to meet the current needs of postgraduate students and align with the demands of pharmaceutical industries and healthcare systems [3]. Nevertheless, institutions offering postgraduate education have a fundamental responsibility to provide high-quality education, necessitating the continuous evaluation and enhancement of their curricula to align with the developing needs of future graduates and prospective employers. This holds particular significance as postgraduate students carry the expectation that their universities have designed high-quality educational programs to fulfill their diverse needs [4].

There is a noticeable absence of a definitive guide on how universities can effectively address the expanding challenges within pharmacy postgraduate education. This is primarily because accreditation bodies focus predominantly on evaluating and reviewing undergraduate curricula, neglecting the unique challenges of postgraduate education in pharmacy. Furthermore, international experiences and needs in pharmacy education vary significantly between countries. This raises the following research question: what insights, perspectives, challenges, and recommendations can inform the optimization of postgraduate (PhD and MSc) pharmacy programs at universities worldwide? To answer this question, it is essential to conduct this scoping review to systematically chart the available evidence and understand the current body of knowledge about pharmacy postgraduate education. Through this endeavor, our objectives are a) to identify current insights, perspectives, challenges, and recommendations that can assist various postgraduate pharmacy programs in addressing potential gaps within their systems and possibly refining their existing educational structures (e.g., curricula) and approaches (e.g., educational methods) to enhance the overall learning process for their students; and b) to develop a framework to optimize postgraduate pharmacy programs.

Methods

Study design

We conducted a scoping review to synthesize and map the available evidence and identify a framework for improving educational programs for postgraduate degrees in pharmacy. Scoping reviews tackle broad subjects and usually aim to recognize research gaps in the existing literature [11]. While conducting this review, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist, which contains 22 reporting items [12]. Our filled PRISMA-ScR checklist for this scoping review is included in Supplementary Material 1.

The study protocol was drafted and reviewed using the Preferred Reporting Items for Systematic Reviews and Meta-analysis Protocols (PRISMA-P) checklist [13]. While it was not previously published, it is available as supplementary material (Supplementary Material 2).

Eligibility criteria

Eligibility criteria for studies included in this scoping review: i) Studies published in peer-reviewed journals; ii) The primary focus of the studies should be on curriculum and education development within MSc and PhD Pharmacy programs; iii) Studies needed to discuss related aspects such as competencies, assessment methods, and courses; iv) They need to be published in English between the period of January 2011- September 2023; v) To encompass various aspects of graduate pharmacy

education, studies were included if they employed qualitative, quantitative, or mixed-method study designs.

Conversely, studies were excluded if they: i) Focused on public health, PharmD, diploma, or clinical practice-based master programs that do not include research/thesis, as these programs often have distinct educational objectives compared to research-based postgraduate programs; ii) Addressed initiatives to improve research unrelated to postgraduate programs, because the focus of this review is solely on postgraduate education; iii) Were centered on dual pharmacy (PharmD)/master of public health (MPH), as these programs are mainly interdisciplinary in nature and do not specifically reflect the unique challenges of research-oriented programs; iv) Focused on genetic counseling, because this field has a distinct aim and is not directly related to postgraduate research-based pharmacy education; v) Were associated with other non-pharmacy-related programs, as our focus is on Pharmacy; vi) Focused solely on university facilities, because our target is the educational content; vii) Were categorized as commentaries or review articles, to avoid bias in reporting and prioritize original research content.

Information sources/literature search

The search for relevant studies was conducted on PubMed, EMBASE, Scopus, ProQuest, Web of Science, and Google Scholar to identify relevant studies published between January 2011 and September 2023. The search strategy utilized related keywords: postgraduate, higher education, graduate, PhD, MSc, masters, education, curriculum, courses, syllabus, skills, competencies, assessment, evaluation, pharmacy, and pharmaceutical sciences. Search limits were applied to the title/abstract and English language. Three investigators independently performed the initial screening of the titles and abstracts to identify eligible articles. Discrepancies were resolved through discussion and agreement. Specialized journals were also specifically reached to identify relevant articles, specifically the 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. The final search strategy for each database is presented in Table S1 (Supplementary Material 3). Finally, the removal of duplicates, title/abstract screening, and full-text screening were conducted using the Rayyan application [14].

Studies selection and data charting

Three reviewers independently screened all included citations and full-text articles and agreed on their eligibility. A standardized data extraction tool was created using Microsoft Excel and utilized to chart data from all eligible articles. In addition, the following information was collected independently by three reviewers: authors, year of publication, focus of the study, title, relevant/irrelevant, objectives, country, challenges, recommendations, and conclusion. Discrepancies were resolved through discussion and agreement between the authors.

We followed the framework proposed by Arksey and 'O'Malley for data synthesis and charting [11]. Eligible studies were grouped based on common themes. Our grouping focused on the following three themes in Table 1: i) Courses, curriculum, and syllabus; ii) Training,

Table 1 Key definitions of the three identified themes employed in this scoping review

Theme	Definition
Courses, curriculum, and syllabus	In general, articles focus on one or more of the following educational terms: a) Courses are the individual units within a program that focus on specific areas of knowledge and skills b) Curriculum is the entire program of study required to earn a specific degree, encompassing all courses, learning experiences, and assessments c) A detailed syllabus provides information on a specific course, required learning objectives, major topics, assessments, and other information
Training, competencies, and skills development	In general, articles focus on one or more of the following terms: a) Training encompasses structured learning experiences implemented through various training programs, which can be both formal and informal, to gain the necessary knowledge, skills, and attitudes necessary for competent professional practice b) Competencies are the observable, demonstrated, and measurable ability or skill required to perform specific tasks and apply knowledge through practical exercises and real-world experiences c) Skill development is the process of acquiring and continuously refining one's practical abilities and skills by utilizing various learning methods needed for competent professional practice and other professional related tasks
Assessment, evaluation, and mentorship methods	Articles focusing on the structured processes, multiple methods, various tools, and evaluation strategies used to measure the students' knowledge, skills, competencies, and attitudes as well as their learning progress throughout the program

competencies, and skills development; and iii) Assessment, evaluation, and mentorship methods.

Development of the conceptual model

To develop a comprehensive conceptual model guiding the creation of collective, high-quality pharmacy postgraduate (MSc/PhD) programs, we conducted a rigorous literature review focusing on the challenges, recommendations, factors, and successful interventions. To synthesize this information, we employed the Arksey and 'O'Malley framework for data synthesis and charting. The model development process involved the following steps:

1. Identification of key themes: Based on the literature review, three primary themes emerged as critical for postgraduate pharmacy program development:
    - Courses, curriculum, and syllabus
    - Training, competencies, and skill development
    - Assessment, evaluation, and mentorship methods
2. Model construction: A conceptual model was constructed around these themes, incorporating essential components, including:
    - Curriculum design and development, including necessary and optional elements
    - Competency-based curriculum development
    - Training and skills development aligned with student, program, and job market needs
    - Diverse assessment and evaluation methods to measure program effectiveness, student learning, and job market impact
    - Successful interventions and international experiences
3. Model enrichment: To ensure comprehensiveness, the model was expanded to include additional factors and emerging trends deemed important to the study team. For instance, under the "courses and curriculum" theme, we incorporated elements like needs assessment, regular evaluation, and program refinement to promote the concept of program sustainability. Additionally, we explored the potential of using advanced tools like artificial intelligence for assessment, evaluation, and mentorship, based on what has been reported within the included studies.

Overall, this systematic approach, grounded in both literature and practical examples, resulted in a robust conceptual model to inform the development and evaluation of collective, high-quality pharmacy postgraduate programs.

Results

Literature search

After removing duplicates, 5542 articles were identified from the different searched databases (Fig. 1). After titles and abstracts screening, 5461 citations were excluded because they matched our exclusion criteria, leaving 81 full-text articles to be further assessed for eligibility. Among them, 45 were excluded and summarized with their exclusion reasons in Table S3 in Supplementary Material 3. The remaining articles ($n=36$) matched our inclusion criteria and were included in this scoping review.

Study characteristics

Based on their primary focus, the included studies were classified into three commonly identified themes, as defined in Table 1. Study characteristics are summarized in Table 2, including the study authors, publication year, focus, objectives, place of origin, design, and main findings. Among them, 14 addressed courses, curriculum, and syllabus issues; 9 discussed training, competencies, and skills development; and 13 targeted topics pertaining to assessment, evaluation, and mentorship methods (Fig. 2). The studies implemented various designs, including quantitative, qualitative, and mixed-method (Fig. 2).

The included publications on various pharmacy postgraduate educational programs (MSc, PhD, or both) were segregated based on their focus on the three themes (Fig. 3). Notably, most research articles concentrated on master's programs compared to PhD programs, validating that more research is conducted on this program type (Fig. 3). In addition, the distribution of research on Master programs across the three themes revealed a larger number of publications focusing on courses, curriculum, and syllabus (Fig. 3). In contrast, research on PhD programs disclosed that training, competencies, and skills development garnered the most attention, implying a distinct focus on research efforts and underlining the necessity of competencies/skills development for PhD graduates (Fig. 3). Details on the distribution of the articles by country are outlined in Fig. 4a.

Courses, curriculum and syllabus

As outlined in Fig. 2, 14 publications were dedicated to enhancing courses and curricula for various specialized MSc and PhD programs. These originated from nine countries, and as outlined in Fig. 4b, most of these studies were conducted in the USA ($n=5$, 35.71%), followed by Australia ($n=2$, 14.29%). Additional contributing countries encompassed Jordan, Iran, Portugal, Malaysia, the Netherlands, Switzerland, and China (Table 2). Five of the identified studies emphasized the importance of

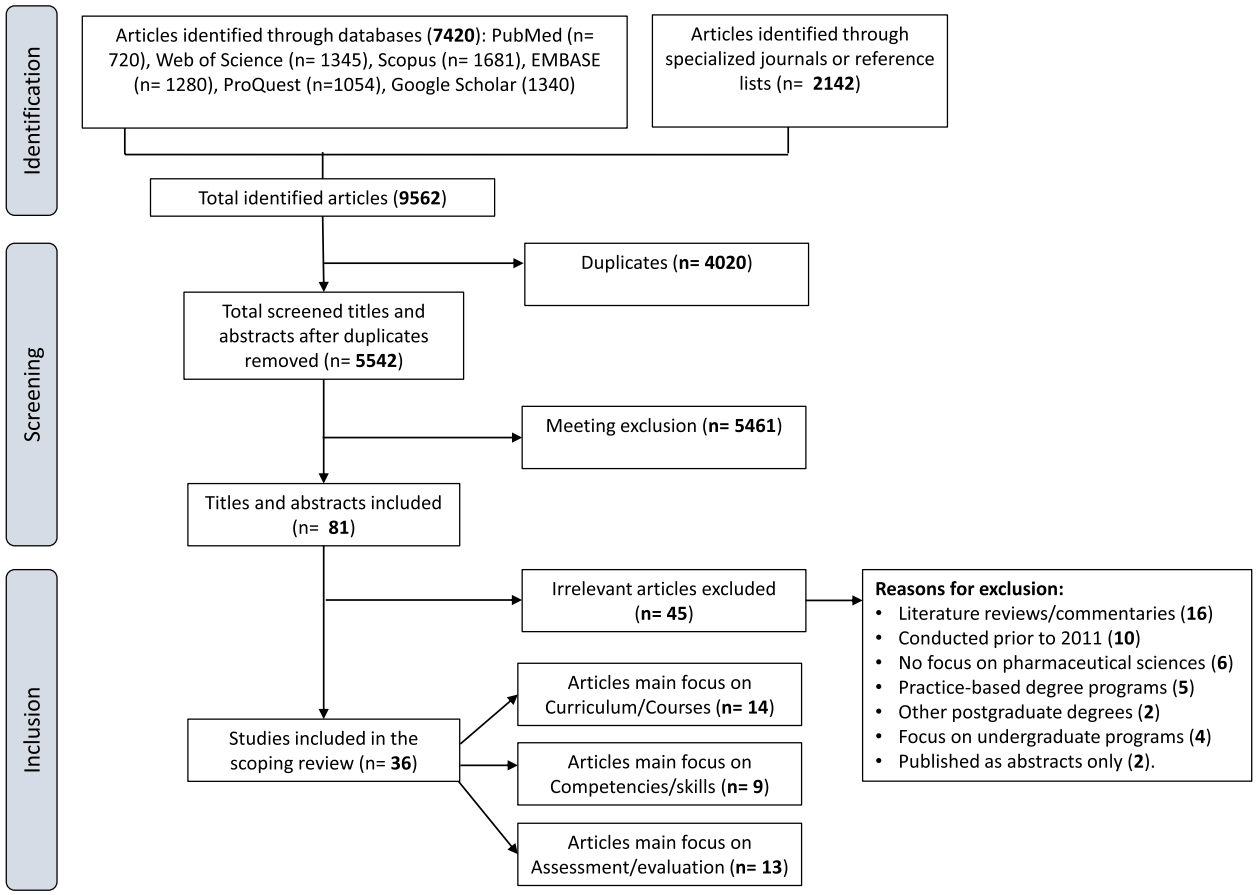

Fig. 1 PRISMA flow diagram of the studies selection process

specialized courses for improving postgraduate education (Table 2), such as research ethics, preparation for future faculty roles, pharmacoinformatics, and laboratory experience [15–19]. In the context of curriculum development, nine studies specifically addressed the design, format, review, and restructuring of postgraduate pharmacy programs to meet students' present and future needs [20–28]. Methodologies utilized in these studies included descriptive analyses, cross-sectional questionnaires, and surveys, as well as the incorporation of focus groups and interviews (Table 2).

Training, competencies and skills development

Nine published studies evaluated specific skills necessary for inclusion in postgraduate curricula (Fig. 2). Most of these studies originated from the USA ($n=7$, 77.7%), with the remaining two published in India and Poland (Fig. 4a). Most studies ($n=8$, 88.9%) primarily focused on PhD students, while only two included MSc students (Fig. 3). The studies shed light on the need for developing competencies and skills in research, curriculum development, communication, health administration and leadership, industrial training, and critical thinking and problem-solving (Table 2). Study designs were varied and encompassed mixed-methods, cross-sectional surveys, retrospective studies, interviews, and descriptive studies (Table 2).

Assessment, evaluation and mentorship methods

The third group of studies ($n=13$) embraced approaches and criteria for assessing students' performance, methods for delivering certain lectures, and mentorship (Table 2). Consistent with the previous themes, the majority of the studies ($n=5$, 38.46%) were based in the USA, while two articles originated from Jordan ($n=2$, 15.38%) (Fig. 4). The remaining studies originated in the United Kingdom, India, Denmark, China, Australia, and Ukraine. Six studies within this group focused on assessment methods, emphasizing the importance of comprehensive evaluation and peer review (Table 2) [38–43]. Two studies specifically emphasized the significance of evaluating students' performance without merely focusing on testing theoretical understanding [41, 42] (Table 2). Additionally, four studies advocated the added value of artificial

Table 2 Characteristics and results of the included studies under each identified theme

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 evaluate the number/type of partnerships and type of content added by mentors, and chart the current career status of the graduates who finished the Preparing Future Faculty (PFF) course	Oklahoma, USA	Descriptive	Most of the PFF graduates have secured faculty positions. PFF was noted to be a sustainable and valuable course for students planning to work in academia
Freitas M, et al. [16]	2016	Biochem Mol Biol Edu	MSc	To equip students with a real laboratory experience, the Non-Stop Lab Week (NSLW) module was created as part of the MSc curriculum	Portugal	Cross-sectional survey	Most of the students found the intensity of the NSLW very suitable and useful for their careers and similar to their experience in their current workplace
Nikravanfard N, et al. [17]	2017	Dev World Bioeth	MSc, PhD	To explore the quality and quantity of research ethics training courses in postgraduate medical sciences programs in Iran	Iran	Descriptive	Research ethics teaching was lacking in the majority of the postgraduate medical programs in Iran
Zainal N, et al. [18]	2017	Ther Innov Regul Sci	MSc	To assess the requirements for pharmacoinformatics courses in pharmacy BSc and MSc programs	Malaysia	Cross-sectional survey	It was reported that MSc degree had higher expectations than BSc, pointing to the need for an in-depth pharmacoinformatics curriculum content
Ahmed W, et al. [19]	2021	PLoS One	MSc	To evaluate research ethics education in MSc pharmacy programs in Jordan and compare it to international programs	Jordan	Descriptive	Research ethics in pharmacy graduate programs was found to be inadequate in Jordan and worldwide
b. Curriculum format							
Fuhrmann C, et al. [20]	2011	CBE Life Sci. Educ	PhD	To recommend a more comprehensive doctoral curriculum that prepares for diverse science- career paths	California, USA	Cross-sectional survey	Students were considering various career paths (research and non–research)
Eddington N, et al. [21]	2016	Am J Pharm Educ	MSc/PhD	To develop an evidence-based report for a competency-based and practical model of graduate and postgraduate education	USA	Cross-sectional focus group and survey	Three main recommendations: the need to focus on career guidance, external peer review, and preparing students for roles in academia

Table 2 (continued)

Authors	Year	Journal	Focus	Objective(s)	Country	Design	Results/conclusion
Barrett J, et al. [22]	2016	Pharmacol. Res	MSc	To present an established MSc in Drug Discovery and Development program and discuss its rational	Pennsylvania, USA	Descriptive	There was a growth in admitted students and successful placement of almost all students in various relevant industrial and research settings
Lypson M, et al. [23]	2016	BMC medical education	MSc/PhD	To recognize and apply changes to advance the activity of the institutional program review committee	Michigan, USA	Cross-sectional focus group and interviews	A committee that employs the expertise of a set of dedicated faculty and previous residents has great benefits over other types of evaluation committees' structures
Allen G, et al. [24]	2018	Ther Innov Regul Sci	MSc	To identify which required updates to the program to meet the future students' educational needs	Australia	Survey/Questionnaire	The program has been revised based on the respondents' recommendations. E.g., it has been shortened to two years of part-time study, a fully online program, with assessment tasks that deliver real-world experience to achieve their target career aims
Keller F, et al. [25]	2018	J Med Educ Curric Dev	PhD	To describe the resulting PhD program's rationale, 10 building blocks and structures	Switzerland	Descriptive	The program demonstrated conceptualized PhD education based on European standards, which may offer guidance to more interdisciplinary health sciences PhD programs
Chisholm O. [26]	2019	Front Pharmacology	MSc	To redesign and evaluate the program to meet modern academic requirements and the local industry needs	Sydney, Australia	Descriptive	The program has transformed from an instructive hybrid model to a completely online interactive model
Koster A, et al. [27]	2020	Pharmacy (Basel)	MSc	To describe the design of three programs allied to community or hospital pharmacists)	Netherlands	Descriptive	The curricula format suggests that these programs would facilitate the development of professional identity and professional expertise
Gu J, et al. [28]	2021	Journal of Chinese Pharmaceutical Sciences	MSc	To examine the current status and emerging trends in professional Master of Pharmacy education in China	China	Surveys (E-mail, telephone, literature)	The master's pharmacy program in China was found to be insufficient to meet demand. Obtaining a professional doctorate is recommended to address complex practical issues in drug production and regulation

Table 2 (continued)

Authors	Year	Journal	Focus	Objective(s)	Country	Design	Results/conclusion
Theme 2: Training, Competencies, and Skills Development							
a. Research competencies							
Poloyac S, et al. [29]	2011	Am J Pharm Educ	PhD	To determine and use core competencies for training students admitted into the clinical pharmaceutical sciences PhD program	Pittsburgh, USA	Descriptive + Retrospective evaluation	Core competencies were developed. Students had above-satisfactory performance in 78.6% of the examination 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 implement and evaluate a curriculum development seminar	Indiana, USA	Cross-sectional focus group	A faculty simulation of curriculum development was found to be an effective method for preparing students for relevant responsibilities
c. Communication skills							
Garces H, et al. [31]	2015	Curr Pharm Teach Learn	PhD	To evaluate and introduce students to communicating their research to lay audience who have no scientific background	Kentucky, USA	Cross-sectional Survey	The event survey showed that mentors and participants recognized an improved confidence in speaking skills to the public. The judges pointed out the need for formal means to improve soft skills essential for professional growth
Ponzio N, et al. [32]	2018	J Microbiol Biol Educ	PhD	To help students communicate their research more clearly to diverse audiences	New Jersey, USA	Descriptive	Upon completion of the course, students were markedly more confident and fluent when communicating their findings
d. Health administration and leadership training							
Colmenares E, et al. [33]	2021	Am J Health Syst Pharm	MSc	To describe the plan, progress, employer and alumni insights of a program merging an MSc degree with a residency training in health-system pharmacy administration and leadership	North Carolina, USA	Descriptive + cross-sectional survey	Respondents indicated achievement of the main outcomes and core competencies. Supervisors pointed out that they would most likely hire this program graduates for administrative positions

Table 2 (continued)

Authors	Year	Journal	Focus	Objective(s)	Country	Design	Results/conclusion
e. Industrial training							
McLaughlin J, et al. [34]	2019	Plos One	PhD	To understand what employers seek in PhD graduates to help colleges better align students' training with workplace needs	North Carolina, USA	Interviews of experts from the different pharmacy disciplines	Breadth and depth of knowledge, communication, adaptability, collaboration, experiential training, research output, and motivation were among the recognized themes
Lebovitz L, et al. [35]	2020	Am J Pharm Educ	PhD	To examine the features of a PhD enrollees and graduates in a full-time program and examine their career readiness and preparation	Maryland, USA	Descriptive	Most graduate programs were found to provide inadequate training for industry-related skills, and therefore, these experiences are required to better train graduates for non-academic careers
f. Critical-thinking and problem-solving							
Panczyk M, et al. [36]	2019	Acta Pol Pharm	PhD	To evaluate the Evidence-Based Practice competencies of doctoral students at the College of Pharmacy at the Medical University of Warsaw	Poland	Descriptive + Cross-sectional Surveys	Insufficient knowledge and approaches in critical appraisal of evidence-based pharmacy of scientific articles and problem-solving were noted. It was also demonstrated that the use of hybrid learning (classroom plus online multi-module course) can enhance the learning experience
Gajbhiye S, et al. [37]	2021	Perspect Clin Res	PhD	To evaluate students' and instructors' perceptions of using critical appraisal tools for research. And to evaluate the students' performance	India	cross-sectional questionnaire-based evaluation	Respondents reported that criticism of journal articles is crucial for postgraduate education. Participation in a JC activity led to the enhancement of critical appraisal of published research
Theme 3: Assessment, Evaluation, and Mentorship Methods							
a. Performance assessment							
Robinson G, et al. [38]	2015	CTSJOURNAL	MSc	To allow for personalized feedback at the midpoint	Pittsburgh, USA	Descriptive	The CCR process could be time-consuming for both students and faculty; however, it is deemed worth the time, cost and efforts
Leak R, et al. [39]	2015	Am J Pharm Educ	MSc, PhD	To use an active-learning strategy to improve grant writing training	Pittsburgh, USA	Descriptive + Cross-sectional survey	Grades had improved considerably upon resubmission. In addition, survey respondents indicated an increase in confidence when writing a grant

Table 2 (continued)

Authors	Year	Journal	Focus	Objective(s)	Country	Design	Results/conclusion
Bloom T, et al. [40]	2016	Am J Pharm Educ	MSc	To cultivate a program-level appraisal method for an MSc degree in pharmaceutical sciences program	North Carolina, USA	Descriptive	A program-level assessment process was developed for the MSc in pharmaceutical sciences program using an iterative process of data collection, peer evaluation, and discussions
Abu Farha R, et al. [41]	2020	J. Acad. Ethics	MSc, PhD	To evaluate postgraduate students' perception, knowledge, and behavior about plagiarism	Jordan	A cross-sectional survey	The postgraduate students demonstrated a high level of understanding of the concept of plagiarism; however, the rate of plagiarism among them was very high
Sweden S, et al. [42]	2020	Heliyon	MSc, PhD	To explore the compliance of graduate students in Jordanian universities to proper practices about informed consent and confidentiality	Jordan	A cross-sectional questionnaire	The study reported unsatisfactory adherence of postgraduate students to maintaining data confidentiality and handling informed consent when dealing with human subjects
Alcorn S, et al. [43]	2022	Currents in Pharmacy Teaching and Learning	MSc	Redesign and evaluate a less labor-intensive approach to VIVA exams [technology-assisted VIVA exam (TaVIVA)] to gauge student acceptability, reduce anxiety, and preserve assessment authenticity	Australia	Post-activity survey	Students expressed high satisfaction with TaVIVA, emphasizing its fairness and reduced anxiety. There was agreement on the need for further development. While considering it to be less authentic, students recognized the necessity of traditional VIVA assessments with assessors present
b. Tools/methods for delivering lectures							
Richardson A, et al. [44]	2013	Am J Pharm Educ	MSc	To investigate whether teaching the molecular basis of the interactions between drugs and their targets using a 3D technology is more successful than traditional 2D graphics	United Kingdom	Randomized controlled trial	Using a 3D presentation of drug-receptor interactions significantly enhanced students' understanding compared to learning from conventional 2D graphics
Swanson H, et al. [45]	2014	J Med Educ Curric Dev	MSc, PhD	A pilot study to assess the value of utilizing technology (Lecture Tools) as an active learning method in teaching Pharmacokinetics and Pharmacodynamics	Kentucky, USA	Descriptive and a Cross-sectional survey	Results imply that Lecture Tools can potentially be successfully used in medical education

Table 2 (continued)

Authors	Year	Journal	Focus	Objective(s)	Country	Design	Results/conclusion
Jalgaonkar S, et al. [46]	2019	Indian J Pharmacol	MSc/PhD	To assess the perception of postgraduate pharmacology students toward computer-simulated method (CSM) as compared to the traditional isolated live tissue-based (LAE) bioassay	India	A questionnaire-based survey	CSM was found to improve the experimental outcomes and confidence when conducted before LAE
Volodymyrovych T, et al. [47]	2022	International Journal of Computer Science and Network Security	MSc	To evaluate the experience in using peer-to-peer platforms and immersive technologies, particularly virtual reality technology in the training of future masters of pharmacy	Ukraine	Pre-post quiz and cross-sectional questionnaire	A substantial improvement, with students' pre-test average at 26% and post-test average at 74% using peer-to-peer platforms and virtual reality. Survey results show an overall 86.73% satisfaction with these technologies in training future MSc of pharmacy students
c. Mentoring							
Soucy K, et al. [48]	2016	CellPress	PhD	To define a new model for graduate guidance and training in collaboration with corresponding laboratories	Maryland, USA	Descriptive	Dual mentorship reduced the time to graduation without minimizing the efficiency or outcomes of the alumni
Raffing R, et al. [49]	2017	BioMed Central	PhD	To investigate PhD supervisors' self-reported requests and desires based on their experiences with supervising PhD students in medical majors	Denmark	A semi-structured interview	The supervisors of PhD students reported a need and aspiration for competence enhancement focusing on PhD supervisors, especially in the clinical context
Yue J, et al. [50]	2019	Stud. Educ. Evaluation	MSc	To help in developing pharmacy mentors by exploring mentors' and graduates beliefs concerning the value of mentor competence	China	A questionnaire-based survey	Mentors' development should be encouraged via supportive policy, time, and appropriate programs. Secondly, mentors' competencies should be examined in terms of mentor coaching and evaluation. Lastly, mentors must endorse all competencies voluntarily

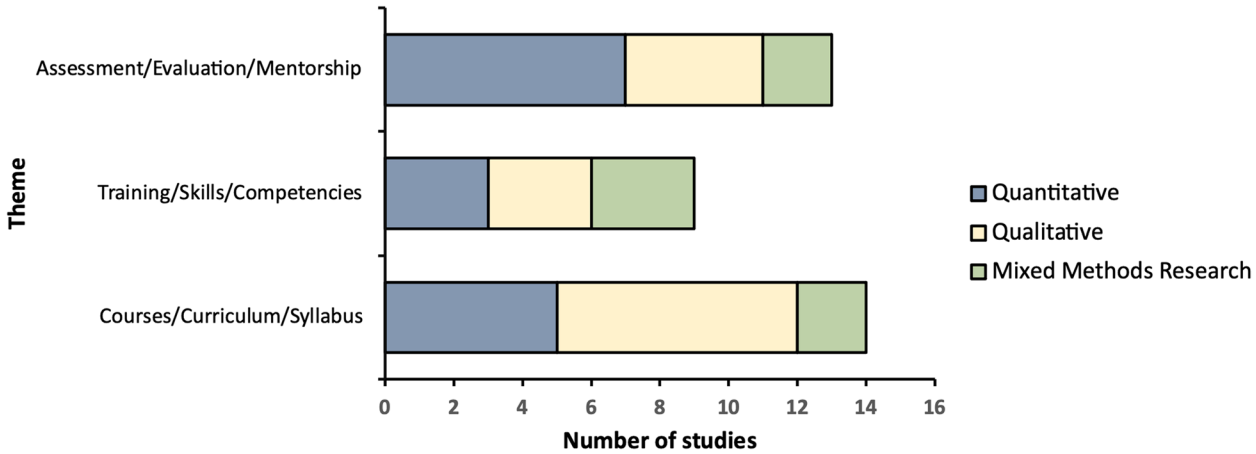

Fig. 2 Distribution of the research methods employed in the included studies per identified theme

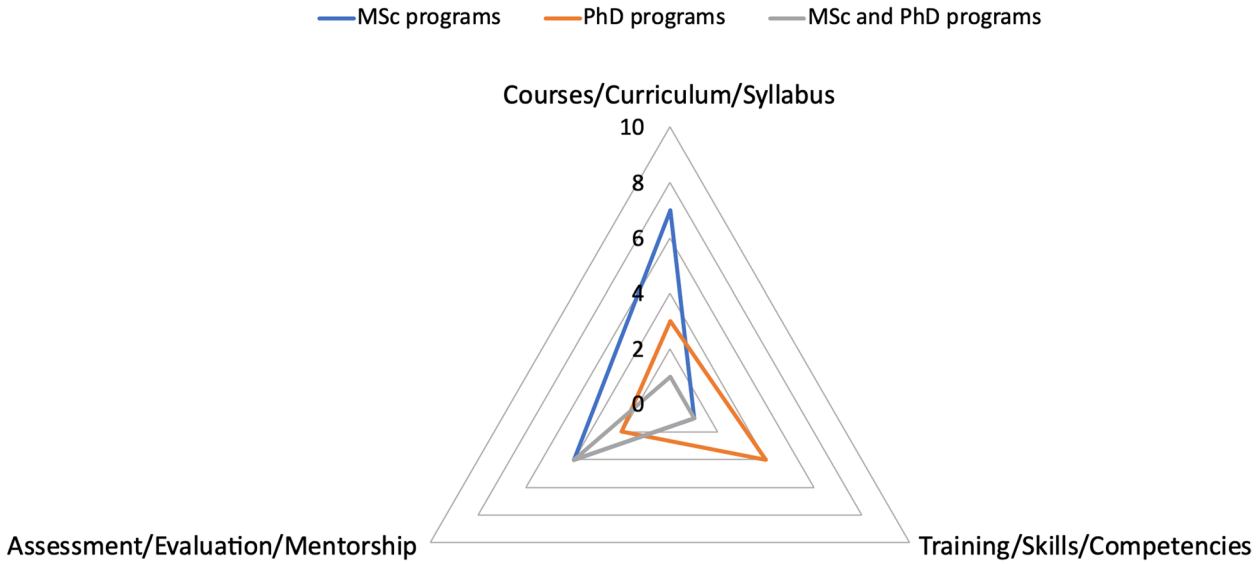

Fig. 3 A radar chart comparing the three identified themes based on the postgraduate program type

intelligence and computer-based tools in delivering lectures and elucidating certain life sciences concepts [44–47] (Table 2). Three studies evaluated postgraduate mentorship models, highlighting the positive impact of dual mentors [48–50] (Table 2).

The conceptual model content

To visualize the relationships among the identified themes and relevant key components, we developed a conceptual model (Fig. 5). Figure 5 presents the final summary derived from our comprehensive literature review of the core elements proposed for a collective high-quality pharmacy postgraduate (MSc/PhD) educational program. To our knowledge, this is the first model to be developed and published on the specific topic of pharmacy postgraduate educational programs. All the identified insights, perspectives, challenges, and recommendations that can inform the optimization of postgraduate pharmacy programs at universities worldwide have been grouped together to allow for the development of this coherent model outlining the following themes:

Courses, curriculum and syllabus

This theme encompasses curriculum design and development. Studies investigating the key concept of curriculum design and development, particularly emphasizing the importance of aligning the curriculum to concepts of competency-based learning, job market demands, career

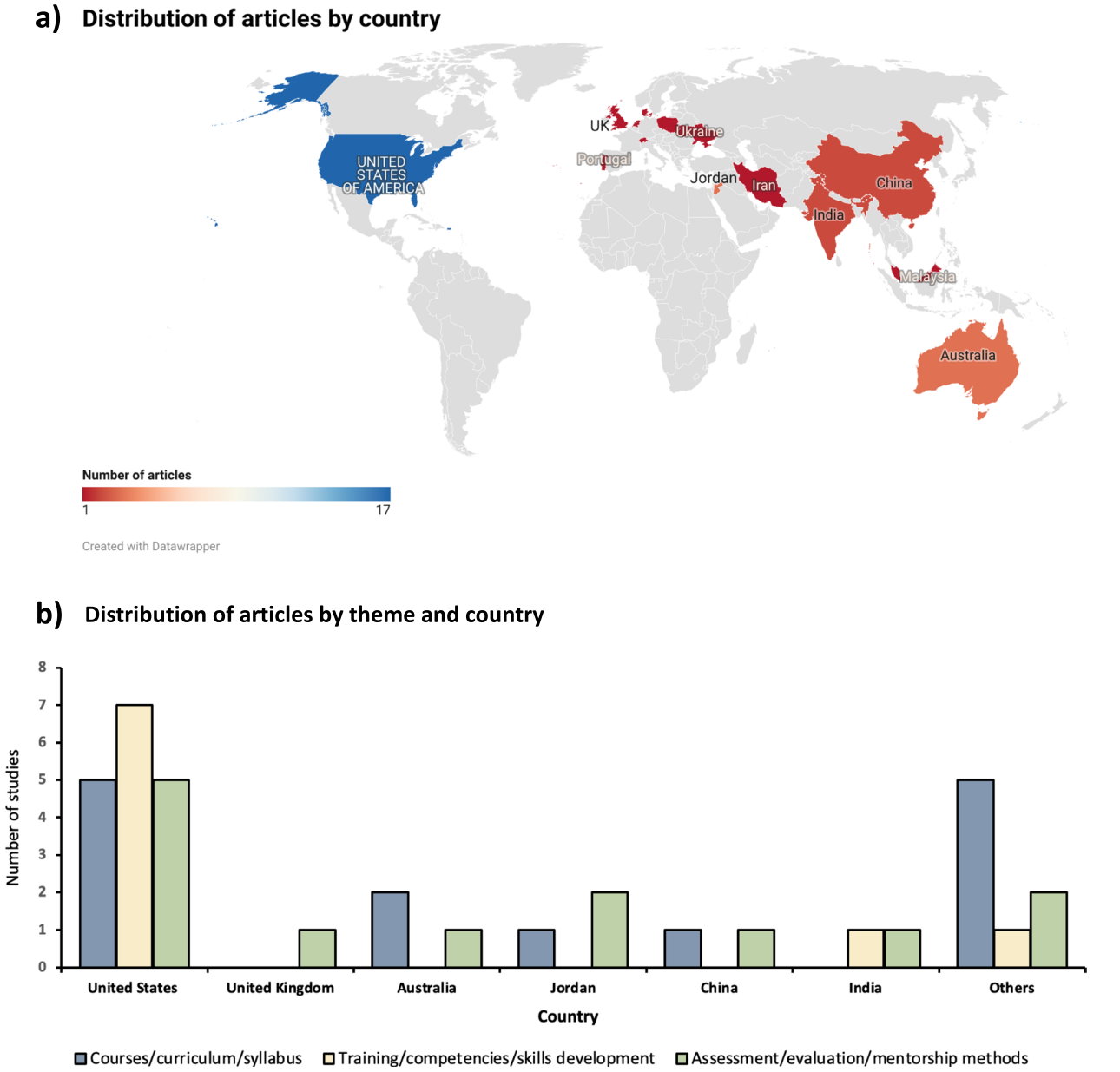

Fig. 4 Distribution of research articles: (**a**) Overall 36 articles by country; (**b**) Articles based on country and identified theme

planning, collaboration, research, specialization areas, and others. It was noted that a number of concepts are needed to develop a comprehensive postgraduate program that is essential for graduates' success and meets the needs of the job market.

Training, competencies and skill development

This theme included the main components a program could target to implement effective change in students' knowledge, skills, attitudes, and competencies required in real-world practice. It was noted that skills relevant to other disciplines, e.g., leadership and management, data science, as well as various non-science communication skills, are highly essential for the modern job market. Additionally, the necessity of providing students with training on additional non-academic career skills was deemed crucial and had a positive influence on students' skills and competencies, as well as the effectiveness of programs to produce graduates who can meet the demands of employers in the modern job market.

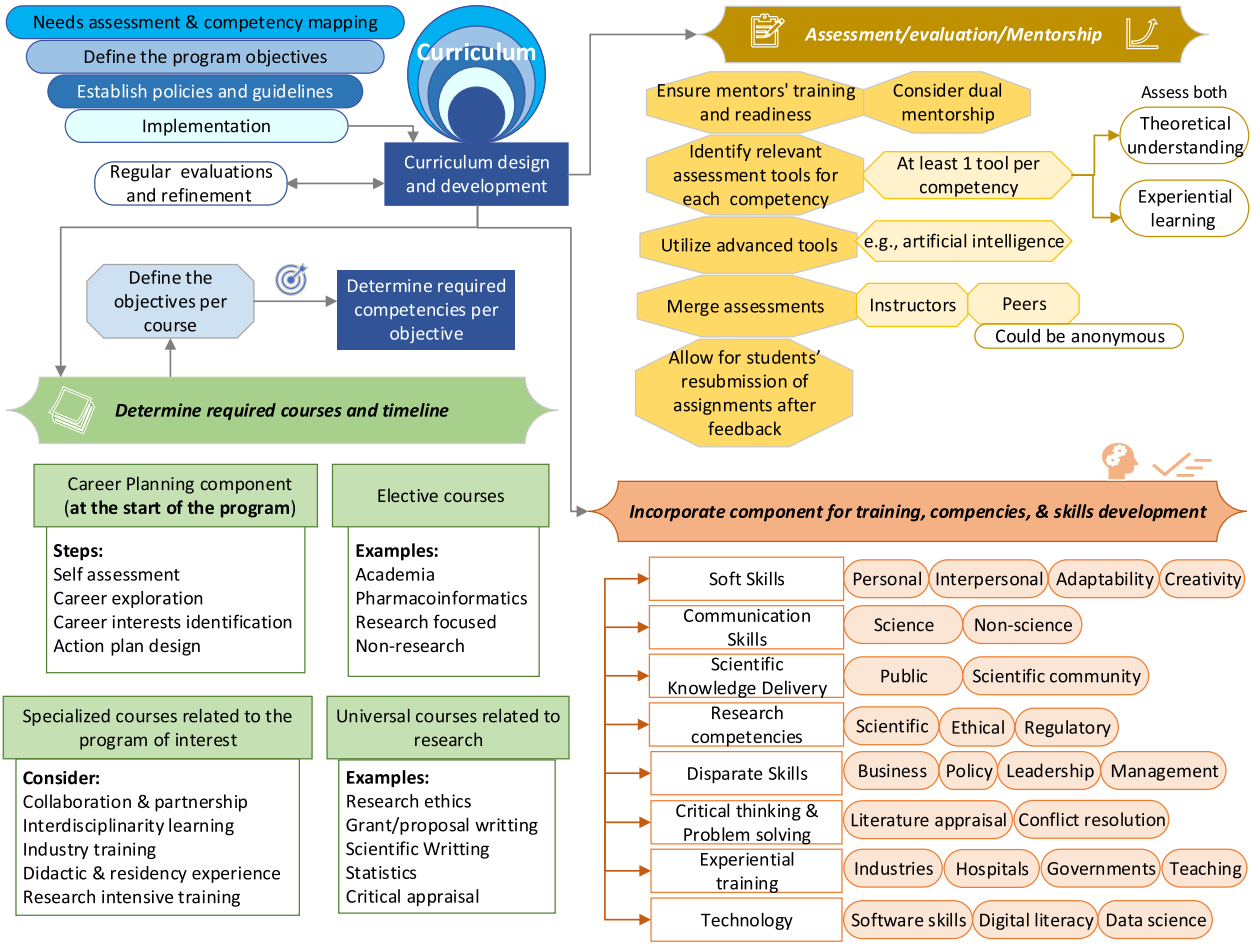

Fig. 5 A conceptual framework for developing a collective high-quality Pharmacy postgraduate (MSc/PhD) educational program. This illustration was developed based on the recommendations discussed in the literature from the relevant identified themes

Assessment, evaluation and mentorship methods

This theme features the role of effective assessment and mentorship in program development and student success. Various assessment strategies, such as mentorship, advanced assessment tools, merged assessment, and peer assessment, were all positive experiences reported in the literature with the potential benefit of conducting successful assessments of students learning and intervention effectiveness, both of which are related to successful program implementation and development.

Discussion

Principal findings

This scoping review aimed to map the existing literature on postgraduate education in pharmacy systematically. We identified 36 primary studies addressing the curriculum, skills development, and/or assessment approaches of postgraduate (MSc and PhD) pharmacy programs on an international scale. The studies were categorized and will be discussed based on their primary focus into three distinct themes: i) courses, curriculum, and syllabus issues; ii) training, competencies, and skills development; and iii) assessment, evaluation, and mentorship methods.

Courses, curriculum and syllabus

A group of studies explored the importance of different universal and specific courses within diverse pharmacy postgraduate curricula.

One of the crucial topics explored in the literature for its critical value in pharmacy postgraduate education is research ethics (RE). RE education is an integral component that equips students with the necessary skills to adhere to ethical standards when designing and conducting clinical and biomedical research [51, 52]. Unfortunately, the findings indicate that ethics training in postgraduate programs related to pharmacy and medical sciences remains insufficient, particularly in developing countries such as Jordan and Iran [17, 19, 42]. Ahmed et al. also reported that, on a global scale, only 10% of research-based master programs offered standalone

research ethics courses, and 40% offered some discussions within their curriculum [19]. Consequently, it is recommended that postgraduate schools consider integrating comprehensive research ethics training into their curricula, especially in developing countries. Furthermore, there is a need for additional studies in developed countries to explore this aspect further.

While many students pursue higher education to enter academia, postgraduate schools often prioritize research skills over teaching skills [53]. Teaching assistantships can offer students interested in academia practical teaching experiences [54]. However, not all students can access such opportunities, necessitating a compromise. For instance, integrating embedded lectures and courses into the curriculum can provide a viable solution. Preparing Future Faculty (PFF) was a valuable course to prepare graduate students and postdoctoral fellows for academic teaching [15]. The course syllabus included practical teaching experience and lecture delivery under dual supervision [15]. By the end of the course, many PFF graduates could secure faculty positions, and the course was distinguished as sustainable and valuable for students planning to work in academia [15]. The same course was taught to doctoral public health students and it showed excellent outcomes [55]. Similar courses can be adopted in postgraduate programs, especially PhD, as optional electives for students interested in academia.

A study by Fox et al. highlighted the urgent need to include pharmacoinformatics courses in pharmacy master's programs [18]. In particular, careers in pharmacoinformatics require students to have advanced conceptual knowledge and hands-on experiential education [56]. Recommended lecture topics encompass drug formulary management, advanced pharmacy and medical informatics, supply chain management, evidence-based medicine, and health policy [18]. Notably, the study revealed higher expectations for pharmacoinformatics knowledge for MSc graduates compared to their BSc counterparts, emphasizing the necessity for developing a comprehensive postgraduate pharmacoinformatics curriculum [18].

Another important curricular element is laboratory experience, particularly in basic sciences postgraduate programs. For example, the Non-Stop Lab Week (NSLW) was formed as part of the master's program at the University of Aveiro, Portugal, to equip students with real-life lab experience [16]. Over 1 week, students independently conducted molecular assay projects in an environment mirroring a real laboratory setting [16]. Most students found the NSLW's intensity very suitable and beneficial for their careers [16]. After graduation, they found this exposure to be similar to their experience in their current workplaces [16]. Often, postgraduate students focus solely on specific skills aligned with their thesis supervisor's area of expertise, potentially missing out on essential skills for future roles in the pharmaceutical industry. Therefore, experiences like the NSLW help expose students to the actual work environment. Likewise, programs may add curricular modules for students to get hands-on exposure to different research projects during their first semester, offering insights into potential future careers and a great scientific breadth while connecting with potential thesis supervisors.

Concentrating on a few specific courses is insufficient, and crafting a comprehensive curriculum poses a complex challenge [57]. There is a notable shift towards Competency-Based Education (CBE) in contemporary postgraduate and undergraduate pharmacy and medical education systems due to its demonstrated effectiveness [58–60]. CBE occurs when a curriculum incorporates comprehensive tasks, such as systems of instruction, didactic and experiential courses, and assessments to demonstrate proficiency in taught skills and concepts [60]. Various studies advocated incorporating CBE when developing postgraduate pharmacy curricula [21, 25–27]. Keller et al. suggested some curricular components and building blocks to be included in postgraduate pharmacy education, encompassing the decision on core competencies, foundational concepts, lectures, syllabus, thematic training, research seminars, research integrity, supervision, student feedback, evaluation, assessment, stipends and financial support, and alumni networking [25]. They also proposed a set of competencies to be taught in PhD health sciences programs, categorized into three domains [25]:

1. Scientific knowledge: information literacy, research methods, scientific writing, ethics and integrity, and professional conduct.
2. Management and Organization: self-management, project management, and teaching.
3. Leadership and personal: leadership and communication.

Pharmacy education continues to adapt to the evolving needs of diverse pharmacy career paths. Initiatives for developing curriculum recommendations have been undertaken, focusing on equipping graduates with knowledge and skills for future career paths. A key initiative is the American Association of Colleges of Pharmacy (AACP) Research and Graduate Affairs Committee report [20]. The AACP report was developed based on data from different universities within the USA [21]. It addressed universal skills applicable to all pharmacy disciplines to be incorporated into different curricula [21]. These identified skills were grouped into five domains [21]:

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

The three key proposals endorsed by the report were the need to concentrate on career guidance, external peer review, and preparing students for roles in academia [21]. In another study by Koster et al., three distinct pharmacy-related master's programs tailored for community or hospital pharmacists were described [27]. These programs were adapted to pharmacy education based on the CanMEDS framework, which originally describes the required skills for physicians to effectively address the needs of the individuals they serve [27]. In addition, the authors highlighted the importance of experiential (workplace) education over traditional on-campus education and the need to expose the students to a mixture of both [27].

A very important curriculum component is career planning and professional skills development. This is particularly important because many postgraduates move into postdoctoral training, even if they do not plan to take a research career path [61]. Regrettably, career discussions usually happen close to graduation [20]. Indeed, early career guidance and mentoring, ideally at the program's commencement, would empower students to make more informed decisions about their future career paths. Traditionally, pursuing a PhD was synonymous with academic positions. Still, this perception has evolved in the last decade, necessitating an educational shift to prepare students for broader career options [20]. The current job market reveals a growing "supply–demand" gap, with limited academic sector vacancies and an increasing number of postgraduate students graduating annually. Therefore, there must be a shift to diversify curriculum content, gearing it towards paths beyond traditional academic careers. For example, in a study by Fuhrmann et al., biomedical PhD students indicated that they were considering various career paths (research and non-research), which underlines the necessity for a comprehensive doctoral curriculum [20]. To aid students in achieving their career goals, the development of their plans, including career planning and professional skills training, can be encouraged through discussions with program mentors. Moreover, programs may allow flexible mandatory electives where students can select their preferred courses based on their constructed career plans.

It is crucial to have regular curriculum revisions to ensure that the educational content remains current and aligns with the expanding industry requirements and needs. An example of these revisions was published by Allen et al., in which a pharmaceutical medicine curriculum was reviewed at an Australian university based on cross-sectional survey findings to identify required updates to the program [24]. They developed a two-year, part-time, fully online program with interactive assessments to support students' career goals [24]. In another study, Barrett et al. presented a qualitative description of an established Master's program in drug discovery and development [22]. The program was initially a course that was refined and expanded based on student and market demands, covering various stages of drug development [22]. The curriculum encompasses topics delivered as courses by different colleges, including epidemiology, nanotechnology, pharmacogenomics, and project management [22]. The authors reported that most program graduates secured jobs in the pharmaceutical industry upon graduation, emphasizing the significance of regular program evaluations and refinement [22]. Similarly, Lypson et al. outlined the newly adopted program evaluation process at the University of Michigan Health System, involving dedicated faculty and formal resident members [23]. This process also benefits from standardization of meetings, content experts, a transition from paper to electronic committee materials, and a focus on continuous improvement efforts for the program [23].

To uphold the quality of pharmacy postgraduate programs, supervisors must ensure students meet program requirements and graduate efficiently. Incorporating blended learning, which combines online and on-campus classroom experiences, has been suggested as a valuable learning tool [62, 63]. Furthermore, introducing dual postgraduate degrees alongside undergraduate education in pharmacy programs can enable students to attain advanced degrees in a shorter duration efficiently. Implementing a hybrid teaching format can also be helpful, particularly for working professionals.

Training, skills and competencies development

Student preparation should extend beyond curricular coursework to encompass practical training and skill development, including cultivating critical thinking skills. Postgraduate pharmacy students must acquire skills and competencies to excel in their future roles. While some skills may be specific to student specialization, others are universally applicable and should be integrated into most specialized medical and pharmaceutical programs. Furthermore, the current job market demands more than traditional scientific research skills. Students may also need to demonstrate disparate skills in business, policy management, and advanced technologies. Therefore, the curriculum should incorporate relevant course content to

address these multifaceted requirements. Competencies are frequently defined as meaningful job-related skills, knowledge, attitudes, and abilities essential for competent performance in distinct professions [60]. Key skills and competencies highlighted in the literature regarding pharmacy postgraduate education encompass research competencies, curriculum development training, communication skills, health administration and leadership training, industrial training, and critical thinking and problem-solving.

In a study published by Poloyac et al., core research competencies for a PhD program were developed in a clinical pharmaceutical sciences curriculum [29]. Eight major competencies were identified for students to integrate preclinical and clinical evidence into their research successfully [29]. These competencies included: i) literature review and evaluation; ii) hypothesis generation; iii) research methods and study design; iv) statistical methods and data evaluation; v) grantsmanship; vi) presentation and delivery of oral and written scientific information; vii) ethical conduct of research; viii) leadership, management, and multidisciplinary teamwork [29]. Each category features subcategories of competencies, and evaluation rubrics were created to assess students' performance [29]. These competencies provide a valuable framework that can be adapted for other research-based postgraduate programs.

As previously discussed, some students pursue higher education to enter academia, emphasizing the need to acquire essential competencies to excel in their potential roles. Given that curriculum development and revision are ongoing and dynamic processes, training postgraduate pharmacy students on curriculum development becomes invaluable for those aspiring to pursue an academic career in pharmacy. Newton et al. demonstrated the effectiveness of incorporating a faculty simulation of curriculum development seminar for MSc and PhD pharmacy students, offering a practical and successful tool to prepare them for the responsibilities associated with academic roles [30].

Research, being a multifaceted interdisciplinary field, demands excellent communication skills. Thus, students must undergo training in presentation, negotiation, and conflict management skills. Additionally, employers' appreciation of diverse soft skills highlights the importance of cultivating a broad skill set in graduates [64]. Studies have highlighted substantial benefits for doctoral pharmacy students who received training to enhance their communication skills, improve confidence in discussing findings, and enhance public speaking abilities [31, 32]. Therefore, integrating courses and lectures focused on communication into the curriculum emerges as an invaluable component, aiding students in cultivating and strengthening their personal and interpersonal communication capabilities.

Specialized programs often require students to develop unique skills and competencies relevant to their areas of study. For instance, a master's degree in health-system pharmacy administration and leadership training (HSPAL) was a novel program developed within the Eshelman School of Pharmacy at the University of North Carolina at Chapel Hill [33]. That program combined Master's education with practical HSPAL residency [33]. The program was designed to provide a balanced curriculum encompassing leadership, management, clinical, administrative, and didactic courses to prepare students for pharmacy administrative positions and leadership careers [33]. The program indicated attainment of the main core competencies and outcomes by enrolled students and graduates [33]. Furthermore, supervisors noted a greater likelihood of hiring graduates for administrative positions [33].

Many pharmacy programs often encompass laboratory components involving traditional basic sciences practice labs. However, there is a recognized need to integrate elements that provide students with the necessary knowledge for pharmaceutical industry practice, particularly those aspiring to work in drug discovery and development. A study revealed that most graduate programs inadequately address industry-related skills, emphasizing the importance of incorporating experiences that better prepare graduates for non-academic careers [35]. In another study by McLaughlin et al., a qualitative analysis of employers' expectations for pharmaceutical sciences PhD graduates was conducted to understand the skills sought by employers [34]. The authors identified themes such as depth and breadth of knowledge, collaboration, communication, adaptability, experiential training, research productivity, and motivation [34]. Thus, integrating a holistic lab experience throughout the study duration, rather than limiting exposure to technical skills, can add significant value. This could be implemented by placing students in local and international pharmaceutical industries for mandatory practical experiences.

Critical thinking and problem-solving are among the highly desired skills in pharmacy postgraduates and are key to successful research conduct and evaluation of published evidence. However, various barriers may hinder their acquisition, including students' perceptions, limited metacognitive skills, biases, and the need for effortful thinking [65]. Though challenging, developing and nurturing these skills is not impossible in a thoughtful and encouraging educational environment. Research from India and Poland explored these skills in pharmacy postgraduate education [36, 37]. Research from India investigated the performance and perception of students and

their instructors regarding utilizing critical appraisal tools [37]. Both students and instructors reported that journal club (JC) criticism activities were vital in pharmacy postgraduate education, contributing to an enhancement in critical appraisal skills among participating students [37]. Research from Poland reported that graduates had insufficient knowledge of and attitudes toward evidence-based pharmacy, especially in their critical appraisal of scientific articles and problem-solving skills [36]. The study suggested that blended learning, combining classroom and online multi-module courses, could enhance the learning experience [36]. Further research evaluating critical-thinking and problem-solving training in pharmacy postgraduate education across diverse countries is essential to draw wide-ranging conclusions and recommend improvements in relevant curricula.

Assessment, evaluation and mentorship

Competency-based education proves beneficial when students' competence is continually assessed throughout the program [66, 67]. A well-defined course syllabus should outline the timeline, assessment approaches, deadlines, and submissions and emphasize feedback and constructive criticism [66, 67]. Course instructors should decide on the course objectives and identify potentially relevant embedded assessment tools to achieve these goals [40]. For instance, a program-level assessment process was developed for an MSc in Pharmaceutical Sciences program using an iterative data collection process, peer evaluation, and discussions [40]. The main assessment domains were cognitive (knowledge-based), affective (emotion-based), and psychomotor (action-based) [68]. The assessment was developed utilizing Bloom's taxonomy, which includes cognitive (knowledge-based), affective (emotion-based), and psychomotor (action-based) domains, and can guide the setting of course goals based on complexity and specificity [40, 68]. Program success can be evaluated through student evaluations and feedback on course content, format, assessment methods, and suggestions [40, 68].

A set of publications explored the performance assessment of pharmacy postgraduate students. In a descriptive study by Robinson et al., a comprehensive competency review assessing postgraduates' competencies was discussed [38]. Students were required to provide written evidence for each competency, and the instructor would either accept it if found satisfactory or reject it while requesting a rewritten version to ensure the development of the required competencies [38]. Based on students' performance, the faculty member may suggest elective courses during the program's second half [38]. Similarly, in a National Institutes of Health (NIH) Grant Application Writing Assessment for pharmacology postgraduate students, grades improved considerably upon resubmission, with survey responses indicating increased student confidence in grant writing capability [39]. The study emphasized improving writing skills through writing, revision, submission, constructive feedback, rewriting, and resubmitting [39]. Together, these findings underline the importance of midpoint evaluations for various competencies. While this process may be time-consuming for students and faculty, it is considered a worthwhile investment in time, cost, and effort.

Assessing students' understanding of theoretical concepts alone may not be sufficient; they should also be evaluated based on their actions and practical applications. For instance, a study conducted in Jordan reported a high theoretical understanding of plagiarism among pharmacy postgraduate students. However, when given practical assignments, overall performance was unsatisfactory, revealing a high prevalence of plagiarism [41]. Therefore, educational institutions should ensure students learn various paraphrasing methods and are educated on useful references for plagiarism checking. In another study conducted in the same country, the adherence rate of postgraduate students to ethical standards related to data confidentiality and informed consent when dealing with human subjects was also inadequate [42]. Hence, assessing students' performance in applying theoretical concepts is also recommended to ensure they are highly competent in real-world settings.

The careful selection of tools and methods for delivering lectures is crucial, especially in the context of advancing technologies and artificial intelligence. In postgraduate education, 3D virtual computer simulation methods were deemed advantageous [44, 46]. In a randomized controlled study, using 3D technology to demonstrate drug-receptor interactions significantly enhanced students' understanding and performance compared to traditional 2D graphics [44]. Similarly, a computer-simulated method in experimental animal modeling in postgraduate pharmacology improved the experimental outcomes and confidence when conducted before an isolated live tissue-based bioassay [46]. Moreover, a pilot study assessing the value of technology (Lecture Tools) as an active learning method in teaching pharmacokinetics and pharmacodynamics demonstrated a positive experience [45]. Lecture Tools is a cloud-based system that permits various question designs, student participation, and in-class evaluations [45]. Students can use any smart device, like laptops, tablets, or mobile phones, and take notes within the same slide of the teaching presentation [45]. Despite the provision of real-time interactions, there are limitations, including weak faculty preparedness for using this tool, the time required for preparing the lecture slides, and limited lecture time [45]. Other

tools have also proven valuable for undergraduate and postgraduate pharmacy education, offering interactive and easily accessible sessions, such as Coursera and EdX platforms, Socrative, Yammer, and the Lecture Capture System [69–71].

Postgraduate supervision is crucial to students' success, emphasizing the need for high-quality and sufficient mentorship. Swedish PhD students indicated that poor supervision prolonged their studies and delayed the completion of their thesis projects [49]. Every student has the right to guarantee that their mentorship is provided by qualified supervisors capable of effectively mentoring postgraduate students. When interviewed, supervisors expressed a need for training regarding the required instructions, guidance, and clarification of their roles as mentors [49]. In a study by Yue et al., which investigated Master's mentor competence, it was reported that a mentor's development can be encouraged via supportive policy, time, and appropriate programs [50]. Secondly, the mentor's competencies should be assessed through mentor training and evaluation [50]. Lastly, mentors should endorse all competencies voluntarily [50]. The dual-mentorship model is a promising key initiative to improve mentorship in postgraduate education. Soucy et al. advocated for the dual-mentored PhD model, where each student is supervised by two expert mentors from different organizations, leading to superior outcomes [48]. Graduates of this program demonstrated great success, graduating two years earlier than traditional Ph.D. program students without compromising the outcomes [48].

After discussing each theme in detail, we employed a visual presentation to summarize the major identified challenges (Fig. 6), offering educators and readers an overview of the current potential challenges. Understanding these barriers can ensure that postgraduate pharmacy programs are effective and subject to continuous improvement. Table S4 (Supplementary Material 3) provides a detailed explanation of the identified challenges.

Study recommendations

Based on the insights driven from this scoping review, we have synthesized and developed a conceptual framework outlining an optimal structure for Pharmacy postgraduate programs (Fig. 5). This framework elucidates evidence-based recommendations for universities to improve the educational experience for students and for refining pharmacy postgraduate programs. While implementing this framework, it is noteworthy that research and improvement efforts should be tailored to each program context and capacity.

This model can be utilized by various stakeholders. The use of such a model should be tailored to the specific target audience and the overall context. Several stakeholders could benefit from the model; for example, investigators could focus their research on a theme or a subcategory to develop and examine the effectiveness of an intervention. Likewise, postgraduate students could use this model to identify the key knowledge areas, skills, and competencies they need to master in order for them to stay ahead of the continuously changing demands of the job market. Additionally, educators, management teams, and administrators at postgraduate programs could use the model for the continuous development and refinement of their postgraduate programs.

This scoping review highlights various recommendations to be explored in future research efforts. First, all included studies were observational and descriptive, with only one randomized controlled trial (RCT) and a limited number of mixed-method studies. Thus, we suggest the need for well-designed RCTs and mixed-method research studies evaluating postgraduate programs focusing on the three presented themes. RCTs would provide valuable high-level evidence to support future research and practice applications. At the same time, mixed-method studies can facilitate the collection and evaluation of unique quantitative and qualitative data in individual program contexts. Second, future research should investigate educational programs from the need assessment and/or program objective development stage to the final evaluation of programs and their improvements. Exploring the utilization of well-established frameworks from the literature will allow the development of research and/or program evaluation following a systematic and comprehensive approach. Third, there are few publications on the assessment and evaluation methods. Accordingly, investigating this theme can provide valuable information on the effectiveness of the implemented programs and guide the process of program improvement and development. Fourth, our findings suggest that research involving MSc programs focuses more on courses, curriculum, and syllabus topics and less on training, competencies, and skills development. Given the growing need for competent professionals, investigating training and competencies within MSc programs will assist in preparing competent graduates. On the other hand, there were limited studies exploring courses and curriculum topics in PhD programs. Therefore, studies investigating the development or evaluation of PhD-tailored curricula and courses, particularly those focusing on competency-based education, should be considered in future research efforts. Finally, we have identified a need for additional international research efforts, from both developing and developed countries, to advance postgraduate pharmacy education on a global scale.

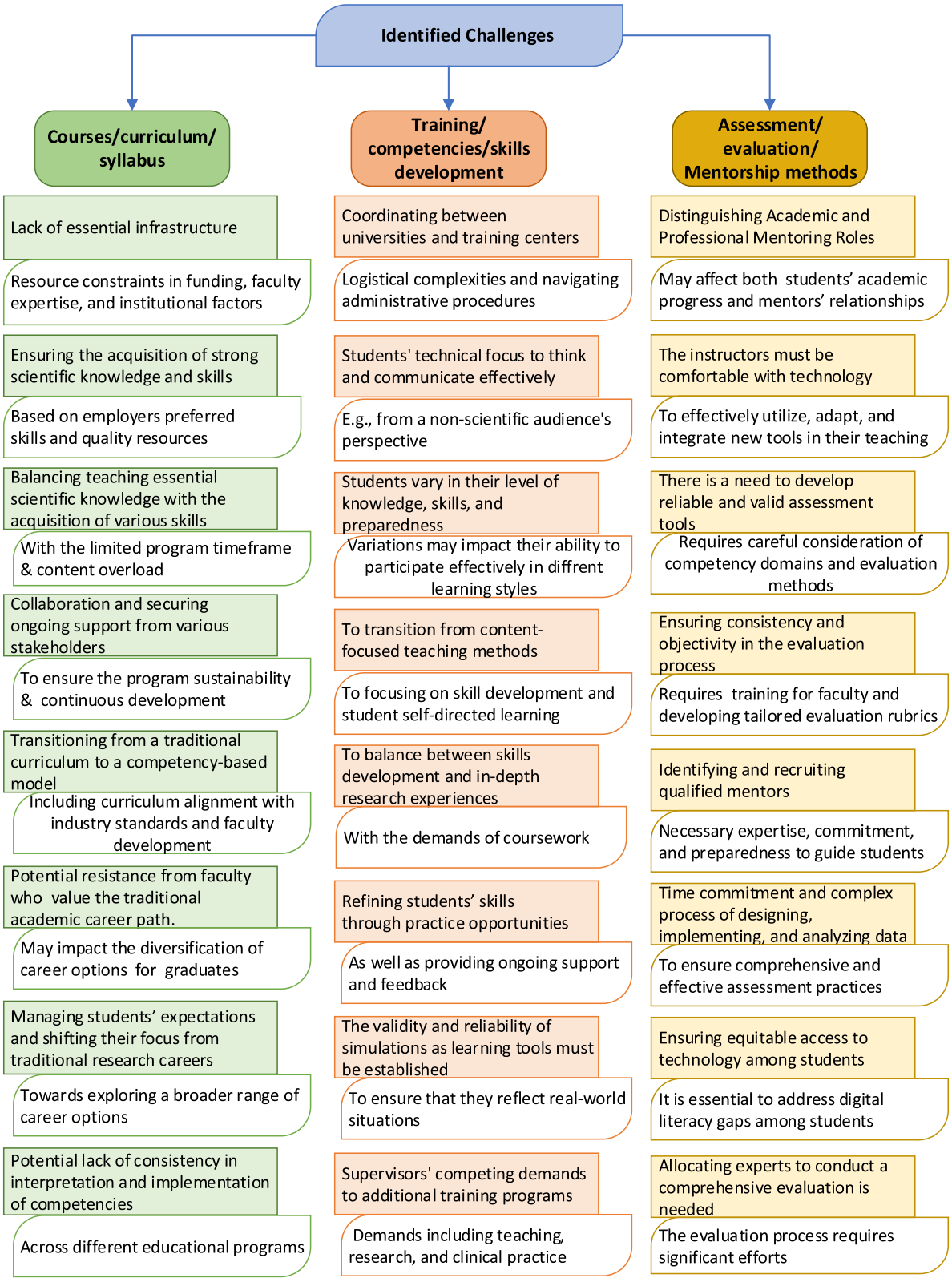

Fig. 6 A summary of the major recognized challenges from each of the three identified themes

Study strengths and limitations

Strengths and limitations inherent to the scoping review

It is noteworthy that this review is, to our knowledge, the first to systematically synthesize and chart available evidence on pharmacy postgraduate (MSc and PhD) education. Such a systematic approach offered many strengths relevant to conceptual and theoretical aspects and other strengths relevant to the standard methodology utilized in this scoping review. Studies discussed educational program implementation in detail, which provided a comprehensive overview and opportunity to learn from programs at various stages of implementation (i.e., both programs at advanced stages with successful implementation practices and nascent programs with identified improvement opportunities). The details provided in this review and in individual studies could be utilized to inform the implementation and improvement of other programs at the international level. Moreover, the included studies utilized diverse research methodologies and offered valuable insights into the current literature landscape on MSc and PhD pharmacy programs. The review also resulted in the development of an evidence-based conceptual framework for enhancing pharmacy postgraduate education. Further, included herein are outcomes of the examination of the postgraduate pharmacy educational curriculum, competency development, and assessment methods. Another strength of this study is the use of these defined themes to guide the framework constriction, analysis and presentation of findings. Additionally, methodological strengths included a) utilization of standard methodology (i.e., PRISMA-ScR) to conduct this review; b) employment of the framework proposed by Arksey and 'O'Malley for data synthesis and charting; c) utilization of a comprehensive search strategy documented in the supplementary material to increase the transparency and replicability of the search strategy; and d) utilization of major databases and journals relevant to the field of pharmacy education research to ensure comprehensiveness. Despite these strengths, this review has some limitations. Firstly, due to its scoping nature, the outcomes of the studies were not assessed using formal quality assessment tools; thus, interpretation of findings and efforts to implement any intervention or recommendation would require further investigation. However, to ensure the inclusion of high-quality data and to mitigate this limitation, we included articles from peer-reviewed journals only. Secondly, the included studies were descriptive and observational, with only one RCT. Thus, well-designed RCT studies evaluating pharmacy postgraduate programs are recommended for future research efforts. Lastly, the inclusion criteria were limited to studies published in English between 2011 and 2023; this might affect the inclusion of articles published in non-English or before 2011.

Limitations of the conceptual model

Although this model can provide a valuable foundation for developing collective, high-quality pharmacy postgraduate programs, there are some limitations to take into consideration before utilizing or interpreting the information provided, which include:

First, concerning methodological rigor, there is a need for a more robust and structured methodology for developing this model, such as the Delphi method, which would ultimately enhance its robustness. Nevertheless, the development of the model relied on a comprehensive literature review and synthesis. The model utilized a rich dataset originating from primary studies and implementing various research methodologies, e.g., survey research, qualitative interviews, and mixed-methods research. The various methodologies used in the primary studies, the various types of data originated and data qualities, as well as the unique experiences of various postgraduate programs, enriched this model and improved its quality.

Second is the issue of contextual applicability. Developing countries can find it difficult and costly to implement or adapt this model into their educational programs, mainly due to the cost and availability of necessary resources. For instance, certain components of the model could require expensive resources that are not readily affordable in low-income countries. Therefore, these educational programs should customize this model in a cost-effective approach, taking into consideration their available resources.

Finally, the consideration of stakeholders' perspectives is crucial. Various stakeholders are required to provide their perspectives and input effectively to evaluate this model before its utilization. To elaborate, educators, program administrators, and employers representing the job market may find the model or some aspects of the model not applicable to their scope of interest or resources or may identify additional factors or priorities that are not explicitly addressed in the model.

Conclusions

Postgraduate pharmacy education represents a vital transition from undergraduate learning to unique, practice-oriented knowledge, preparing graduates for exceptional service across diverse pharmacy areas, topics, pursuits, and settings. Therefore, tailored pharmacy programs at higher education institutions must constantly evaluate various aspects of their educational systems with ongoing updates to remain relevant. This scoping review offered a wide breadth of

evidence-based suggestions, recommendations, gaps, improvement opportunities, and conclusions pertaining to key areas of a) practice-oriented courses, curricula, and modules; b) performance-based assessments; c) real-world competencies, applied skills, and training; d) diverse tools and methods for teaching and learning; e) programs emphasizing the crucial role of mentorship and support in diverse pharmacy postgraduate topics. This review resulted in developing a conceptual framework, which can serve as a reverence for improving and developing Pharmacy postgraduate educational programs. Various opportunities for further research were also recognized to address various challenges and identified gaps in pharmacy postgraduate education.

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Authors' contributions

DK, OH, & MI worked on developing the study protocol. DK, OH, & NA screened and identified eligible articles. DK, OH, & AH grouped the studies, extracted the required data, and summarized the results. DK drafted the initial manuscript. AH, IA, & MI revised and edited the manuscript. MI supervised all the steps and provided guidance and feedback throughout the whole process of constructing this review. All the authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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