

Development of Competency Profile for Doctoral Candidates in Diagnostic Healthcare Fields: A Scoping Review

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Abstract

Background: Competency frameworks play a crucial role in guiding the education and training of doctoral candidates in diagnostic healthcare Fields. This scoping review aims to systematically map the existing literature on the development of competency frameworks and competency profiles tailored for doctoral-level education in diagnostic healthcare professions, particularly Pathology.

Methodology: The Arksey and O'Malley framework was applied to undertake this scoping review. A comprehensive search strategy was developed using a combination of medical subject headings (MeSH) terms and keywords related to competency frameworks, clinical competence, professional competence, diagnostic healthcare profession, doctoral education, and synonyms. Electronic databases such as PubMed, Scopus and Web of Science were searched, along with targeted searches of grey literature sources like Google scholar. We screened studies for inclusion by title and abstract, and we included studies of any type that described the development of a competency profile/framework for doctoral candidates in a Diagnostic healthcare profession. Data compilation was qualitative.

Results: The total records identified from the databases were n=204,351. Out of these the records removed before screening were Duplicate records removed (n =137,300). Records marked as ineligible by automation tools (n =51030), Records removed for other reasons (n =12,521). Records screened were n=3500. Based on the exclusion criteria n=3253 records were excluded. Reports which could not be retrieved were n=122. Finally, n=135 reports were assessing for eligibility and out of these n=71 were excluded from Allied Health Sciences and n=64 were excluded because they focused primarily on competencies of Nursing students. Finally, n=21 studies were included in the scoping review and the findings were charted.

Conclusion: We observed significant variation within the conduct and reporting of the competency framework development process. While some variation can be expected given the differences across and within medical professions, our results suggest there is some difficulty in determining whether methods were fit-for-purpose, and therefore in making determinations regarding the appropriateness of the development process. This uncertainty may unwillingly create and legitimize uncertain or artificial outcomes. There is a need for improved guidance in the process for developing and reporting competency frameworks.

Keywords: Diagnosis Strategies, Healthcare, Pathology.

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Introduction

Competence profiles outline the essential knowledge, skills, and attributes required for proficient practice in diagnostic health sciences, particularly Pathology. By identifying these competencies, educators can design and deliver high-quality doctoral programs that adequately prepare candidates for their roles in the field.¹ Competence profiles help align doctoral education with

professional standards and regulatory requirements. They ensure that doctoral candidates acquire the necessary competencies to meet the expectations of accrediting bodies, licensing boards, and professional organizations.

Diagnostic health sciences play a critical role in patient care and safety. Competence profiles guide doctoral candidates in developing the skills needed to perform accurate diagnoses, interpret results, and communicate effectively with patients and healthcare teams, thereby

enhancing the quality and safety of healthcare delivery.² Competence profiles often encompass interdisciplinary skills, fostering collaboration among healthcare professionals from different specialties.

By identifying common competencies across disciplines, doctoral programs can facilitate interprofessional education and teamwork, leading to improved patient outcomes and holistic care. Competence profiles serve as a foundation for lifelong learning and professional development. They provide doctoral candidates with a roadmap for continuous skill development and self-assessment throughout their careers, enabling them to stay abreast of advances in diagnostic technologies, evidence-based practices, and ethical standards. Clear competence profiles can facilitate career advancement and mobility for doctoral candidates in diagnostic health sciences.

By demonstrating mastery of essential competencies, candidates can enhance their employability, pursue advanced roles or specialties, and transition seamlessly between different healthcare settings or geographic locations.³ Competence profiles can also inform research agendas and drive innovation in diagnostic health sciences. By identifying emerging competencies related to new technologies, methodologies, or healthcare trends, doctoral programs can prepare candidates to contribute to cutting-edge research, develop novel diagnostic tools, and address evolving healthcare challenges. Competence profiles promote accountability and transparency in doctoral education. They provide stakeholders, including students, faculty, employers, and the public, with clear expectations regarding the knowledge, skills, and behaviors that doctoral candidates should possess upon completion of their programs, thereby fostering trust and confidence in the healthcare workforce.⁴

Supervisors in diagnostic pathology typically possess extensive expertise and experience in the field. Their firsthand knowledge of the profession, including its evolving practices, technological advancements, and regulatory requirements, allows them to provide valuable insights into the competencies required for doctoral candidates to succeed in the discipline. Supervisors are actively engaged in the practice of diagnostic pathology, often serving as practicing pathologists themselves. Their perspectives are closely aligned with the realities of clinical practice, laboratory operations, and professional standards, ensuring that competence profiles accurately reflect the skills and knowledge needed for effective performance in the field. Supervisors play a central role in shaping the professional development of doctoral candidates in diagnostic pathology.⁵ Through mentorship, guidance, and feedback, they help candidates acquire and refine the competencies outlined in the profiles, fostering their growth as competent and

ethical practitioners. Supervisors' input into competence profiles ensures that doctoral training programs support candidates' holistic development as future pathologists.

Diagnostic pathology is a dynamic field influenced by scientific advances, technological innovations, and evolving healthcare trends. Supervisors' perspectives enable competence profiles to adapt to these changing needs over time, ensuring that doctoral training remains responsive to emerging challenges and opportunities in the discipline.

Hence, aim of the study is identifying competence profiles for doctoral candidates in diagnostic health sciences particularly Pathology through scoping review of literature that are essential for promoting excellence in education, enhancing patient care and safety, fostering collaboration and innovation, and ensuring the continued advancement of the healthcare profession.

Methods

A comprehensive search strategy was developed using a combination of medical subject headings (MeSH) terms and keywords related to competency frameworks, clinical competence, professional competence, diagnostic healthcare professions (e.g. pathology), doctoral education, and synonyms. Electronic databases such as PubMed, Scopus and Web of Science were searched, along with targeted searches of grey literature sources like Google scholar.

The five stages of Arksey and O'Malley's (2005) framework were applied, comprising:

1. determining the research question
2. locating pertinent studies.
3. improving the parameters for study selection,
4. gathering pertinent information from every article, and
5. gathering, compiling, analyzing, and reporting the data

Results were presented in accordance with Annexe 1 of the PRISMA Extension for Scoping Reviews. After the citations were manually eliminated from EndNote X8 (Clarivate Analytics, Philadelphia, PA), they were imported.

Research Questions

What are the essential competencies that a PhD student in Diagnostic Pathology should possess upon completion of his training to succeed as a teacher, researcher and clinician?'

Finding Relevant Studies: Research that created a competency framework or competency profile for doctorate candidates in the health sciences, or that entailed a PhD in a healthcare profession, was eligible for inclusion. Included were studies that provided explicit descriptions of the development process and the supervisors' or teachers' perspectives on doctoral training in health sciences and diagnostics, particularly pathology. We only included the version of the data that gave the most complete information when the same data were published in multiple publications (such as a thesis and a journal article). Included were reviews, original publications, whole texts, meta-analyses, and critical reviews.

Refining The Study Selection Criteria: Studies more than 8 years old, articles in language other than English, articles where full text was not available, articles lacking a competency framework, competency profile, conference proceedings, those with unclear methodology, books, associated data and duplicate articles were excluded.⁶

Charting the Data

Charting the data for a scoping review was done by organizing and summarizing relevant information extracted from the included studies. The charting process typically involved creating a data extraction form or table to systematically capture key details from each

study. This table included a structured overview of the data extracted from each included study, including details such as the study ID, authors, year of publication, title, aim/objective, methodology, sample size, diagnostic specialty, competency components addressed, and key findings/themes identified. This format facilitated the synthesis and analysis of findings across studies during the scoping review process.⁷

Results

The records identified from the databases yielded n=204,351 articles. Records removed before screening were as follows: Duplicate records removed (n =168,300), Records marked as ineligible by automation tools (n =21030),Records removed for other reasons as per the exclusion criteria (n =11,521). The remaining 3500 articles were screened using automation and AI tools and those not fulfilling the specific inclusion criteria, those which could not be retrieved and those pertaining to Allied Health Sciences and Nursing were excluded (Annex-1).

Characteristics of the Studies included:

Sr. No.	Author, Year of publication	Research objective	Study Design	Major findings	Limitations, Gaps	Conclusion & Future research
1	McCloskey et al.,2017	To provide trustworthy professional activities that include primary anatomic and clinical pathology resident training for pathology graduate medical education.	Qualitative, Delphi, Graduate Medical Education Committee of the College of American Pathologists	Nineteen entrustable professional activities were developed, including 7 for anatomic pathology, 4 for clinical pathology, and 8 that apply to both disciplines with 5 of these concerning laboratory management.	The ability of programs to incorporate the idea of EPAs into their particular programs in a way that improves direct observation of resident performance, contributes to resident education, and avoids overly complicating the evaluation process or burdening faculty or program administration is the last obstacle facing the EPA model.	The entrustable professional activities outlined by the Graduate Medical Education Committee are meant to provide an initial framework for the development of entrustable professional activity-related assessment
2		To create and implement an instructional	expert work group of 20 pathologists to identify critical pathology	Work group researched and developed 38 peer-	The addition of new curriculum elements presents practical	It will help to better prepare all pathology residents

		framework and curriculum in pathology informatics that directs pathology residency programs in providing residents with essential knowledge and abilities in pathology informatics.	informatics training outcomes.	reviewed outcome statements identifying the knowledge and skills that all residents should have in pathology informatics to practice pathology upon completion of their residency program.	implementation obstacles, mainly related to faculty expertise and time constraints.	for the modern practice of pathology.
3		A redesigned pathology residency program that satisfies and promotes ongoing changes to the Accreditation Council for Graduate Medical Education and American Board of Pathology standards.	Qualitative, Expert Group	This model is based on five structural components: (1) an advanced credit pathway that involves involving trainees during medical school; (2) a "onboarding" procedure at the beginning of training; (3) a boot camp that converts to a core curriculum that offers foundational training throughout the AP/CP continuum; (4) advanced training modules customized to the trainee's career objectives; and (5) a period of intense and progressive responsibility culminating in independent practice experience. These components all have separate uses.	With the dawn of a new era comes new problems and the need for programs that address seemingly incompatible objectives: improving, expanding, and streamlining training.	Reduce the time to readiness for practice, and produce more effective, interactive, and adaptable pathologists.
4		Report discusses the need for a Doctorate in Clinical Laboratory Sciences program and describes a curriculum to train Doctorate in Clinical Laboratory Sciences students.	The University of Texas Medical Branch (UTMB) in Galveston, Texas, offers a Doctorate in Clinical Laboratory Sciences (DCLS) degree. This program's characteristics and outcomes are the subject of a report and survey-based Quality Improvement/Quality Assurance initiative. An anonymous survey was completed by a total of 28 faculty physicians who oversaw the students during their clinical service rotations. 33	The candidate pool's preadmission accomplishments were higher and the admission rates were lower in the last two admission cycles (2018–2019 and 2019–2020). Following the training, more than half of the graduates took up new jobs. The majority of our graduates have become laboratory directors	A clinical doctoral degree has been created for individuals who obtained nondoctoral degrees in pharmacy	DCLS programs continue to evolve, it will be critical to collect and analyze data to obtain evidence of the full impact of DCLS graduates on patient care.

			DCLS students who had completed more than half of their clinical rotations responded anonymously to a cross-sectional survey.			
5		Explores the lived experiences of biochemistry, microbiology, and pathology residency program directors to better understand how they utilize the CanMEDS competencies.	Study phenomenographic. Semi-structured interviews with eight directors of laboratory medicine programs across Canada were conducted one-on-one, and inductive thematic analysis was used to examine the collected material.	The results demonstrate how the existing framework is out of step with the particulars of laboratory medicine, with certain competences appearing to be unrelatable when compared to the current set of standardized criteria and expectations.	To make it accessible more autonomy is required to adapt the framework	Newer renditions of the CanMEDS Competency Framework should better consider the realities of non-clinical disciplines.
6		The procedure and results of a pilot project that examined whether six pathology residency programs that volunteered for the study could use two anatomic pathology and two clinical pathology EPAs in pathology training.	Pre- and post-study surveys were given to participating residents, faculty, and program directors to gauge baseline practices and to gather feedback on the EPA implementation experience.	Results demonstrated overall good feasibility in implementing EPAs. Faculty acceptance of EPAs varied and was less than that of program directors.	There are still certain obstacles to overcome, such as gaining faculty support and creating an electronic platform with data analytic capabilities and easy access.	The expanded use of EPAs in a way that makes sense for pathology residency, furthering the national goals of competency-based medical education.
7		His article explores the following question: which research competences are being imparted or acquired during medical studies and the doctorate?	Qualitative research project. Information gathered from the N=455 Bavarian Medical Graduate Panel Survey (MediBAP), in which participants evaluated their own research proficiencies. We conducted qualitative interviews with doctorate medical graduates and E-Prom research participants (N=14) in order to aggregate the data.	Quantitative analyses show that medical graduates evaluate the medical curriculum's research contents and their acquired competences as rather low.	The validity of the quantitative data returns is limited as a result of the item formulations. It would be beneficial to comprehend and specify which competencies should be acquired at various stages of medical studies due to the diversity of research competencies.	Such features, as well as the acquisition of research competencies within the ordinary medical curriculum and the PhD phase, should be able to be distinguished in the future.
8		Prom projects looked at the influence of the doctoral phase on the careers of young scientists in the life sciences using the example of doctoral graduates from biological and medical faculties.	Using quantitative techniques, a longitudinal survey of more than one thousand PhD graduates (N = 1796) from North Rhine-Westphalia, Saxony, and Bavaria was conducted at various stages after the degree. Furthermore, two qualitative investigations were carried out to enhance comprehension	Certain advantages of structured doctoral programs over conventional individual doctorates are shown via analysis. The differences between these PhD techniques, however, are not as great as first thought. Overall, there are	Unfortunately, the data do not provide any strong explanatory factors for their disadvantage	This design can already be applied in the doctoral researcher selection process, or it can be useful in the future for monitoring doctoral researchers inside the doctoral process.

			of the doctoral stage and professional entrance, as well as to illuminate the circumstances surrounding advanced postdocs in their future career planning.	significant differences in the actual design of PhD programs.		
9		Aim of the present article was the analysis of research competences among medical graduates with the newly developed Munich Medical Research Competences Scale that was piloted at the medical faculties in Bavaria.	All medical graduates from the medical faculties of FAU Erlangen-Nuremberg, LMU Munich, TU Munich, University of Regensburg, and JMU Würzburg in 2017–18 were targeted by the online survey.	The findings show that medical graduates' research competencies require improvement, particularly in the areas of study design, execution, and interpretation. The results imply that the gender effect is mediated by intrinsic motivations for pursuing a PhD	The findings are based on data from five faculties in Bavaria; nevertheless, due to contextual variations, such as improved training of research skills in redesigned medical programs, the findings may differ despite the large data base.	Using the scale at different points in time from the beginning to the end of the study programme could reveal in which phases competence acquisition takes place and in which phases it stagnates. On this basis, targeted adjustments could be made to the curriculum.
10		Review paper aims to offer deep insight into the issues affecting doctoral students by reviewing and critically analyzing recent literature on the doctoral experience	In this paper, 163 empirical articles about PhD education are examined and analyzed. Following the retrieval of all pertinent articles, the first author read and used a conventional content analysis method to analyze them.	. The prior review contained factors that may be simply categorized as internal or external to the PhD candidate. In this review, external influences are those relationships and systems involving people, things, and organizations outside of the student that could directly or indirectly affect their advancement toward a PhD.	It is important to note that although this review paper explored these external and internal variables as discrete contributing factors, they are nonetheless largely intertwined.	Future research in which the confluence of the factors discussed in this review, particularly With respect to the cross-cutting impact of socialization variables, is recommended
11		Based on our experience as graduate and postdoctoral program leaders, we recognized the need both to identify core competencies and to develop a process to assess these competencies.	Qualitative study. Proposal for a competency-based framework	Rather, we identified observable behaviors that align with the basic competencies and show how knowledge, abilities, and attitudes evolve over the course of training. We identified ten fundamental skills from the combined list that are necessary for all PhD scientists, regardless of field or career choice.	Potential confirmation bias	We suggest that such a competency-based assessment be used to guide periodic feedback between PhD students or early-career scientists and their mentors or supervisors.
12		concerns about the competencies developed through doctoral training to make the candidate	In this context, we performed a national survey answered by 2794 PhDs.	A reference framework containing 111 competencies organized in 6 main	Soft skills need to be addressed	study therefore demonstrates that PhDs develop a set of common competencies and

		ready for the industry		categories was built.		delineate its boundaries.
13		Study focuses on doctoral students' professionalisation as future academics across academic disciplines,	. The current study employs descriptive and regression analyses to compare the factors impacting doctorate students' assessed skills in terms of tasks, concepts, and attitudes. It does this by using data from 490 respondents in Hong Kong.	Results show that the competencies of doctoral students are influenced by various factors, such as curricula, supervision style and learning culture.	Small sample size and single region study	Study suggests that the formal and informal learning experiences of doctoral students must be carefully designed and implemented to foster the development of their professional knowledge, skills and values.
14		Developing a comprehensive list of statistical competencies that can be used as a guide for what medical research learners should know about statistics	Delphi technique, 18 experts in biostatistics, epidemiology, and research design proposed levels for the 21 statistical competencies.	According to our research, students who want to be primary investigators need to comprehend more than students who want to be coinvestigators do. Rather than offering a one-size-fits-all solution, educational institutions should think about evaluating their learning alternatives to make sure that information is provided at all levels.	More stake holders should be included.	This work will help strengthen statistical training to medical research learners and can help enhance undergraduate statistics education.
15		Main aim of this project is to improve the quality of doctoral education by implementing new teaching methodologies based on interdisciplinary approaches and international cooperation.	Delphi technique, expert group	Structure, content and main competences required for training highly qualified researchers.	Not an independent study	Developing communicative skills by PhD students in the framework of Foreign Language Course which is included Doctoral degree programs.
16		Testing the viability of developing a script concordance exam to gauge clinical reasoning and critical thinking abilities in the field of hematology. 2. Sharing test creation and validation experiences to help others duplicate the procedure for additional pathological areas	The experts' reactions and their satisfaction about the test were obtained.	Analysis performed with 22 vignettes having 66 items revealed a statistically significant difference between the scores of the experts and the students.	More focus on assessment of competence	Using AMEE Guide 75 and our in-detail description of the process of development, optimisation and validation of script concordance test will enable faculty in many specialities to develop and include it for use in their respective fields.

17		To critically review the African scenario with respect to doctoral supervision for Basic Medical Sciences and proffer potential solutions in the form of a supervisory model.	Narrative review of literature, critical appraisal of the current prevalent scenario, and proposition of a supervisory model.	This article presents a model that might employ effective, innovative, and practical approaches to address the current situation.	There is a need to conduct research on relevant subjects to provide further insight into the prevalent scenarios, the root cause of the problems and postulate potential solutions to the problems.	A model that might employ effective, innovative, and practical approaches to address the current situation.
18		Aimed primarily at preparing students for innovative roles in their fields, they include variously structured approaches to curricular offerings, as well as other program components applicable across specialties (eg: supervisor support, scientific conduct, transferable skills).	Qualitative study	The conceptual underpinnings, justification, structures, and ten building blocks of the resulting interdisciplinary PhD program are described in this article. These include student portfolios, thematic training, interdisciplinary research seminars, student-initiated interdisciplinary activities, financial support for course participation, top-up and extension stipends, PhD supervision, research integrity, alumni follow-up network, and promotional tools like a dedicated website.	The PPHS needs to be interpreted in the context of a policy that provides major incentives for PhD education.	Based on European norms, the Basel PPHS represents the cutting edge of health sciences PhD education and provides other organizations with advice from program conception to launch for multidisciplinary PhD programs in the health sciences.
19		To present revised core competencies for doctoral programs in health services research (HSR), modalities to deliver these competencies, and suggested methods for assessing mastery of these competencies.	Update/ review article. Core competencies were originally developed in 2005, updated (but unpublished) in 2008, modestly updated for a 2016 HSR workforce conference, and revised based on feedback from attendees. Additional feedback was obtained from doctoral program directors, employer/workforce experts	The current version (V2.1) competencies include the ethical conduct of research, conceptual models, development of research questions, study designs, data measurement and collection methods, statistical methods for analyzing data, professional collaboration, and knowledge dissemination.	However, there is little evidence to support this supposition or the conditions under which these modalities realize optimal student outcomes.	Core competencies in HSR are a continually evolving work in progress because new research questions arise, new methods are developed, and the trans-disciplinary nature of the field leads to new multidisciplinary and team building needs.
20		One Health (OH) is an integrated approach that aims to sustainably balance and optimize the health of people, animals, and	Commentary/Review	. To address the complexity of OH concerns in socio-ecological systems, trainees must grasp the fundamentals of multiple disciplines,	How to develop doctoral OH programs that are coherent with their educational objectives still requires more work.	To maximize the impact of future OH research and interventions.

		ecosystems. On the basis of a review of OH doctoral programs, we advocate for integrating social-ecological systems thinking in OH doctoral training		including the social sciences. Systems thinking must be integrated in OH core competencies.		
21		The EU-funded CHAMELEONS project aimed to identify and fulfill the needs of Ph. D. students towards pursuing a career in digital and connected health industry.	A range of courses or educational material provided by CHAMELEONS consortium members, or available in open platforms were identified, organized and offered to 15 students of diverse background, enrolled in the program through a State-of-the-Art (SotA) toolkit.	Students selected courses not actually improving hard skills needed for their research, but soft skills in the business and career management direction, focusing mostly on creativity, innovation, and communication.	More diverse groups should be included	The students mentioned that the drive for their selection was based on self-awareness tools which identified the underdeveloped skills required for a successful career.

List of Citations included in the Review:

Serial No.	Title of study	Citation
1.	Curriculum Content and Evaluation of Resident Competency in Clinical Pathology (Laboratory Medicine) A Proposal.	Smith BR, Wells A, Alexander CB, Bovill E, Campbell S, Dasgupta A, Fung M, Haller B, Howe JG, Parvin C, Peerschke E. Curriculum Content and Evaluation of Resident Competency in Clinical Pathology (Laboratory Medicine) A Proposal. Pathology Patterns Reviews. 2006 Jun 1;125(suppl_1):S3-7.
2.	Pathology informatics essentials for residents: a flexible informatics curriculum linked to accreditation council for graduate medical education milestones (a secondary publication)	Henricks WH, Karcher DS, Harrison Jr JH, Sinard JH, Riben MW, Boyer PJ, Plath S, Thompson A, Pantanowitz L. Pathology informatics essentials for residents: a flexible informatics curriculum linked to accreditation council for graduate medical education milestones (a secondary publication). Academic pathology. 2016 Jul 8;3:2374289516659051.
3.	Training pathology residents to practice 21st century medicine: a proposal. Academic Pathology.	Black-Schaffer WS, Morrow JS, Prystowsky MB, Steinberg JJ. Training pathology residents to practice 21st century medicine: a proposal. Academic Pathology. 2016 Sep 27;3:2374289516665393.
4.	The doctorate in clinical laboratory sciences: a new curriculum to enhance the connection of the laboratory to health care providers.	Salazar JH, Zahner CJ, Freeman VS, Laposata M. The doctorate in clinical laboratory sciences: a new curriculum to enhance the connection of the laboratory to health care providers. Academic Pathology. 2021 Aug 6;8:23742895211034121.
5.	The CanMEDS Competency Framework in laboratory medicine: a phenomenographic study exploring how professional roles are	Bogaty C, Frambach J. The CanMEDS Competency Framework in laboratory medicine: a phenomenographic study exploring how professional roles are applied outside the clinical environment.

	applied outside the clinical environment.	Canadian Medical Education Journal. 2024;15(1):26-36.
6.	National pilot of entrustable professional activities in pathology residency training.	Bryant BH, Anderson SR, Brissette M, Childs JM, Gratzinger D, Johnson K, Powell DE, Powell SZ, Timmons CF, Chute D, Cummings TJ. National pilot of entrustable professional activities in pathology residency training. <i>Academic Pathology</i> . 2024 Apr 1;11(2):100110.
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9.	The Munich Research Competence Scale: Research Competence among Doctoral Candidates and Graduates in Medicine Results from the second Wave of the Bavarian Graduate Study in Medicine	Epstein N, Reimer M, Gartmeier M, Fischer MR, Berberat PO, Huber J. The Munich Research Competence Scale: Research Competence among Doctoral Candidates and Graduates in Medicine Results from the second Wave of the Bavarian Graduate Study in Medicine. <i>Beiträge zur Hochschulforschung</i> . 2021;4:210-26.
10.	The PhD experience: A review of the factors influencing doctoral students' completion, achievement, and well-being.	Sverdlík A, Hall NC, McAlpine L, Hubbard K. The PhD experience: A review of the factors influencing doctoral students' completion, achievement, and well-being. <i>International Journal of Doctoral Studies</i> . 2018 Sep 16;13:361-88.
11.	Competency-based assessment for the training of PhD students and early-career scientists.	Verderame MF, Freedman VH, Kozłowski LM, McCormack WT. Competency-based assessment for the training of PhD students and early-career scientists. <i>Elife</i> . 2018 May 31;7:e34801.
12.	The core competencies of PhDs. Studies in Higher Education.	Durette B, Fournier M, Lafon M. The core competencies of PhDs. <i>Studies in Higher Education</i> . 2016 Aug 2;41(8):1355-70.
13.	Learning experience and perceived competencies of doctoral students in Hong Kong.	Jung J. Learning experience and perceived competencies of doctoral students in Hong Kong. <i>Asia Pacific Education Review</i> . 2018 Jun;19:187-98.
14.	The importance of statistical competencies for medical research learners.	Oster RA, Enders FT. The importance of statistical competencies for medical research learners. <i>Journal of Statistics Education</i> . 2018 May 4;26(2):137-42.
15.	Development of soft skills by doctoral students.	Valeeva E, Ziyatdinova J, Galeeva F. Development of soft skills by doctoral students. In <i>The Impact of the 4th Industrial Revolution on Engineering Education: Proceedings of the 22nd International Conference on Interactive Collaborative Learning (ICL2019)–Volume 2</i> 22 2020 (pp. 159-168). Springer International Publishing.
16.	Addressing the need to develop critical	Kelkar AJ, Bhandary S, Chacko TV. Addressing the need to develop

	thinking skills in the new competency-based medical education post graduate curriculum in pathology: Experience-sharing of the process of development and validation of script concordance test.	critical thinking skills in the new competency-based medical education post graduate curriculum in pathology: Experience-sharing of the process of development and validation of script concordance test. Archives of Medicine and Health Sciences. 2022 Jul 1;10(2):160-7.
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Discussion

a) Compilation and Synopsis

Graduates of doctoral degrees in the medical sciences have the advanced knowledge and abilities necessary to take on leadership roles in clinical practice, research, and education. Different programs place different emphasis on different essential competencies.

Numerous important issues emerge from the literature on the abilities of doctorate candidates in the medical sciences.

b) Knowledge Specific to a Discipline

A thorough awareness of the latest research trends and the scientific underpinnings of the particular discipline of medical science.

C. Research Skills: The capacity to plan, carry out, evaluate, and interpret scientific research; this includes

having a solid understanding of data analysis, statistical procedures, and research **methodologies**.

Critical thinking is the ability to assess scientific literature critically, formulate research questions, and create solid research methods.

Communication Skills: Ability to effectively communicate both orally and in writing to audiences in the scientific and lay domains in order to share research findings. articles grant proposals, creating scientific presentations, and producing scientific articles are all included in this.

Maintaining ethical standards in research, such as authorship rights, data management, and scientific integrity, is a sign of professionalism and responsible conduct.

Research abilities, critical thinking, clinical reasoning, multidisciplinary knowledge, and communication were the main capabilities found. The implementation of

competency-based approaches has brought to light some notable challenges, such as inadequate curriculum design, scarce faculty assistance, and insufficient resource allocation. Obstacles like lack of experience and time constraints

Research abilities, critical thinking, clinical reasoning, multidisciplinary knowledge, and communication were the main capabilities found. The implementation of competency-based approaches has brought to light some notable challenges, such as inadequate curriculum design, scarce faculty assistance, and insufficient resource allocation. Time restrictions and a lack of experience were highlighted as further barriers. In order to present a competency-based model that focused on the outcomes, various assessment techniques were suggested, such as script concordance tests, entrustable professional activities (EPAs), and qualitative evaluations. Research has demonstrated the significance of continuous evaluation and input in guaranteeing the achievement of competencies. As a step toward outcome-based medical education, competency-based training has been linked to improved readiness for roles in the industry and modern medical practice. According to reports, PhD holders were hired to work as instructors, laboratory directors, and business executives. The major competencies identified were research skills, critical thinking, clinical reasoning, interdisciplinary knowledge, and communication. The prominent issues highlighted in implementing competency-based approaches, including lack of faculty support, weak curriculum design, and limited resource allocation. Suggestions were made to include soft skills development, interdisciplinary perspectives, and alignment with industry needs. Some studies identified gaps in competency development, particularly in areas such as study design, implementation, and interpretation.

C. Appraisal of the Literature

The literature on competencies for doctoral candidates in medical sciences highlights a focus on research-driven expertise. However, some potential grey areas are evident which are relatively less mentioned such as:

Interpersonal Skills: While communication skills are mentioned, there may be less emphasis on collaboration, teamwork, and conflict resolution – crucial for navigating complex research environments.

- **Teaching Skills:** Doctoral programs may not fully prepare graduates for teaching roles, which could be particularly relevant for those pursuing academic careers.

- **Leadership Skills:** Leadership development might be under-represented, even though doctoral graduates are expected to take the initiative and lead research teams.

Conclusion

The body of research emphasizes how crucial competency-based methods are to training PhD candidates for a variety of medical scientific careers. But in order to overcome implementation obstacles, adjust to changing industry demands, and guarantee the efficacy of competency-based training initiatives, more research and innovation are required. Consequently, merely stating the significance of competency-based education would not fulfill the review's objectives; rather, it emphasizes the necessity of developing impartial procedures for these competency-based approaches' implementation and evaluation. Overall, the literature highlights the importance of competency-based approaches in preparing doctoral candidates for diverse career paths in medical sciences. However, there is a need for ongoing research and innovation to address implementation challenges, adapt to evolving industry demands, and ensure the effectiveness of competency-based training programs. Therefore, mere identification of the importance of competency based education will not suffice the purpose of the review, infact it points towards the need to establish objective methods of implementation and assessment of these competency based approaches.

Limitations

Limitations included small sample sizes, lack of regional focus, and potential biases in survey-based research

Recommendations

- This scoping review will open avenues for researchers to develop a competency framework for the doctoral candidates in diagnostic healthcare fields.
- It will also form a foundation to develop a competency-based curricula for PhD in Diagnostic Healthcare fields.
- Entrustable professional activities against each competency may be developed to contribute towards outcome based medical education.

Further Research Opportunities

- Investigate the specific competencies required for different career paths in medical sciences (e.g., academia, industry, government).

- Explore the integration of transferable skills (e.g., interpersonal skills, leadership) into doctoral programs.
- Assess the effectiveness of current doctoral programs in preparing graduates for the demands of a medical science career.

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