Article:
Ou, Q., Tang, D., Chen, S. et al. (8 more authors) (2025) The landscape and challenges of postgraduate dental basic research education: a scoping review. BMC Oral Health, 25. 849. ISSN 1472-6831

https://doi.org/10.1186/s12903-025-06227-4

BMC Oral Health

SYSTEMATIC REVIEW Open Access

The landscape and challenges of postgraduate dental basic research education: a scoping review

Qianmin Ou[1†], Deqian Tang[1†], Shijie Chen[1†], Zhuohong Gong[1], Manqing Liu[1], Xuejing Gan[1], Gengbin Cai[1], Xiaolan Li[1], Xuebin B. Yang[2], Yun Hong[1*] and Zetao Chen[1*]

Abstract

Background Scientific research plays an important role in the advancement of dentistry. Postgraduate Dental Basic Research Education (PDBRE) is essential for enhancing the research knowledge and skills of research-focused students. This scoping review aims to identify the landscape and challenges of PDBRE, while also proposing future directions to further strengthen and optimize its effectiveness.

Methods The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Extension for Scoping Reviews and followed a descriptive approach based on Arksey and O'Malley's framework. A systematic search was conducted across PubMed, Web of Science, Embase, and the Education Resources Information Center (ERIC) databases to identify relevant literature up to May 20, 2024.

Results The review screened 660 publications and selected 10 articles based on strict inclusion and exclusion criteria. These articles focused on curriculum contents, teaching methodologies, assessments, outcomes, and challenges related to effective research education in PDBRE.

Conclusions PDBRE can enhance research-focused students' foundational scientific research abilities by diversifying the curriculum content and teaching methodologies. However, challenges such as resource constraints, faculty shortages, workload, and student engagement hinder its development. To address these issues, we suggest strengthening faculty expertise and student involvement, alongside implementing a more systematic curriculum and improved assessment tools.

Clinical trial number Not applicable.

Keywords Medical education, Dentistry, Basic research, Postgraduate

†Qianmin Ou, Deqian Tang and Shijie Chen contributed equally to this work.

*Correspondence:
Yun Hong
hongjun5@mail.sysu.edu.cn

Zetao Chen
chenzet3@mail.sysu.edu.cn
[1]Hospital of Stomatology, Guanghua School of Stomatology, Guangdong Provincial Key Laboratory of Stomatology, Sun Yat-sen University, 56Lingyuan Road West, Guangzhou, Guangdong 510055, P. R. China
[2]Biomaterials and Tissue Engineering Group, School of Dentistry, University of Leeds, Leeds LS9 7TF, UK

Introduction

Dentistry has continuously evolved along with advancements in basic sciences including biology, chemistry, and materials science [1, 2]. Basic research in dentistry is pivotal in developing a comprehensive understanding of oral biology [3]. It has provided insights into the mechanisms underlying dental diseases, such as the role of microorganisms in dental caries and cellular pathways in periodontal disease [4–6]. Given the pivotal role of basic research in advancing dental science, equipping postgraduate students with robust research competencies becomes imperative.

Postgraduate medical education comprises two important components: academic and clinical sciences [7]. Research-focused students in postgraduate programs focus more on academic sciences and are willing to become professionals who become the main driving forces for the advancement of dental sciences [8]. The Postgraduate Dental Basic Research Education (PDBRE) program was specifically designed to equip postgraduate students with essential research skills and foundational knowledge in dentistry [9, 10]. The program is tailored to build on their existing dental knowledge and foster a research-oriented mindset, contributing significantly to the professional development of those who aspire to pursue academic research in dentistry [11–13]. Through the PDBRE program, students understand the mechanisms and principles underlying various dental diseases and conditions. This knowledge enables them to develop innovative solutions and approaches to clinical problems, thereby contributing meaningfully to solving real-world challenges in dentistry and ultimately advancing both scientific and clinical fields.

Despite the growing interest in research-oriented postgraduate education in dentistry, PDBRE remains an emerging concept. While PDBRE is gaining recognition as a key component of dental education, it is not yet universally standardized or implemented across institutions. Globally, the content and format of PDBRE vary significantly. For example, in the United States, PDBRE is typically implemented *via* standardized curricula and structured courses [14]. In contrast, Germany tends to offer more personalized and research-oriented curricula that prioritize independent study and mentorship guidance [14]. This variability, while understandable given differing institutional contexts, may result in significant disparities in the quality and outcomes of research education [15]. While students entering the PDBRE program typically have an undergraduate dental education, some may also have exposure to biomedical sciences or related fields [16, 17]. Moreover, the lack of standardized content, teaching methodologies, and assessment systems across programs can lead to inconsistent training experiences and unclear benchmarks for success. While variability in program structure can allow for flexibility and innovation, it also creates challenges in ensuring that students receive a comparable and high-quality education across different institutions. Given the increasing global emphasis on research excellence, it is critical to identify common challenges and opportunities within PDBRE programs. A clearer understanding of these programs can facilitate cross-institutional collaboration, enhance the exchange of best practices, and ensure that PDBRE programs are better equipped to meet both local needs and international standards.

This scoping review aims to outline the landscape and challenges of the different PDBRE programs available. We aim to provide a comprehensive overview that can guide the enhancement of educational strategies and highlight areas for further research and development within this field. In line with the objectives of this scoping review, our primary focus is to examine the educational strategies, encompassing curriculum content and methodologies. Subsequently, we will evaluate the outcomes based on their assessment practices and uncover the underlying challenges that hinder optimal PDBRE implementation. The research questions (RQ) were as follows:

RQ 1 What are the curriculum contents and methodologies in PDBRE programs?

RQ 2 What are the educational outcomes based on these assessment systems?

RQ 3 What specific challenges impede the effective implementation of PDBRE programs?

Methods

This scoping review employed a descriptive approach based on Arksey and O'Malley's five-stage framework: (1) identifying the research question; (2) identifying relevant studies; (3) selecting studies; (4) charting the data; and (5) collating, summarizing, and reporting the results [18]. Our methodology adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Extension for Scoping Reviews [19].

Identifying relevant studies

A systematic search was conducted across four databases: PubMed, Web of Science, Embase, and Education Resources Information Center (ERIC). The search strategy was developed in collaboration with an experienced medical librarian and included keywords and subject terms related to dental education, postgraduate studies, educational methodology, and basic research (as detailed in Supplementary Table 1). The literature search was restricted to publications before May 20, 2024.

Table 1 Exclusion and inclusion criteria

Criteria	Inclusion	Exclusion
Educational Level	Programs detailing education for postgraduate dental students	Studies not specific to postgraduate dental education
Relevance	Peer-reviewed articles, conference abstracts, and dissertations related to PDBRE	Reviews or studies not specific to postgraduate dental education
Content focus	Publications discussing educational strategies, assessments, outcomes, or barriers in PDBRE	Articles not focusing on research education components
Language	English language literature	Non-English language studies

Study selection

This review's inclusion and exclusion criteria were as follows (Table 1). We restricted the language of the literature to English. The selection process involved two independent reviewers screening the titles and abstracts according to the eligibility criteria. Any discrepancies were resolved through discussion or by involving a third reviewer. After the initial screening, the remaining articles underwent a full-text reading and quality assessment. The literature screening process is encapsulated in a flow diagram (Fig. 1).

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram provides a detailed overview of the information retrieval and literature screening process.

Charting the data

A data extraction form was developed to collect information on the type of article, curriculum contents, teaching methodologies, assessments, outcomes, and challenges. The data were extracted by two reviewers, and any inconsistencies were resolved through discussion.

Results and discussion

Synthesis of results

After conducting a thorough search, we found 660 articles, which were carefully assessed for relevance and eligibility. Ultimately, 10 articles were included in this scoping review based on strict inclusion and exclusion criteria. These studies were conducted in various countries: two in the United States, and one each in Pakistan, the Syrian Arab Republic, Turkey, New Zealand, Canada, India, the United Kingdom, and China. Collectively, these articles provide diverse insights into postgraduate dental basic research education (Fig. 1). Table 2 and Supplementary Table 2 provide a detailed overview of the basic information for each of the included articles.

Curriculum contents

Fundamental knowledge in research-focused subjects

The curriculum of PDBRE programs is designed to provide a robust foundation in essential subjects crucial for dental research education. Students are exposed to a diverse range of disciplines, including oral oncology, orthodontics, restorative dentistry, histology, embryology, anatomy, and more [20–23]. By delving into these foundational areas, students gain a deep understanding of the biological, anatomical, and pathological aspects relevant to dental research. This knowledge is essential for critically analyzing scientific literature,

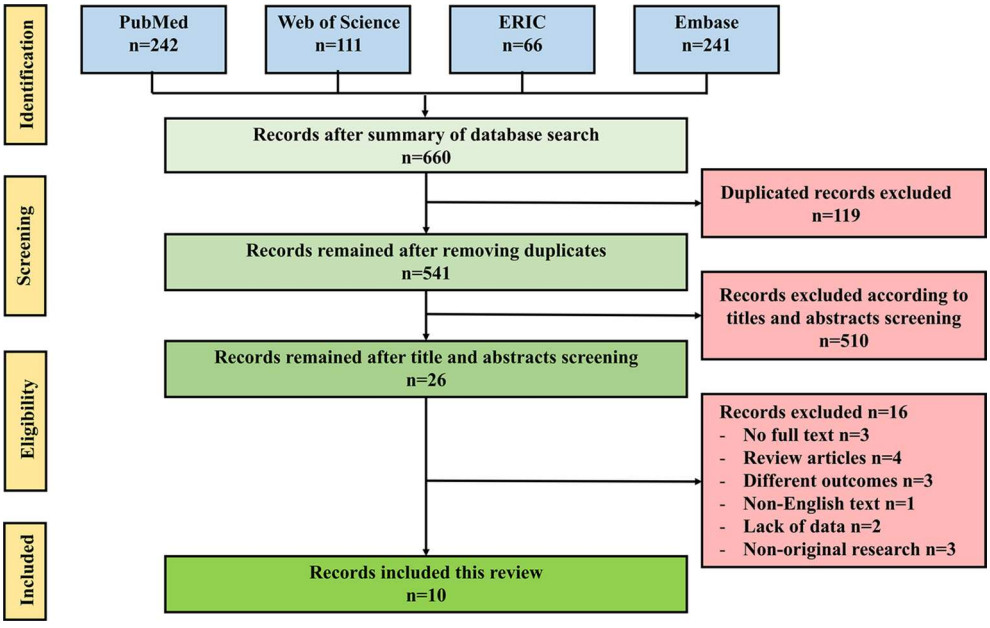

Fig. 1 PRISMA flow diagram

Table 2 Summary of basic information and content of included literatures

Author, Year	Country/Origin	Curriculum contents	Teaching methodologies	Assessments	Outcomes	Challenges
Ambrina Qureshi 2015	Pakistan	Writing guidance; Research methodology	Strengthen EBP skills	Student skills and knowledge levels	Improved ability to formulate questions and search for evidence	Low initial understanding of EBP
Hsiang Yang 2019	China	Fundamental knowledge; Research methodology	Problem-based learning, panel discussions	Student skills and knowledge levels	Enhanced clinical and basic science knowledge integration	Technical issues, financial burden, limited time
Ibrahem Hanafi 2024	Syrian	Writing and publication guidance	Online peer-run writing workshop	Future career planning	Improved writing knowledge and confidence	Limited resources and expertise
Muhammet Fidan 2024	Türkiye	Fundamental knowledge in research-focused subjects	Flipped classroom model with video-driven discussions	Student skills and knowledge levels	Enhanced problem-solving, critical thinking, and practical skills	Limited time, technical issues
Emily Roudnitsky 2022	United States	-	Research-oriented projects and mentor guidance	Research outputs	Higher academic achievements	Scarcity of academic faculty, lack of financial support
Margaret A. Jergenson 2017	United States	Fundamental knowledge; Writing guidance	Master's program with research thesis in Oral Biology	Research outputs	Successful transition and enhanced interest	Faculty shortage in dental education
J. Subramanian 2013	New Zealand	-	Supervision and guidance from the mentor	-	Improved academic learning	Insufficient supervisory methods cultural insensitivity
A. Beaudin 2016	Canada	-	Supervision and guidance from the mentor	-	The majority of students are satisfied with the supervision quality	Insufficient communication and subjective supervision
Sheeja Saji Varghese 2019	India	Research methodology instruction	Blended learning	Satisfaction with the program	Better academic performance with blended learning	-
Johnson King 2022	United Kingdom	Fundamental knowledge in research-focused subjects	Blended approach	Satisfaction with the program	Better academic performance with blended learning	Technology issues, social interaction

formulating research hypotheses, and conducting rigorous experiments.

Practical research skills training

A pivotal component of the PDBRE curriculum is its focus on cultivating essential research skills. The program strongly emphasizes practical training in various research methodologies, including literature retrieval, experimental design, experimental skills, and data analysis [17, 23, 24]. This hands-on approach ensures students not only understand theoretical concepts but also gain proficiency in designing experiments, conducting research operations, and analyzing data effectively. The emphasis on practical experimental skills training enhances students' academic capabilities and prepares them for successful careers in research-intensive fields.

Writing and publication guidance

Mastering scientific writing skills and understanding the publication process is crucial for the professional growth of research-focused students. In the PDBRE program, students primarily acquire these skills through a combination of academic writing and publication seminars, as well as didactic courses. The curriculum includes detailed lessons on the structure of scientific articles, the basics of scientific writing, plagiarism detection, and the publication process [20, 25]. These components are taught through a mix of active engagement in research, where students apply their knowledge, and structured didactic methods. The aim is to ensure that students not only understand theoretical concepts but also develop practical skills in effectively communicating and disseminating their research findings. This integrated approach to scientific writing prepares students to contribute to the scientific community with high-quality publications.

Overall, the PDBRE programs focus on foundational knowledge, research skills training, and writing instruction. There is considerable variability among programs in terms of their curriculum contents. It is also observed that there is less emphasis on specific experimental techniques, which could be attributed to the reliance on mentorship within research groups and the availability of detailed procedural learning through online resources.

Teaching methodologies

The instructional methodologies can be categorized into three broad pedagogical approaches: research-related classes, instructor guidance, and innovative educational approaches. Together, these approaches create a multifaceted educational framework that caters to the diverse needs of postgraduate dental students seeking research-related competencies.

Research-related classes

Postgraduate students are equipped with a variety of research-related competencies through theoretical and experimental classes [20]. Qureshi et al. designed a workshop that focused on strengthening evidence-based practice (EBP) skills, where students learned to search for evidence and utilize PubMed effectively [24]. The educational journey is further enhanced by their participation in academic conferences, which provide a platform for intellectual exchange and networking [21]. PDBRE programs also developed online scientific writing and publishing courses. The curriculum included the structure of scientific articles, the fundamentals of scientific writing, understanding plagiarism, and the intricacies of the publication process [25]. Moreover, a strong emphasis is placed on cultivating a deep understanding of research ethics and responsibilities, ensuring that students are well-prepared to contribute responsibly to their fields of study [16].

Instructor guidance

Traditional mentorship in postgraduate education often lacks systematic and comprehensive instruction, which may lead to knowledge gaps among students [26]. In PDBRE programs, instructors provide systematic guidance on scientific research through a variety of methods, including face-to-face meetings, video instruction, and active facilitation [16]. These instructors typically possess relevant teaching and research experience, and some may also be practicing clinicians, though their primary role is to guide and mentor students in research-related activities [16, 20, 27]. Instructors guide students in developing essential skills and encourage them to pursue careers in academic dentistry [20]. Additionally, as highlighted by Subramanian et al., instructor supervision includes regular one-on-one meetings, timely feedback, and supportive encouragement. Some faculty mentors are actively involved in research projects with students, providing direct mentorship throughout the research process, which significantly contributes to enhancing students' learning outcomes and academic progress [28]. The effectiveness of instructor guidance is evident in contexts where students require continuous support in navigating complex research projects and where personal mentoring is crucial for academic development.

Other innovative methods

PDBRE programs incorporate innovative educational strategies to boost learning outcomes. The flipped classroom model, which integrates video-driven discussions, enhances practical performance and advanced thinking skills [22]. This method enables students to engage with foundational theories and research methodologies before class and apply their knowledge during in-person

sessions. Similarly, Varghese et al. conducted a blended learning approach that included video lectures to provide foundational knowledge, facilitated small-group learning to encourage collaborative inquiry and problem-solving, and included hands-on exercises with statistical software like SPSS. In addition, students participated in projects requiring them to design research studies and conduct data analysis, along with formative and summative assessments to monitor their progress and understanding [17]. In Hsiang Yang's study, the educational approach focused on interdisciplinary, problem-based learning (PBL) in small-group settings. Students interact with clinical and basic science subjects through in-depth literature searches and engaging panel discussions [23]. These innovative methods are most effective in dynamic and interactive learning environments, where students are encouraged to engage with complex problems and collaborate with peers.

Assessments

The efficacy of programs is assessed to ensure they meet the dynamic needs of research-focused students. PDBRE projects are scrutinized from various angles, including: (1) Student skills and knowledge levels: Assessments encompass both theoretical understanding and practical application, often through a combination of questionnaires and skill tests [22–24]. (2) Research outputs: Roudnitsky et al. examined the influence of PDBRE on academic careers and productivity, focusing on h-index and publication numbers [27]. Jergenson et al. also assessed the diversity of research topics undertaken by students, which reflected the breadth of their scholarly engagement [20]. (3) Future career planning: The readiness of students for professional roles is assessed through questionnaires and interviews [25]. (4) Satisfaction with the program: Student satisfaction is evaluated using questionnaires that capture feedback on the relevance and effectiveness of course content and teaching methods [17, 21].

Assessments in PDBRE cover various aspects of student capabilities, with some programs also including assessments of student satisfaction. However, due to the lack of mid-term effectiveness assessments, there is a need to establish a more systematic and comprehensive feedback and adjustment system, allowing for necessary adjustments based on real-time feedback, thereby optimizing educational outcomes. Additionally, assessments vary significantly across programs and lack uniformity, highlighting the need for further development towards a more systematic and comprehensive evaluation framework.

Outcomes

Research skills enhancement

PDBRE programs have led to a significant enhancement in research skills. This includes the ability to formulate research questions, apply scientific methodologies, and critically analyze data. As evidenced by Qureshi et al., there is a notable improvement in the ability to perform evidence-based searches and formulate answerable questions, which are fundamental to research competency [24]. The workshop in Syria showed significant improvements in knowledge and confidence in academic writing. Participants' knowledge scores increased from 17 pre-course to 20 post-course, and confidence increased from 25 to 33 [25]. The structured research projects have facilitated students' understanding of scientific methodologies and contributed to their research capabilities [20, 22, 25].

Academic achievements

Postgraduate students enrolled in this program have demonstrated enhanced academic achievements [28]. For instance, the interdisciplinary learning approach has resulted in a more comprehensive understanding of research, empowering students to produce high-quality academic work [23]. Beaudin et al. found that 77.4% of postgraduate students agreed that their supervisors had helped them in academic advancement and career development [16]. However, it is important to note that the studies included in this review provide limited information on the specific publication rate or concrete research outputs.

Career development

The PDBRE programs have played a crucial role in supporting the career development and professional growth of postgraduate students. A qualitative study highlighted the significant impact of effective supervision on students' career decisions [28]. The improved student's practical skills and critical thinking abilities also contribute to career advancement in both academic and clinical settings [17, 22, 24]. Jergenson et al. noted that all ten postgraduate students from the Master of Science in Oral Biology program at Creighton University continued into dental school, with 90% expressing interest in academic dentistry [20]. This indicates the program's success in nurturing research-oriented careers.

Challenges

The pursuit of excellence in PDBRE presents interrelated challenges, including resource constraints, faculty shortages, knowledge gaps, and student engagement.

Resource constraints and technical limitations

One of the main challenges in postgraduate research education is the lack of sufficient funding, which impacts the

ability to provide essential resources for research projects. In resource-limited settings, implementing PDBRE is constrained by inadequate infrastructure, which hinders stable academic environments [25]. Financial constraints also restricted recruiting, training, and retaining quality academic faculty [27]. Moreover, technical limitations, such as the requirement for sophisticated equipment to facilitate innovative course formats, may impede the adoption of effective educational approaches [22, 23].

Faculty shortage and inadequate guidance

The impact of faculty shortages and inadequate guidance is evident across various studies [20, 24, 27, 29]. While most of the reviewed programs did not report specific faculty-to-student ratios, they consistently highlighted the shortage of specialized instructors for PDBRE as a major challenge [27]. The lack of sufficient faculty resources not only limits the scale and effectiveness of these programs but also impedes their long-term sustainability [20]. Additionally, instructor guidance often suffers from a lack of effective communication with students and incorrect supervision methods [24, 29]. This inadequacy in mentorship can hinder students' research progress and create a suboptimal learning environment. Inadequate or unsuitable guidance, particularly when coupled with faculty shortages, can significantly affect students' academic development, as it leads to insufficient support for navigating complex research processes.

Additional time commitments

Additional time commitments have been identified as significant challenges. Muhammet Fidan et al. noticed that incorporating video-driven discussions requires a significant amount of time for both preparation and engagement [22]. Similarly, Hsiang Yang et al. discovered that students perceived distance education as less efficient due to the additional time needed to understand and interact with course materials [23]. These studies indicated that while PDBRE aims to enhance learning, it may also require extra time investments from students, which lead to feelings of inefficiency and time constraints.

Low engagement and motivation

Low student participation and a lack of enthusiasm for research activities are common issues. The panel discussion and PBL approach could result in uneven engagement levels due to differing student knowledge backgrounds [23]. Additionally, we found that participant numbers varied significantly, ranging from as few as 16 to as many as 294 students per program, further contributing to the disparity in student engagement. The absence of customized educational resources and expertise can lead to disengagement among students who may find the materials either too complex or not engaging enough [25]. Furthermore, the initial resistance to EBP components [24], suggests that the integration of EBP into the curriculum should be approached with strategies to overcome students' apprehensions.

Insufficient disciplinary adaptation

A significant challenge faced by PDBRE is the limited focus on creating and reporting tailored content for specific dental specialties [17, 20, 25]. While general PDBRE frameworks exist, they often fail to address the unique research needs and clinical intricacies associated with dental fields such as orthodontics, periodontics, endodontics, and oral surgery. This lack of specialization in research training programs has led to insufficient integration between basic research and the clinical practices of these specialties. As a result, there is a noticeable disconnect between the research conducted in postgraduate education and the practical application of that research in clinical settings. It is important to encourage further studies that explore the specific skills required by each dental specialty [30, 31], both in terms of research and clinical practice. Such studies can provide valuable insights to guide the future development of PDBRE, ultimately fostering stronger connections between basic research and clinical practice.

Future directions

Traditional educational systems often fail to adequately prepare students for the transition from undergraduate to postgraduate studies in academic research [32–34]. PDBRE is the appropriate approach to handle this situation. Since the implementation of PDBRE, there has been a noticeable improvement in students' scientific research capabilities [11, 20, 27]. However, the diversity in how PDBRE is implemented across institutions, along with the absence of standardized frameworks, may influence the comparability and broader applicability of the findings. After conducting the comprehensive review, we have identified several areas for enhancing and expanding PDBRE and propose the following directions.

Faculty enhancement

A recurring challenge is the shortage of academic faculty [20, 27]. To address this, several strategies can be implemented. Utilizing technology through online education platforms and digital tools allows existing faculty to extend their reach to a broader student population. Meanwhile, engaging adjunct and visiting lecturers to deliver specialized courses is an effective way to diversify the curriculum, thus enriching the educational experience with a variety of perspectives and expertise. These combined efforts can establish a more robust educational

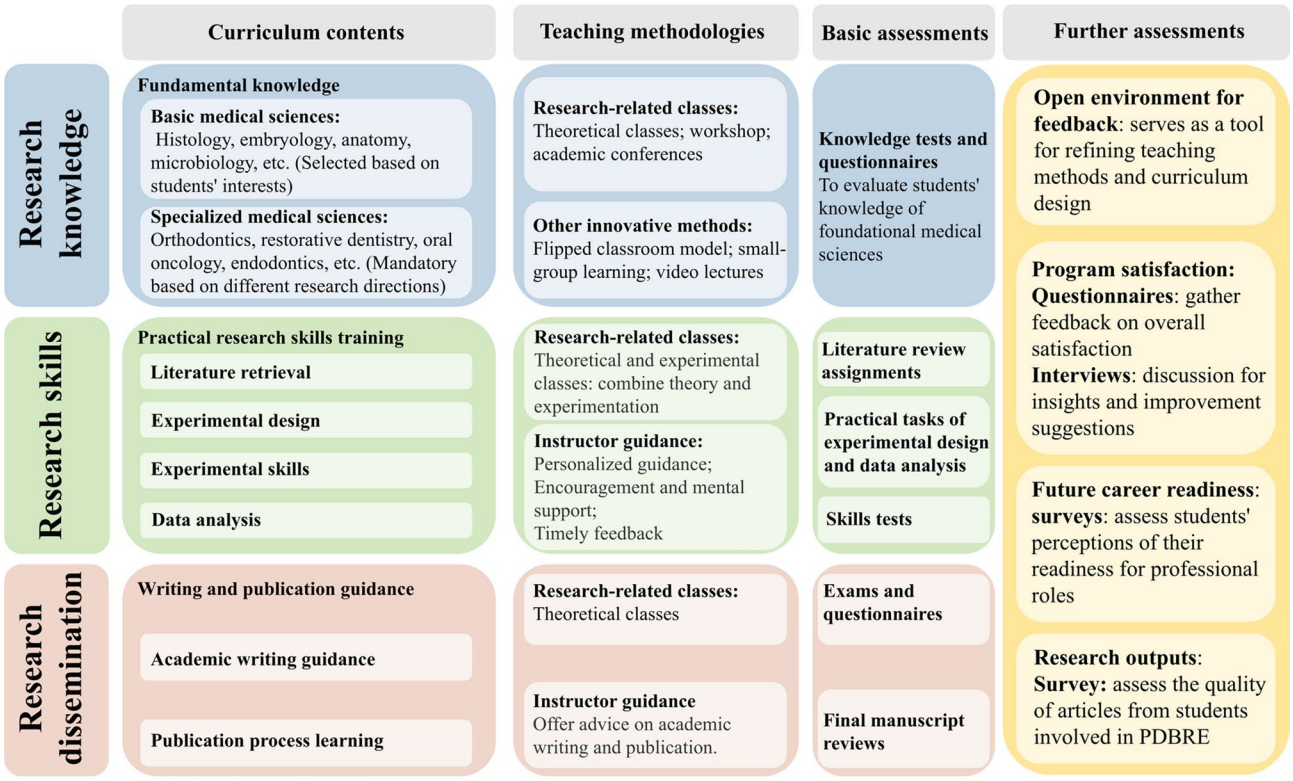

Fig. 2 A proposed schematic diagram of the Postgraduate Dental Basic Research Education (PDBRE) program

framework that not only addresses the current shortage but also fosters a dynamic academic community.

Student engagement strategies

Furthermore, there is a critical need to enhance student enthusiasm and foster their active engagement in PDBRE [22, 24]. These approaches must be central to PDBRE initiatives and can be effectively accomplished through initiatives such as student-led research projects, hosting research symposiums, and organizing academic competitions. It is important to set clear objectives and provide a structured framework because students are more likely to engage when they understand the purpose and expectations. Additionally, incorporating facilitating interdisciplinary collaborations and offering opportunities for publishing in peer-reviewed journals or presenting findings at conferences can further elevate student involvement and enrich their learning experiences.

Comprehensive courses

A prevalent issue is that these programs often prioritize the cultivation of a single skill set over a comprehensive approach to research education [25]. To ensure a well-rounded curriculum, it is essential to diversify the skills emphasized within courses. This includes not only a strong theoretical foundation but also the cultivation of practical skills, communication, teamwork, and innovative thinking. Furthermore, investing in faculty development is crucial. Training for instructors empowers them to guide students effectively through complex and integrated learning experiences.

Assessment and feedback mechanisms

The current evaluation methods for PDBRE vary across studies and lack standardization [16, 28]. These methods are incomplete and unsystematic, failing to capture student performance comprehensively and ignoring one or more critical aspects. To ensure the quality of PDBRE, it is essential to develop a robust assessment tool that allows for long-term tracking and supports timely improvements. An effective assessment tool should incorporate both formative and summative evaluation components [35, 36]. Formative assessments, such as regular peer reviews and feedback sessions, can provide ongoing insights into student development, while summative assessments, including final projects and research publications, can capture overall academic growth. Additionally, establishing clear, transparent criteria for evaluating student performance and research contributions, such as innovation, methodological rigor, and the ability to communicate findings, will allow for more objective and meaningful assessments.

The framework integrates curriculum content, teaching methodologies, and assessments in a progressive

structure, demonstrating systematic advancement from foundational knowledge acquisition to mastery of advanced research skills.

Conclusion

This scoping review presents a comprehensive evaluation of the PDBRE across various institutions. We highlight the importance of PDBRE in training research-focused students by equipping them with essential research skills and knowledge, thereby enhancing their academic development. However, the development of PDBRE is impeded by challenges such as limited resources, faculty shortages, increased workload, and issues with student engagement. We depict a proposed PDBRE program intending to serve as a useful reference for educators (Fig. 2). Further research and practice are necessary to refine the design and execution of PDBRE, particularly in the development of effective assessment and feedback mechanisms.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-025-06227-4.

Supplementary Material 1

Supplementary Material 2

Acknowledgements
Not applicable.

Author contributions
ZC and YH conceived the study and designed the review protocol. QO, DT and SC conducted the literature search and data extraction. ZG, ML, XG, GC and XL performed the data analysis and synthesis. QO, DT and SC drafted the manuscript. ZC, XY and YH revised the manuscript. All authors critically reviewed the manuscript and approved the final version.

Funding
This work was supported by the Construction Project of the Postgraduate Demonstration Course of Guangdong Province, the Undergraduate Education Quality Program of Sun Yat-Sen University, and the Guangdong Medical Science and Technology Research Foundation (A2024558).

Data availability
The data from this scoping review are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 16 March 2025 / Accepted: 21 May 2025
Published online: 29 May 2025

References

1. D'Souza RN, King LM, Webster-Cyriaque J, Shum L, Fischer DJ. Practice-based research integrating multidisciplinary experiences in dental schools for culture change: increasing clinical research capacity through dental education. J Am Dent Assoc. 2023;154(12):1037-40. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=38008524&query_hl=1; https://doi.org/10.1016/j.adaj.2023.10.003.
2. Sischo L, Broder HL. Oral health-related quality of life: what, why, how, and future implications. J Dent Res. 2011;90(11):1264-70. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=21422477&query_hl=1 https://doi.org/10.1177/0022034511399918.
3. Xie Z, Shen Z, Zhan P, Yang J, Huang Q, Huang S et al. Functional dental pulp regeneration: basic research and clinical translation. Int J Mol Sci. 2021;22(16). Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=34445703&query_hl=1 https://doi.org/10.3390/ijms22168991
4. Lacruz RS, Habelitz S, Wright JT, Paine ML. Dental enamel formation and implications for oral health and disease. Physiol Rev. 2017;97(3):939 – 93. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=28468833&query_hl=1 https://doi.org/10.1152/physrev.00030.2016.
5. Lamont RJ, Koo H, Hajishengallis G. The oral microbiota: dynamic communities and host interactions. Nat Rev Microbiol. 2018;16(12):745 – 59. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=30301974&query_hl=1 https://doi.org/10.1038/s41579-018-0089-x.
6. Meyle J, Chapple I. Molecular aspects of the pathogenesis of periodontitis., Periodontol 2000. 2015;69(1):7–17. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=26252398&query_hl=1 https://doi.org/10.1111/prd.12104.
7. Buja LM. Medical education today: all that glitters is not gold. Bmc Med Educ. 2019 2019;19(1):110. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=30991988&query_hl=1 https://doi.org/10.1186/s12909-019-1535-9.
8. Holman SD, Wietecha MS, Gullard A, Peterson JM. U.s. Dental students' attitudes toward research and science: impact of research experience. J Dent Educ. 2014;78(3):334 – 48. Available from: https://www.embase.com/search/results?subaction=viewrecord&id=L373097850&from=export.
9. Kumari A, Wu DT, Motiani KK, Wu KY, Palumbo M, Tran SD. Career pathways and professional skills of postgraduate students from a dental research-intensive programme. Eur J Dent Educ. 2019;23(2):143 – 50. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=30582648&query_hl=1 https://doi.org/10.1111/eje.12413.
10. Polverini PJ, Krebsbach PH. Research and discovery science and the future of dental education and practice. J Dent Educ. 2017;81(9):S97-107. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=28864810&query_hl=1 https://doi.org/10.21815/JDE.017.040.
11. Alard P, Kosiewicz MM. Enhancing engagement of graduate students in class via use of an interactive teaching platform improves learning and long-term retention. J Immunol. 2021;206(1). Available from: https://www.embase.com/search/results?subaction=viewrecord&id=L642305698&from=export https://doi.org/10.4049/jimmunol.206.Supp.54.20.
12. D'Souza RN, Colombo JS, Embree MC, Myers JM, DeRouen TA. Our essential and endangered dentist-scientist workforce. JDR Clin Trans Res. 2017;2(1):10–22. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=30938647&query_hl=1 https://doi.org/10.1177/2380084416673346
13. D'Souza RN, Colombo JS. How research training will shape the future of dental, oral, and craniofacial research. J Dent Educ. 2017;81(9):S73-82. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=28864807&query_hl=1 https://doi.org/10.21815/JDE.017.037.
14. Vargas N, Romanos GE. Dental academic degrees in germany compared to the usa. Dent J (Basel). 2022;10(6). Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=35735640&query_hl=1 https://doi.org/10.3390/dj10060098.
15. Subramanian J, Anderson VR, Morgaine KC, Thomson WM. Improving the quality of educational strategies in postgraduate dental education using student and graduate feedback: findings from a qualitative study in new

zealand. Eur J Dent Educ. 2013;17(1):e151-58. Available from: https://www.embase.com/search/results?subaction=viewrecord&id=L368013586&from=export https://doi.org/10.1111/eje.12006.
16. Beaudin A, Emami E, Palumbo M, Tran SD. Quality of supervision: postgraduate dental research trainees' perspectives. Eur J Dent Educ. 2016;20(1):32–38. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=25564935&query_hl=1 https://doi.org/10.1111/eje.12137.
17. Varghese SS, Ramesh A, Veeraiyan DN. Blended module-based teaching in biostatistics and research methodology: a retrospective study with postgraduate dental students. J Dent Educ. 2019;83(4):445 – 50. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=30745352&query_hl=1 https://doi.org/10.21815/JDE.019.054.
18. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Method. 2005;8(1):19–32. Available from: https://doi.org/10.1080/1364557032000119616.
19. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D et al. Prisma extension for scoping reviews (prisma-scr): checklist and explanation. Ann Intern Med. 2018/09/04;169(7):467 – 73. Available from: https://doi.org/10.7326/M18-0850.
20. Jergenson MA, Barritt LC, O'Kane BJ, Norton NS. Master in oral biology program: a path to addressing the need for future dental educators. Anat Sci Educ. 2017;10(6):607 – 12. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=28561922&query_hl=1 https://doi.org/10.1002/ase.1706.
21. Johnson KO, Ryan F, Cunningham S. Postgraduate student perceptions of face-to-face and distance education in orthodontics: a cross-sectional qualitative study. J Orthod. 2022;49(3):280 – 87. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=35302421&query_hl=1 https://doi.org/10.1177/14653125221077108.
22. Muhammet F, Mustafa F. The effects of video-driven discussions integrated into the flipped classroom model on learning achievement, practical performance, and higher-order thinking skills in dental education. J Comput Assist Lear. 2024 158 – 75. Available from: https://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1407203&site=ehost-live https://doi.org/10.1111/jcal.12869.
23. Yang H, Chen HY, Lin HY, Chen HM. The learning experience of basic science and clinical dentistry by postgraduate students in institute of clinical dentistry and institute of oral biology. J Dent Sci. 2019;14(3):277 – 80. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=31528255&query_hl=1 https://doi.org/10.1016/j.jds.2019.01.001.
24. Qureshi A, Bokhari SA, Pirvani M, Dawani N. Understanding and practice of evidence based search strategy among postgraduate dental students: a preliminary study. J Evid Based Dent Pract. 2015;15(2):44–49. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=25987379&query_hl=1 https://doi.org/10.1016/j.jebdp.2014.08.002.
25. Hanafi I, Kheder K, Sabouni R, Gorra Al Nafouri M, Hanafi B, Alsalkini M et al. Improving academic writing in a low-resource country: a systematic examination of online peer-run training. Teach Learn Med. 2024:1–15. Available from: https://www.embase.com/search/results?subaction=viewrecord&id=L643873245&from=export https://doi.org/10.1080/10401334.2024.2332890.
26. Donovan A, Donovan J. Mentorship in postgraduate training programmes: views of canadian programme directors. Med Educ. 2009;43(2):155 – 58. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=19161486&query_hl=1 https://doi.org/10.1111/j.1365-2923.2008.03258.x.
27. Roudnitsky E, Hooker KJ, Darisi RD, Peacock ZS, Krishnan DG. Influence of residency training program on pursuit of academic career and academic productivity among oral and maxillofacial surgeons. J Oral Maxil Surg. 2022;80(2):380 – 85. Available from: https://www.embase.com/search/results?subaction=viewrecord&id=L2015688396&from=export https://doi.org/10.1016/j.joms.2021.09.019.
28. Subramanian J, Anderson VR, Morgaine KC, Thomson WM. Effective and ineffective supervision in postgraduate dental education: a qualitative study. Eur J Dent Educ. 2013;17(1):e142-50. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=23279402&query_hl=1 https://doi.org/10.1111/j.1600-0579.2012.00774.x.
29. Komabayashi T, Ahn C, Kim KJ, Oh HW. Comparison of traditional six-year and new four-year dental curricula in south korea. J Oral Sci. 2012;54(2):191 – 96. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=22790412&query_hl=1 https://doi.org/10.2334/josnusd.54.191.
30. Mahdavifard H, Noorollahian S, Omid A, Yamani N. What competencies does an orthodontic postgraduate need? Bmc Med Educ. 2024;24(1):1461. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=39695531&query_hl=1 https://doi.org/10.1186/s12909-024-06475-y.
31. Preshaw PM, Ramseier CA, Loos BG, Balčiūnaitė A, Crnić T, Davey K et al. Contemporary educational methods in periodontology. J Clin Periodontol. 2024;51 Suppl 27:117 – 92. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=38724458&query_hl=1 https://doi.org/10.1111/jcpe.13986.
32. Almohaimede AA, Bendahmash MW, Dhafr FM, Awwad AF, Al-Madi EM. Knowledge, attitude, and practice (kap) of radiographic protection by dental undergraduate and endodontic postgraduate students, general practitioners, and endodontists. Int J Dent. 2020;2020:2728949. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=32399032&query_hl=1 https://doi.org/10.1155/2020/2728949.
33. Li HA, Ju X, Dreyer C, Jamieson L. Motivations of postgraduate dental students in australia and new zealand to pursue a dental specialty training program and their concerns. Heliyon. 2021;7(1):e6060. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=33537486&query_hl=1 https://doi.org/10.1016/j.heliyon.2021.e06060.
34. Zheng JW, Zhang SY, Yang C, Guo L, Shen GF, Feng XP et al. Current undergraduate and postgraduate dental education in china. J Dent Educ. 2013;77(1):72–78. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=23314469&query_hl=1.
35. Perkins SQ, Dabaja A, Atiemo H. Best approaches to evaluation and feedback in post-graduate medical education. Curr Urol Rep. 2020;21(10):36. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=32789759&query_hl=1 https://doi.org/10.1007/s11934-020-00991-2.
36. Mogali SR, Rotgans JI, Rosby L, Ferenczi MA, Low BN. Summative and formative style anatomy practical examinations: do they have impact on students' performance and drive for learning? Anat Sci Educ. 2020;13(5):581 – 90. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=31733172&query_hl=1 https://doi.org/10.1002/ase.1931

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