BMC Medical Education

RESEARCH

Open Access

# Evidence of the effectiveness of projects, programs, and/or strategies for curricular innovation in undergraduate health courses: systematic review and meta-analysis

Magno Marcio de Lima Pontes[1*], Vitoria Karoline Rodrigues Molica[1], Tabata Isabely Souza Neves[1], Liriel Aparecida Miranda[2], Emily de Souza Ferreira[1], Tiago Ricardo Moreira[2], Ramón López Martín[3] and Rosângela Minardi Mitre Cotta[1]

## Abstract

**Context** The need for curricular innovation, especially in university education, is incorporated into the agenda of universities for undergraduate health courses, whether through the models adopted in educational institutions, referenced by their curricula, or through traditional practices that still prevail in the 21st century as a form of teaching, to the detriment of innovative practices. With high retention and dropout rates in university courses, the contemporary scenario calls for the development of strategies to reorganize curricula that meet the new demands of student training, implementing new projects, programs, and/or tools that stimulate new teaching and learning processes. Therefore, the objective of this study was to analyze the evidence of the effectiveness of projects, programs, and/or strategies for curricular innovation in undergraduate health courses through a systematic review and meta-analysis.

**Methods** The systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and were carried out in two stages: (a) search and selection and (b) analysis and evaluation. Eight databases were used: Cochrane Library; Education Resource Information Center (ERIC); Embase; Latin American and Caribbean Health Sciences Literature (LILACS); PubMed-Medline; SCOPUS; Scientific Electronic Library Online (SciELO); and Web of Science. The review included qualitative research, cohort studies, cross-sectional and quasi-experimental analytical studies that addressed evidence of the effectiveness of projects, programs, and/or strategies for curricular innovation in undergraduate health courses. The quality of the selected studies was assessed based on the Joanna Briggs Institute evaluation criteria. The meta-analysis was based on data on student satisfaction prevalence, self-efficacy, and academic performance. Publication bias was investigated by visual inspection of funnel plots and Egger's test.

*Correspondence:
Magno Marcio de Lima Pontes
magno.pontes@ufv.br

Full list of author information is available at the end of the article

**Results** Ninety-nine studies were included in the systematic review and 23 in the meta-analysis, covering publications from 1995 to 2024 in 19 countries, with a time span of almost three decades of studies on curricular innovations and evaluations in the health field, which provided an overview of the advances in this area. The interventions were classified into seven thematic areas: clinical simulation, interprofessional training, diversity and equity, assessment and feedback, educational leadership, humanistic education, and digital teaching. The studies analyzed highlighted that curricular innovations promote the improvement of critical skills, such as critical thinking, clinical reasoning, and interprofessional teamwork, in addition to increasing student satisfaction and engagement. Advances were also observed in the development of humanistic skills, cultural sensitivity, and adaptation to digital technologies and online education. These interventions positively impacted health education, strengthening technical competencies and clinical skills, while transforming institutional culture by valuing collaborative teaching practices. Students exposed to early practical experiences reported greater motivation, confidence, and satisfaction with the course, reflecting more robust preparation for professional challenges. In addition, the results of the meta-analysis showed a weighted prevalence of 82% (76%-88%) for student satisfaction, 67% (49%-86%) for self-efficacy, and 70% (64%-75%) for academic performance after the implementation of curricular interventions. Furthermore, it was observed that most studies showed significant positive effects on outcomes after the adoption of these interventions.

**Conclusion** The findings suggest that curricular interventions have the potential to positively impact the training of health professionals. Thus, we conclude that curricular innovation strategies in health courses are promising, based on improvements in self-efficacy, academic performance, and student satisfaction, promoting indicators of teaching quality in the contexts in which they were carried out. We recommend the development of longitudinal and multicenter studies that investigate the effects of these innovations on professional practice and the quality of health care, considering different cultural and institutional contexts.

**Keywords** Curricular innovation, Higher education in health, Curricular reorganization, Educational strategies, Health training, Professional competencies

## Introduction

University education in the health field faces challenges due to the increasing complexity of health systems, with constant demands for the incorporation of technological innovations and high demand for humanizing practices centered on the patient, in addition to a focus on interdisciplinary skills with integration between theoretical and practical fields. This has led to the need for changes in institutional curricula that effectively prepare students to face the multiple realities of professional practice, taking into account social, political, socioeconomic, and teaching and learning changes [1, 2].

In this scenario, curricular innovation projects, programs, and strategies have emerged as crucial tools for promoting meaningful learning. According to Harden (2024), curricular innovation in health refers to the search for a curriculum that is flexible and responsive in preparing future professionals for the challenges and needs of the contemporary world. The author also notes that curricular innovation is not an isolated concept, but rather a process of constant adaptability and improvement [3].

By integrating active methodologies and opportunities for practice in real contexts, such as Problem-Based Learning (PBL), clinical simulations, and virtual learning environments, these approaches contribute to the development of competencies (knowledge, skills, and attitudes) essential for professional practice based on socio-emotional, technological, and interprofessional training. In this context, effective training requires students to empower themselves by exercising and applying strategies aimed at decision-making and problem-solving, such as confidence and assertiveness [4].

Although the benefits that curricular innovations bring to training processes are widely recognized in the scientific literature, there are still significant gaps in terms of how innovations contribute to the strategic improvement of undergraduate student training, indicating that the possibilities of their impact on professional practice in the health field have not yet been sufficiently explored [5–7]. Furthermore, there are few studies that comprehensively analyze different approaches, such as distance learning, problem-based learning, medical humanities, and interprofessionality, in a single curriculum [8–10].

In addition, the review studies available to date tend to address fragmented aspects, such as empathy, student satisfaction, and even the use of technologies, without integrating the impact of these innovations on training, professional practice, and institutional sustainability.

The need to verify the sustainability of interventions over time, in terms of costs, maintenance, and adaptation to constant technological and social changes, is indispensable, as these aspects are considered crucial for these innovations to be truly viable and accessible in different

contexts [4–6, 11]. When reviewing the studies developed by Lombardo L, Ehlers J, and Lutz G (2023), a tendency was found for research to focus on specific aspects, such as empathy [12]. Similarly, the studies by Çakmakkaya et al. (2024) evaluated student satisfaction as the main focus, while Wang et al. (2023) and Rodríguez et al. (2022) explored satisfaction as part of the implementation of technologies as a method of innovation for teaching. This highlights the limitation of studies focusing on specific aspects, as they do not evaluate broader impacts, such as overall academic performance, clinical practice, or even the social return on these innovations [13–15].

Understanding the needs of teachers and developing strategies to prepare them to adopt educational innovations are approaches that have been little explored in the literature. Studies such as those by Johnson et al. (2023) and Silva et al. (2021) highlight specific barriers, such as lack of pedagogical training, individual beliefs, and structural limitations, which directly impact the implementation of new practices [15–17]. Thus, elements related to understanding how much these strategies help health students acquire practical skills and apply them in their daily professional lives is an issue that still needs further attention.

Furthermore, research such as that conducted by Klasen et al. (2022) and Souza et al. (2020) reinforces the need for ongoing training and support so that teachers can adapt to the demands of active methodologies and innovative assessments [18, 19]. An open mindset and willingness to receive feedback, discussed by Lombardo et al. (2023), also emerge as essential factors in creating educational environments that support meaningful change [12]. These aspects highlight the importance of investments in teacher training, ensuring that innovations fulfill their pedagogical and educational objectives.

Thus, the purpose of this article is to provide, in a systematic, expanded, and in-depth manner, the development of insights that enable structural changes and promote discussions about institutional curricula based on scientific evidence, thereby strengthening the performance of health professionals, with a focus on the training of undergraduate students in health courses, a scope that has been little explored in the scientific literature.

In this context, the objective of this article is to analyze the effectiveness of projects, programs, and strategies for curricular innovation in undergraduate health courses through a systematic review and meta-analysis.

## Methods

### Study protocol and registration

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) [20] and registered in the International Prospective Register of Systematic Reviews (PROSPERO) under protocol number CRD42024556510.

### Search strategy

A preliminary search was conducted with the help of a senior librarian to specify the keywords and optimize the search strategy. The databases were searched using terms from DeCS/MeSH – Health Sciences Descriptors/Medical Subject Headings. The following descriptors were used: "Curricular Change," "Teaching methods," "Teaching," "Learning," "Schools, Health Occupations," and "Curricular innovation." To take into account evidence of the effectiveness of projects, programs, and/or strategies for curricular innovation in undergraduate health courses, the search terms were used in the following combinations: (Curriculum innovation) AND (Schools for Health Professionals); (Curriculum innovation) AND (Teaching Methods OR Teaching) AND Learning AND (Schools for Health Professionals) and (Curriculum change) AND (Teaching Methods OR Teaching) AND Learning AND (Schools for Health Professionals). The search was performed without language or publication period restrictions, using Boolean operators (AND, OR) between the descriptors. The complete search syntax used in the PubMed database is available in Additional File 1 – Full Search Syntax – PubMed.

### Data sources

The data sources for this systematic review and meta-analysis were the following electronic databases: Medical Literature Analysis and Retrieval System Online (PubMed-Medline); Excerpta Medica dataBASE (EMBASE); Latin American and Caribbean Health Sciences Literature (LILACS); SCOPUS; Web of Science; Cochrane Library; Scientific Electronic Library Online (SciELO) and Education Resources Information Center (ERIC). The last search was performed in June 2024 to identify eligible studies, and no restriction filters were used.

The research question was designed following the PICO structure, in which we had as P (Population): Undergraduate students in the health field; I (Intervention): Institutionalized curricular innovation projects, programs, or strategies; C (Comparator): Traditional curricula or absence of intervention (when applicable); and O (Outcome): Effects on academic training, skills acquisition, perception, performance, or impact on professional practice.

### Selection of studies

The review included qualitative research, cross-sectional and quasi-experimental analytical studies, as well as cohort studies that addressed the effectiveness of projects, programs, and/or strategies for curricular

innovation in undergraduate health courses in an institutionalized manner. Studies that explicitly relate to curricular innovation in undergraduate health courses were included.

Non-original studies were excluded, as were articles that focused on already trained professionals, articles that reported experiences in undergraduate courses outside the health field, and innovations that were not incorporated as curricular and institutionalized changes, in addition to lato sensu courses in residency, continuing education, specialization, and MBA programs, and stricto sensu courses in master's and doctoral programs.

Studies from which it was not possible to extract relevant data for analysis were also excluded, such as letters, editorials, conference proceedings, comments, reports, study protocols, pilot studies, case reports and experience reports, abstracts, reviews, theses, dissertations, or institutional reports, in order to ensure the replicability of the search and methodological rigor. There were no restrictions on date, location, or language. In addition, gray literature was excluded due to high methodological variability and systematic access. Studies published in English, Portuguese, and Spanish were considered.

The title, abstract, and full text were independently evaluated by three reviewers (MMLP; VKRM; TISN), and disagreements were discussed by other reviewers (ESF and LAM). Each of the three reviewers selected studies for possible inclusion based on the title and content of the abstract. Studies considered to meet the inclusion criteria were analyzed in the full-text review.

The articles were first selected based on their titles. After reading the abstract, those that did not fit the research were excluded, meeting the exclusion criteria. If the abstracts were not available, the full-text articles were retrieved for evaluation. After this selection of articles, all selected articles were read in full to verify compliance with the inclusion criteria. Any disagreement in the evaluation of the articles was resolved through discussion within the review team. Thus, the criteria followed aimed to ensure the inclusion of studies focused on initial health education that had been established as institutionalized interventions, in line with the scope of this review.

### Quality of studies (assessment of evidence certainty – PRISMA)

The quality of the selected studies was assessed based on the evaluation criteria of the Joanna Briggs Institute tool, specific for qualitative research, cohort studies, cross-sectional analytical research, and quasi-experimental research. The results were measured in percentages for each item on the checklist: 1 point for "YES," 0.5 points for "not clear," and 0 for "NO." Good quality studies were those that scored above 75% [20–22].

The domains evaluated initially included methodological adequacy. To this end, they were evaluated according to the type of research. For qualitative studies, congruence and credibility were verified, ensuring the validity of the representation of the participants' voices and philosophical alignment. Next, for cohort studies, the focus of the analysis was on group similarity and follow-up fidelity over time, with special attention to the measurement of exposure and outcome. For cross-sectional analytical studies, clear definition of the sample and validity of measurements were crucial to the accuracy of the association between exposure and outcome. Finally, for quasi-experimental research, the evaluation focused on the clarity of the cause-effect relationship and comparability between groups, in addition to consistency in the measurement of outcomes. In all types of studies, methodological adequacy, clear inclusion criteria, reliability of measurements, and validity of analysis were rigorously applied, as recommended by the JBI checklists. The complete description can be found in Additional File 2 – JBI Checklists with Criteria by Study Type.

### Data extraction

Rayyan software was used to analyze titles and abstracts. The authors (MMLP; VKRM; TISN) extracted all data, and a reviewer (ESF) analyzed the data for accuracy.

The following data were collected: article title, authors, year of publication, and type of study; research location, study question/problem, innovation implemented, sample characteristics with number of participants, instruments used for data collection and analysis, main results achieved, study impact, and limitations. We created a Microsoft Excel spreadsheet to extract all the information mentioned above.

### Data synthesis and analysis

The random effects model was chosen due to the expected heterogeneity between institutional contexts, populations, and types of intervention. Subgroup analysis was performed based on the type of curricular innovation and sensitivity analysis excluding studies with a high risk of bias.

The meta-analysis was performed using a random effects model. Heterogeneity was assessed using Pearson's chi-square ($\chi 2$) test with significance at $P < 0.10$, and its magnitude was determined by the I-square (I2). The analyses were performed using the Metaprop command of the Stata program (version 11.0). The statistical significance of the prevalence of effectiveness (measured by student satisfaction, self-efficacy, and academic performance) of projects, programs, and/or strategies for curricular innovation in undergraduate health courses was determined by the 95% confidence interval (CI). The existence of the small-study effect was assessed through

visual inspection of the funnel plot and Egger's test [23]. The possible sources of heterogeneity considered were: type of intervention, place of implementation, and methodological design. The individual risk of bias of the studies included in the meta-analysis was analyzed using RevMan (version 5.4).

## Results

### Studies identified and included

We searched eight databases and obtained 6,155 articles. The first step was to exclude duplicate articles using Rayyan software, which resulted in 4,792 articles. In the second step, studies were excluded by screening titles and abstracts, resulting in 600 articles. In the third step, studies were excluded through careful screening of the full text of the articles, resulting in 300 articles. In the end, following the inclusion and exclusion criteria, 99 articles were included in the systematic review, of which 23 contained all the data necessary for inclusion in the meta-analysis. The retrieval and selection process is shown in Fig. 1.

For articles to be included in the meta-analysis, they needed to have quantitative data related to the aspects we wanted to evaluate. The data used for these analyses were the average prevalence values, which referred to student satisfaction, self-efficacy, and academic performance. The sixty-six articles that were not included in the meta-analysis did not contain this data in its entirety, which made it impossible to use them for statistical analysis.

### Characteristics of the included studies

A total of 99 studies were included in the systematic review, published between 1995 and 2024, from 19 countries. The most represented countries were the United States ($n = 30$), Canada ($n = 6$), Australia ($n = 5$), and the United Kingdom ($n = 4$). Publications from South Africa and Germany ($n = 3$ each); New Zealand, Pakistan, Switzerland, and Singapore ($n = 2$ each); and China, Scotland, India, Iran, the Netherlands, Jordan, Lebanon, Taiwan, and Zimbabwe ($n = 1$ each) were also identified. The estimated total number of participants was 10,608, considering only studies that reported sample size, with an average of 145 individuals per study.

Due to the size of the sample ($n = 99$), we chose to present a representative summary of the studies in the body of the text (Table 1) and to keep the complete table with all characteristics in the supplementary material (Additional File 3). – Characterization Table of the Systematic Review Studies, in accordance with the presentation guidelines for systematic reviews. The supplementary file contains a table that presents a detailed summary of the included studies, organized by type of curricular innovation. The main findings, perceived impact, reported limitations, and methodological quality assessment based on the Joanna Briggs Institute (JBI) checklist are presented.

Most participants were undergraduate medical and nursing students, including first-year students, interns, and students in global immersion programs. Some studies also included educators, mentors, teachers, and students from other health fields, such as dentistry, pharmacy, occupational therapy, and social work. To a lesser extent, some studies addressed the perspective of academic managers and institutional leaders.

Related to problem- and task-based teaching methods and interventions, we highlight Problem-Based Learning (PBL) as studied by Baig et al. (2006), Tsou et al. (2014), and Srinivasan et al. (2005), which highlight the use of PBL to develop problem-solving and self-criticism skills [24, 34, 35]. The method promotes student-centered learning, with an emphasis on solving real cases to strengthen clinical reasoning. In the study by Al-Dabbagh et al. (2005), task-based teaching proved effective in family medicine, guiding students toward practical skills and focusing on activities that simulate real work scenarios [36].

Relevant results were also addressed in the context of interprofessional education and community partnerships, as in the studies by Bradley et al. (2018), Cohen Fineberg et al. (2004), and Filies et al. (2021), which employed interdisciplinary practices in which students from different areas collaborated to better understand professional roles in health. These methods focus on building teamwork and interprofessional communication skills [25, 37, 38]. Studies such as Aponte et al. (2016) and Dongre et al. (2010) involved community practices, providing students with the opportunity to interact directly with communities and apply their knowledge in resource-limited contexts, strengthening practical learning [31, 39].

The use of information and communication technologies, as well as other online tools, was also addressed in some articles included in our systematic review, such as Simulation and Virtual Patients, in which Goolsby et al. (2015) and Berman et al. (2009) used hybrid simulations and virtual patients to develop practical skills in a safe environment, allowing students to practice complex medical procedures without risk [40, 41]. Studies such as Creedy et al. (2007) and Miller et al. (2014) introduced online modules to facilitate flexible learning [32, 42]. In the study by Atack et al. (2009), an interprofessional online course was used to increase competence in disaster management and improve collaboration [43].

Regarding education for cultural and ethical awareness, we highlight the bioethics curriculum developed in the study by Allana et al. (2024) and the focus on the humanities in Thacker et al. (2019), which encouraged ethical reflection and empathy in students [27, 44]. Such

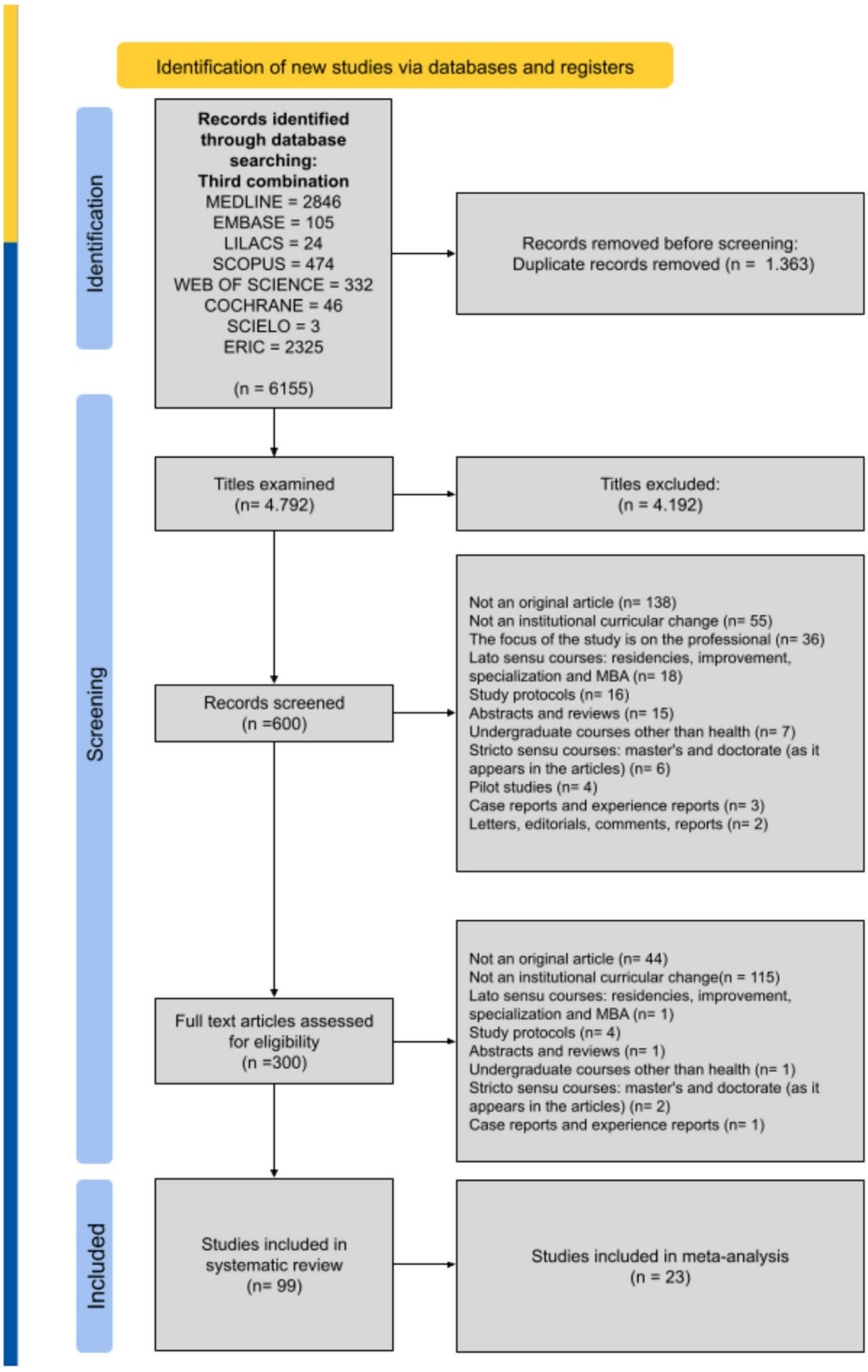



**Fig. 1** Flowchart of preferred reporting items for selection of studies for systematic reviews and meta-analyses (PRISMA)

**Table 1** Representative studies by type of curriculum innovation, main findings and methodological assessment (JBI)

| Author/Year | Location | Type of Curricular Innovation | Main Findings | Study Impact | Conclusion | JBI Appraisal (%) |
|---|---|---|---|---|---|---|
| Tsou et al., 2014 [24] | Taiwan | Problem-Based Learning (PBL) | Improvement in clinical reasoning and problem-solving | Students became more autonomous and engaged | PBL promotes active, student-centered learning | 100% |
| Bradley et al., 2018 [25] | South Africa | Interprofessional Education | Integration among students from different programs | Development of collaborative and communication skills | Improved perception of health roles and responsibilities | 95% |
| Goolsby et al., 2015 [26] | USA | Simulation and Virtual Patients | Increased clinical safety and practical skills | Controlled environment enhanced hands-on performance | Simulations are effective for teaching complex procedures | 90% |
| Allana et al., 2024 [27] | Pakistan | Bioethics Education | Enhanced ethical reflection and empathy | Development of moral awareness | Bioethics curriculum supports humanistic training | 90% |
| Gray et al., 2010 [28] | Australia | Evidence-Based Practice | Students demonstrated better use of scientific literature | Strengthened evidence-based clinical decision-making | Reinforces scientific and clinical reasoning | 95% |
| D'Alessandro et al., 2014 [29] | Canada | Theater and Reflective Education | Students reported increased empathy toward patients | Theater served as a transformative tool for empathy | Innovative method for addressing subjective aspects of care | 95% |
| Heise et al., 2010 [30] | USA | Student Participation in Curriculum Management | Students became more engaged and satisfied with the curriculum | Student inclusion contributed to curriculum improvement | Active participation fosters belonging and engagement | 90% |
| Aponte et al., 2016 [31] | USA | Immersion in Vulnerable Communities | Practical application of sociocultural competencies | Strengthened understanding of social needs | Community-based teaching promotes contextualized learning | 100% |
| Creedy et al., 2007 [32] | Australia | Flexible Online Learning Module | Improved learning autonomy | Learning adapted to the student's pace | Feasible strategy to complement face-to-face teaching | 90% |
| Mousavi et al., 2016 [33] | Iran | Objective Structured Clinical Examination (OSCE) | Structured assessment enhanced clinical performance | Strengthened self-efficacy and practical readiness | OSCE proved reliable as a clinical assessment tool | 95% |

Legend:Results organized according to location of intervention, thematic diversity, main findings, study impact, conclusions, and methodological quality (JBI ≥ 90%). The full text of the 99 studies can be found in the supplementary material

curricula helped develop a broader ethical approach and the ability to deal with moral dilemmas. The studies by Cooper et al. (2018) and Sopoaga (2012) implemented programs focused on specific populations, such as LGBT people and Pacific communities, improving students' understanding of the cultural and health needs of historically marginalized groups [45, 46].

Regarding practical and evidence-based learning models, the studies by Gray et al. (2010) and Moch et al. (2007) focus on evidence-based practice and reinforce the importance of applied research and scientifically based clinical decision-making [28, 47]. These models aim to develop research skills and the use of scientific literature to guide practice. Simulation curricula and Objective Structured Clinical Examinations (OSCE) were analyzed in the study by Mousavi et al. (2016) to assess clinical skills in a structured manner, providing students with practical experience that simulates real clinical conditions [33].

Another focus addressed in the articles analyzed in our systematic review refers to innovative and theatrical methods for promoting empathy and reflection, such as the study by D'Alessandro et al. (2014), which used theater as an educational tool to develop empathy and reflection on the patients' experience [29]. These approaches encourage a deeper understanding of the emotional aspects of medical practice. The use of Course Councils and Student Participation was also addressed in the study by Heise et al. (2010), in which the implementation of a course council allowed for a collaborative environment where students could express concerns and participate in curriculum development [30].

These practices and methods reflect a diversity of interventions that aim to adapt and innovate health education, promoting both clinical and practical skills as well as cultural awareness and ethical reflection. Although each study included in the systematic review has a different approach to projects, programs, and strategies with different evaluations in some aspects, we can highlight that they have in common the positive impact of curricular reforms on health education and show advances in both

technical and humanistic skills, supported by student satisfaction with the new educational approaches.

In terms of results, significant improvements were found in specific knowledge and skills through training programs and curricular interventions, such as geriatric care, disaster management skills, and knowledge of bioethics. In addition, practical skills such as medical procedures and clinical reasoning appear to have improved for students.

There was also a trend observed in studies on increased confidence in clinical and professional skills, with studies based on PBL and evidence-based practices, community nursing practice, and competence in assisting subjects/patients in complex conditions. Aspects related to humanistic practices and social sensitivity can be represented by the promotion of empathy and cultural awareness, demonstrating a greater understanding of vulnerable populations and immersion in global health, as pointed out in some studies. In addition, the results demonstrate Interprofessional Education (IE) as a tool for promoting teamwork, appreciation of complementary roles in health, collaborative care, and readiness.

The effectiveness of Problem-Based Learning (PBL) stands out as beneficial for the development of self-criticism and communication skills, while Case-Based Learning (CBL) stands out for its structure and clinical applicability. The improvement of clinical and ethical practices has a positive impact after curricular interventions, increasing understanding and promoting more humanized and reflective approaches.

Participants in interventions that involve research as a premise demonstrate greater motivation and appreciation of scientific methodology, positively impacting the completion of the courses offered and possible future involvement in research.

Adaptive processes and curricular satisfaction were measured to the extent that students' overall satisfaction with new teaching models was well received, especially in contexts where curricula were reformulated, promoting the application of skills practices, as evidenced in simulation-based teaching and in public health and geriatric courses. In addition, hybrid and flexible teaching models were also well received, although it is argued that some students faced challenges in terms of workloads and teacher adaptation.

**Table 2** Studies included in the meta-analysis ($n = 10$, reduced version)

| Autor/Ano | Title (short)) | Student satisfaction | Student Self-Efficacy | Academic Performance |
|---|---|---|---|---|
| AL-DABBAGH et al., 2005 [48] | Task-based model in family medicine | Satisfaction between 91.4% and 100% | 100% of students reported an increase in clinical confidence | Experimental group with 89.3% in the post-test vs. 51.8% control |
| ALANA et al., 2024 [27] | Bioethics curriculum | > 60% consideraram relevante | 59–60% reported using critical skills | 71% reported improved decision-making |
| Chan et al., 2010 [49] | Nursing skills for disasters | 93% rated the course positively | Score rose from 2.09 to 3.71 | 70% average in the final exam |
| Cohen Fineberg et al., 2004 [37][50] | Palliative care education | Average score 6.8/7 for interdisciplinary teaching | Self-efficacy increased by 2.33 points (doctors) | Improved understanding of professional roles |
| CREEDY et al., 2007 [32] | Resume for web support nurse | Média de satisfação: 28,63/35 | 61,4% relataram maior competência em informática | Satisfação relacionada ao uso de tecnologia |
| Dongre et al., 2010 [39] | Campanha educacional ROME | 85.6% rated it positively | 76.5% reported the ability to diagnose with few resources | Strengthened primary care practices |
| ELEAZER et al., 2006 [51] | Longitudinal curriculum in geriatrics | Average 4.08/5 in overall satisfaction | 87.6% reported being prepared to care for the elderly | 85.7% learned about the needs of the elderly |
| FINK et al., 2011 [52] | Cultural immersion activities | 83.3% rated it positively | Preparation to work in remote areas | Preparation for clinical activities |
| Rockfeld et al., 2020 [53] | Lifestyle medicine | Sessions with an average > 4.15/5 | Confidence increased from 3.8 to 4.3 ($p < 0.001$) | Understanding of lifestyle: 4.5 to 4.7 ($p = 0.003$) |
| Srinivasan et al., 2007 [54] | PBL vs. CBL | 89% preferred CBL | 52% reported more practical confidence | CBL best performance in exams (56.9%) |

Legend: Results organized according to satisfaction, self-efficacy, and academic performance outcomes. The full text of the 23 studies can be found in the supplementary material

### Meta-analysis results

Of the 99 articles included in the systematic review, 23 were eligible for meta-analysis. A total of 4,354 participants were included. These studies evaluated three main outcomes: student satisfaction, perceived self-efficacy, and academic performance after the implementation of innovative curricular interventions.

In accordance with editorial guidelines, the included studies were organized thematically in a summary table, Table 2, inserted in the body of the text for better visualization of the findings. Ten most representative studies were selected, considering data clarity, geographic diversity, and variety in types of intervention (such as PBL, use of technology, bioethics, and interprofessional practices). The full version of the 23 studies included in

the meta-analysis, with complete information, is available in the supplementary material (Additional File 4 – Characterization Table of the Studies Included in the Meta-analysis).

Quantitative analyses were performed using the prevalence averages from the studies after the interventions were implemented. Nineteen studies measuring student satisfaction were included; 15 studies examined the self-efficacy of the interventions, and 15 studies assessed academic performance.

As shown in Figs. 2 and 3, and 4, the eligible articles presented a weighted prevalence of 82% (76%–88%) for student satisfaction, 67% (49%–86%) for self-efficacy, and 70% (64%–75%) for academic performance after the implementation of curricular innovation interventions in undergraduate health courses. It was also observed that most studies indicate a significant difference in results after the implementation of curricular interventions.

There was high heterogeneity among the included studies, with $I^2$ values of 97.33% ($p < 0.001$) for student satisfaction (Fig. 2), 98.90% ($p < 0.001$) for self-efficacy (Fig. 3), and 88.60% ($p < 0.001$) for academic performance (Fig. 4). Subgroup analyses were performed, and no variables associated with the prevalence of student satisfaction, self-efficacy, and academic performance were found.

### Risk of publication bias

Figures 5 and 6, and 7 illustrate the results found in the funnel plots used to assess the risk of publication bias in the included studies. An asymmetric dispersion of studies outside the funnel limits can be observed in all outcomes analyzed, suggesting the presence of publication bias risk.

The Egger test revealed evidence of statistically significant results for studies that evaluated student satisfaction ($p = 0.001$) and academic performance ($p = 0.020$). However, regarding the evaluation of studies on perceived

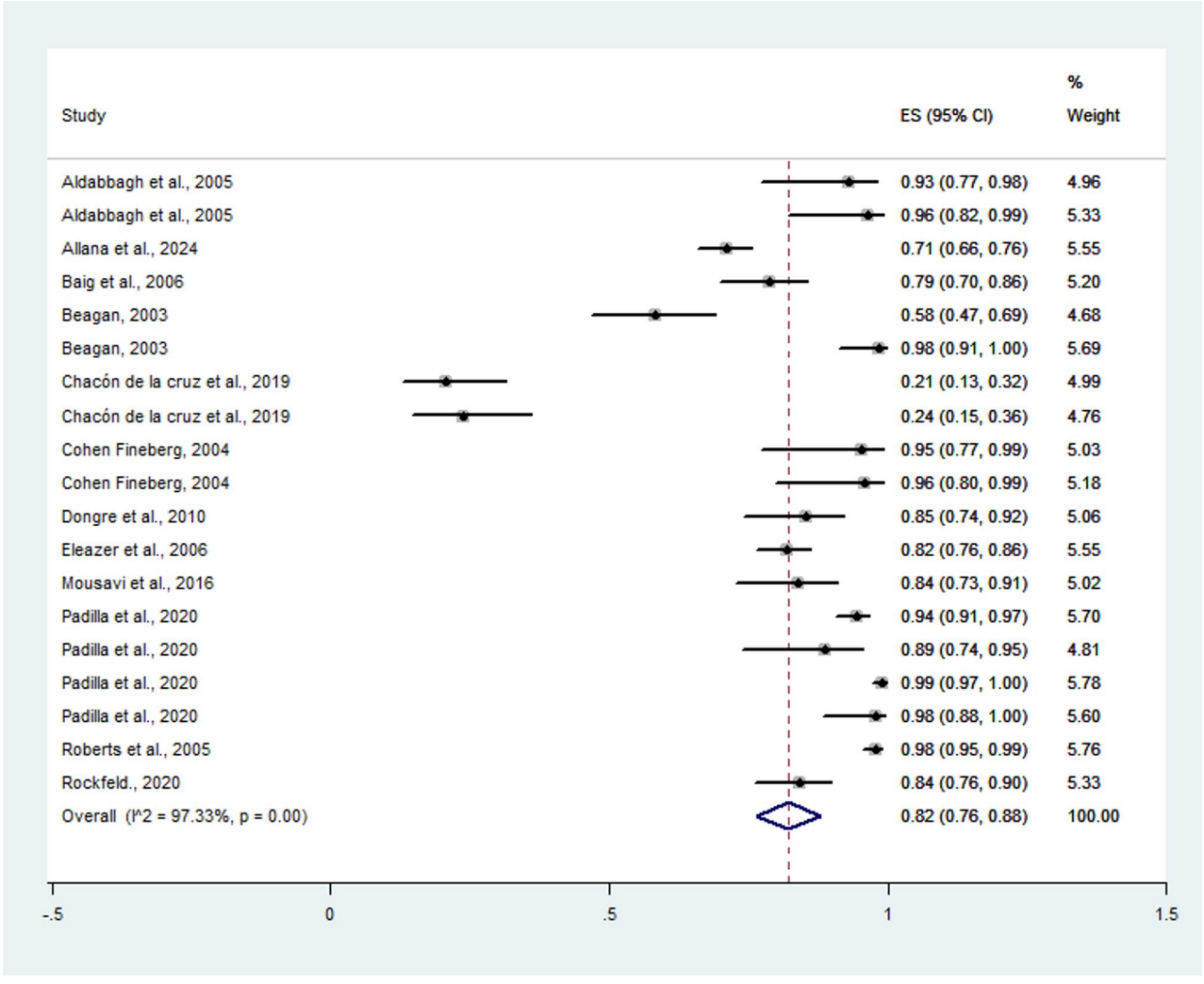



**Fig. 2** Forest plot of student satisfaction prevalence after curricular interventions

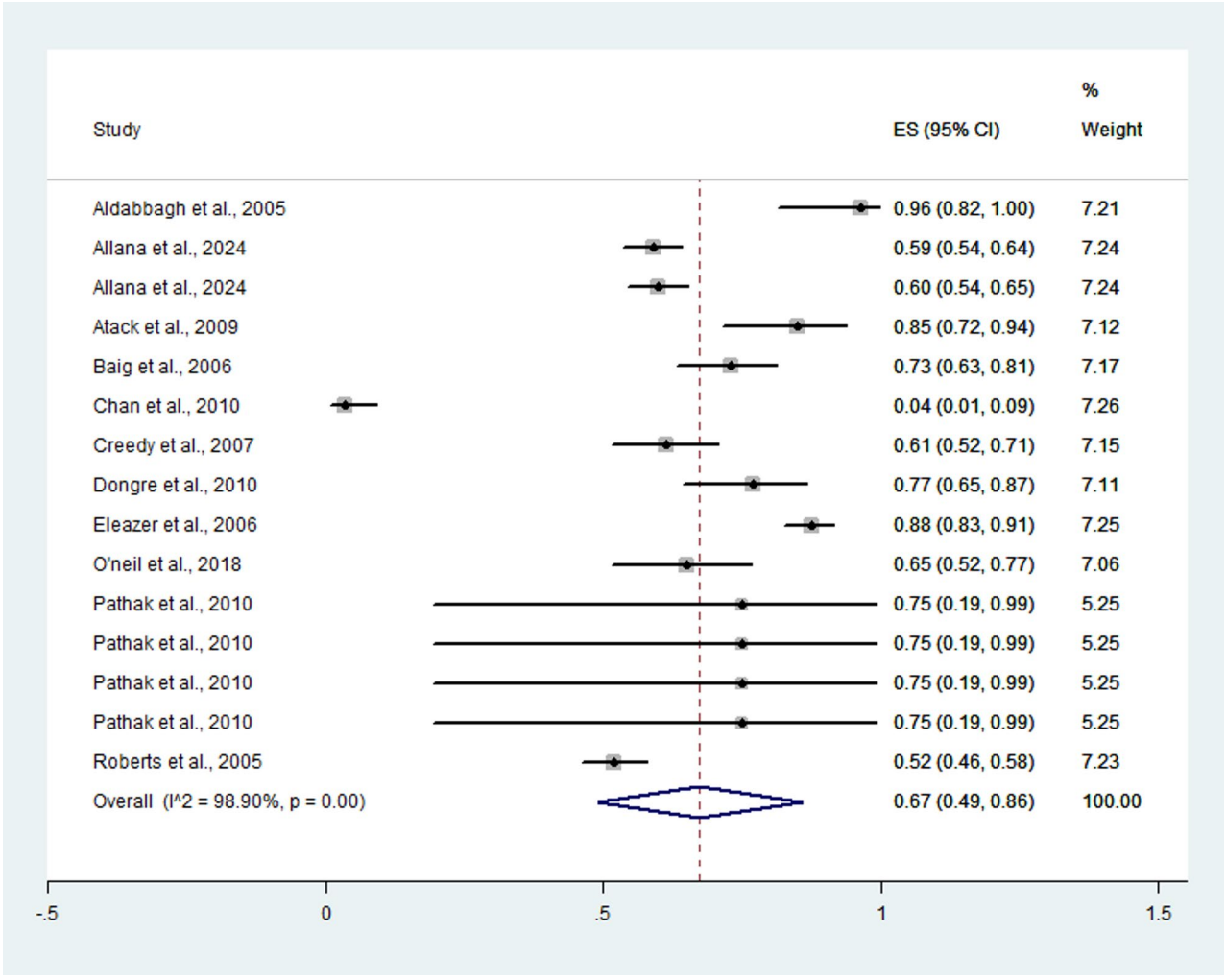



**Fig. 3** Forest plot of student self-efficacy prevalence after curricular interventions

self-efficacy, the test did not show statistical significance ($p = 2.247$). This asymmetry can be explained by the high heterogeneity observed among the studies, as mentioned above.

### Individual risk of bias in studies

Figure 8 presents a detailed analysis of the risk of bias in the various studies included, with the evaluation of different methodological criteria. Although no study fully met all quality criteria, no high risk of bias was identified in all domains evaluated, which allowed the inclusion of all articles in the meta-analysis.

The categories with the highest proportion of high risk of bias were: blinding of participants and personnel; blinding of outcome assessment; allocation concealment; and random sequence generation, which also have considerable contributions from unspecified bias.

In contrast, the categories of selective reporting and other biases had a higher proportion of low risk, indicating consistency and transparency in the selection and presentation of results.

### Methodological quality assessment

Of the 99 articles included in the systematic review, 25 articles (25.25%) scored less than 50%; while 44 studies (44.44%) scored between 50% and 75%, and 30 articles (30.30%) scored above 75% in the quality assessment using the Joanna Briggs Institute evaluation criteria. These results are summarized in (Additional File 3 – Characterization Table of the Systematic Review Studies).

## Discussion

As our main objective was to analyze the evidence of the effectiveness of curricular innovation projects, programs, and/or strategies in undergraduate health courses, it is necessary to highlight that the study achieved its objective, understanding that there is indeed evidence of the effectiveness of these curricular and institutional interventions.

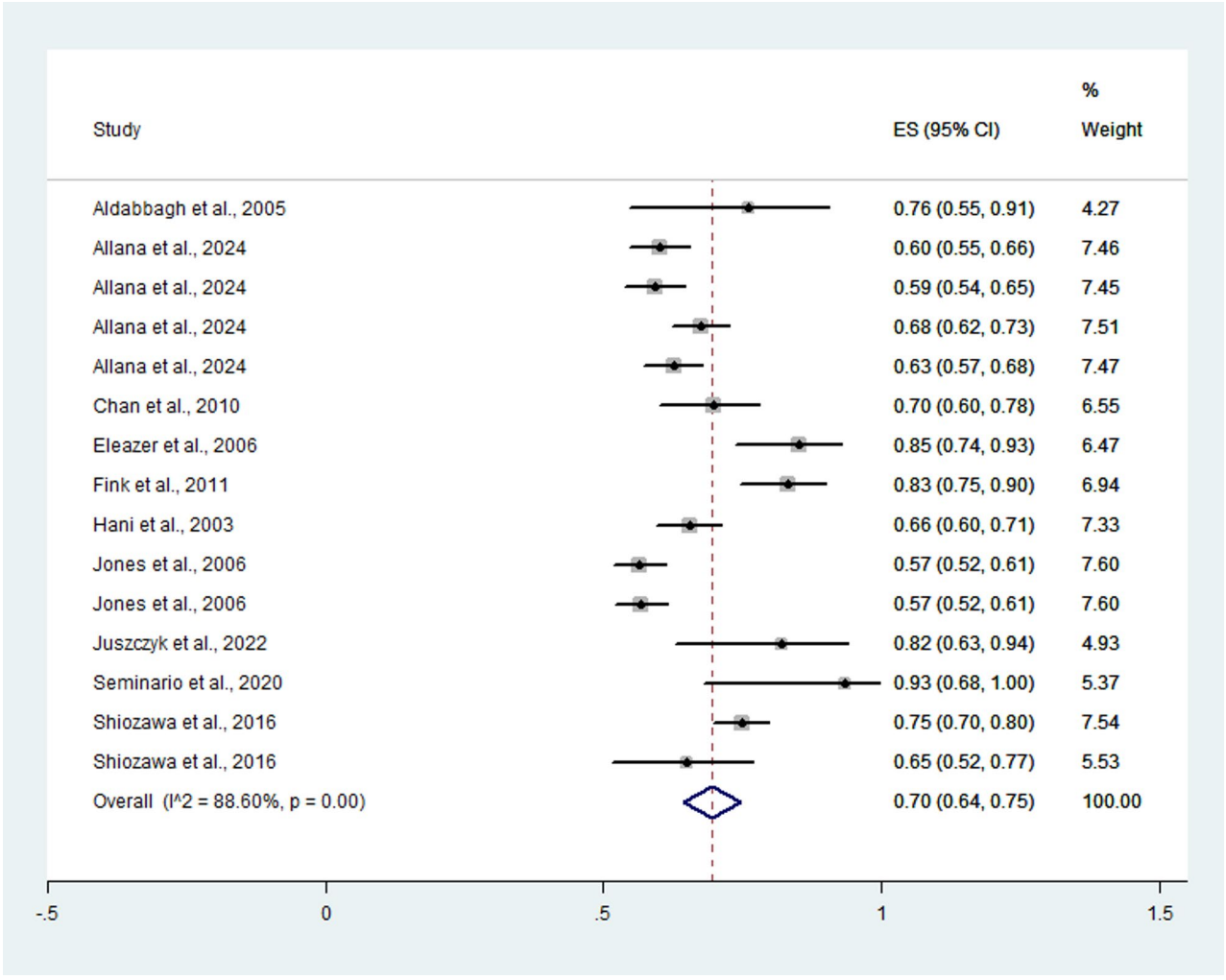



**Fig. 4** Forest plot of academic performance prevalence after curricular interventions

The articles found represent a plurality of countries that have published studies on curricular innovations and evaluations in the field of health and medical education. Considering only the main institutional affiliations mentioned, our analysis reveals a broad global representation, with greater emphasis on English-speaking countries, especially the United States, which leads in the number of publications on medical education and curricular innovations.

In this sense, it is essential to classify the curricular interventions mapped in this review, grouping them into seven thematic areas, which enable reflection on the main trends in innovation in approaches to medical science education: (1) simulation and clinical practice; (2) interprofessional training; (3) diversity and equity; (4) assessment and feedback; (5) educational leadership; (6) humanistic education; and (7) digital teaching.

In the area of simulation and clinical practice, interventions such as the Cadaveric Skin Biopsy Project, which simulates the collection of biopsies, and Rome Camp, focused on practical exposure in community settings, stand out; both have proven effective in developing students' technical skills and confidence before working in real-life care settings. Additionally, practices involving dissection combined with simulations of surgical procedures on cadavers have demonstrated a significant impact on the understanding of clinical and surgical techniques, strengthening preparation prior to professional practice by promoting experiential learning [55–57].

In the area of interprofessional training, experiences such as Interprofessional Hotspotting and the OHIO Project stand out, which have strengthened collaboration in public health by integrating multidisciplinary teams in community settings, with a focus on serving vulnerable populations. Such interventions have demonstrated that collaborative work between different areas improves care and the resolution of complex cases. In addition, they reinforce patient-centeredness and the importance of interdisciplinary work, as highlighted in the studies by Jensen et al. (2023), by demonstrating that

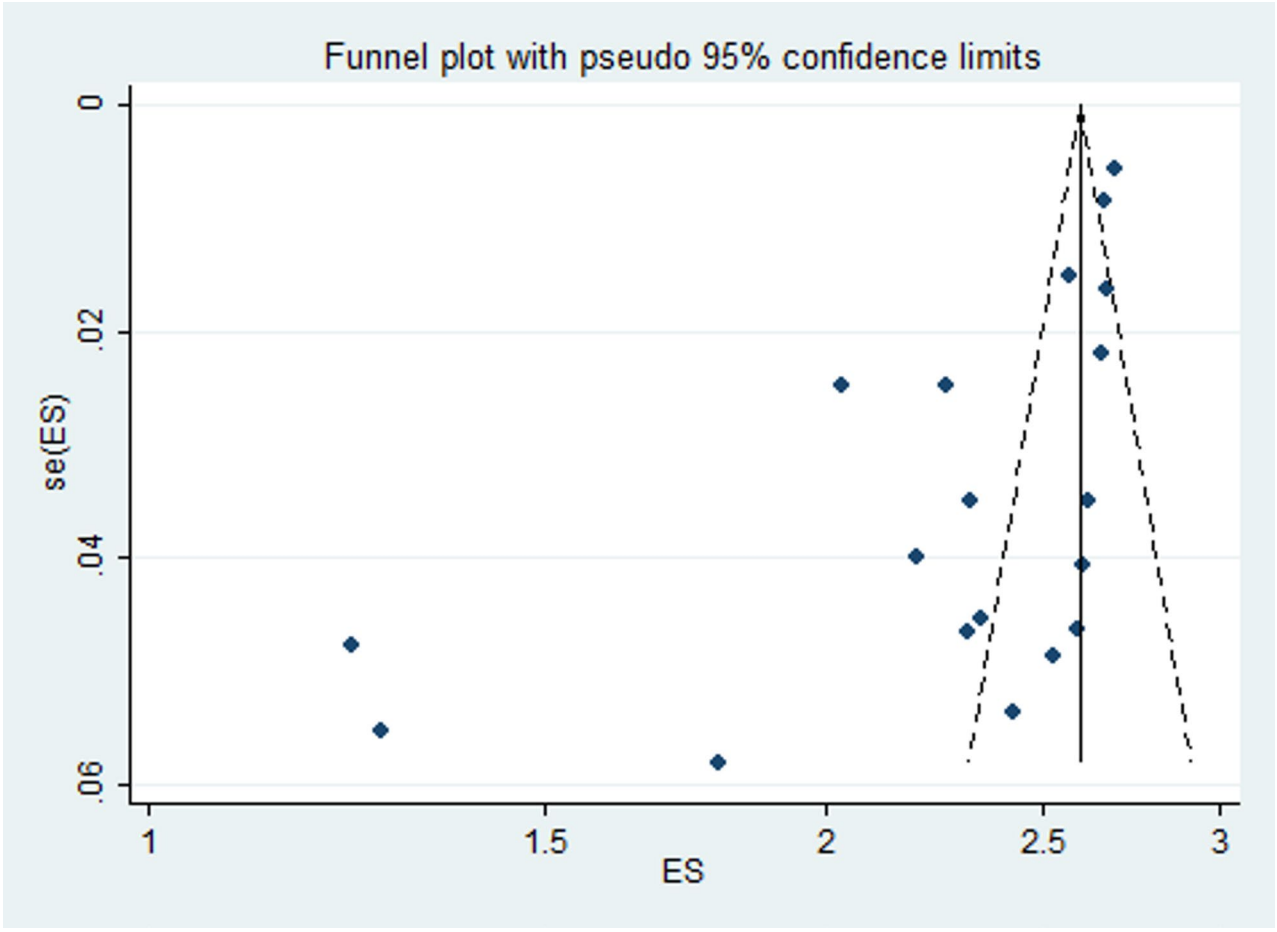



**Fig. 5** Funnel plot for studies on student satisfaction after curricular interventions

interprofessional learning improves interaction between students and patients, placing them at the center of the educational experience. Initiatives such as student-led interprofessional clinics, as described by Hulme et al. (2024), reveal that collaborative action in public health is effective in managing chronic conditions, highlighting the positive impact of interprofessional education in community contexts [58, 59].

In the area of diversity and equity, interventions aimed at increasing students' sensitivity to the needs of historically marginalized populations stand out. Projects such as workshops on Aboriginal culture have promoted critical reflection on the intersections between Aboriginal cultural identity and care, contributing to the expansion of the sociocultural competence of future professionals. Similarly, curricula that integrate topics related to the health of sexual and gender minorities, accompanied by continuous impact assessments, have proven effective in strengthening empathy, respect for diversity, and cultural competence. Such approaches represent a significant advance in health education, transcending technical and biological content and incorporating ethical and sociocultural perspectives, which are essential to person-centered care and the promotion of equity [60]– [61].

Assessment and feedback strategies emerge as central components in contemporary medical education, prioritizing the progressive improvement of student performance. In this review, interventions such as the use of the Objective Structured Clinical Examination (OSCE) stand out, replacing traditional assessment methods with structured practical exams, allowing for targeted feedback in an immediate context. Another relevant initiative was the development of an electronic questionnaire to map competencies in holistic nursing practices, highlighting the potential of digital technological tools to improve data collection and support formative assessments. These strategies not only enhance the quality of learning but also promote greater autonomy by offering continuous and individualized feedback. Aligned with international guidelines for good teaching practices, such as those established by the World Federation for Medical Education (WFME), these approaches emphasize feedback as an essential component for progressive

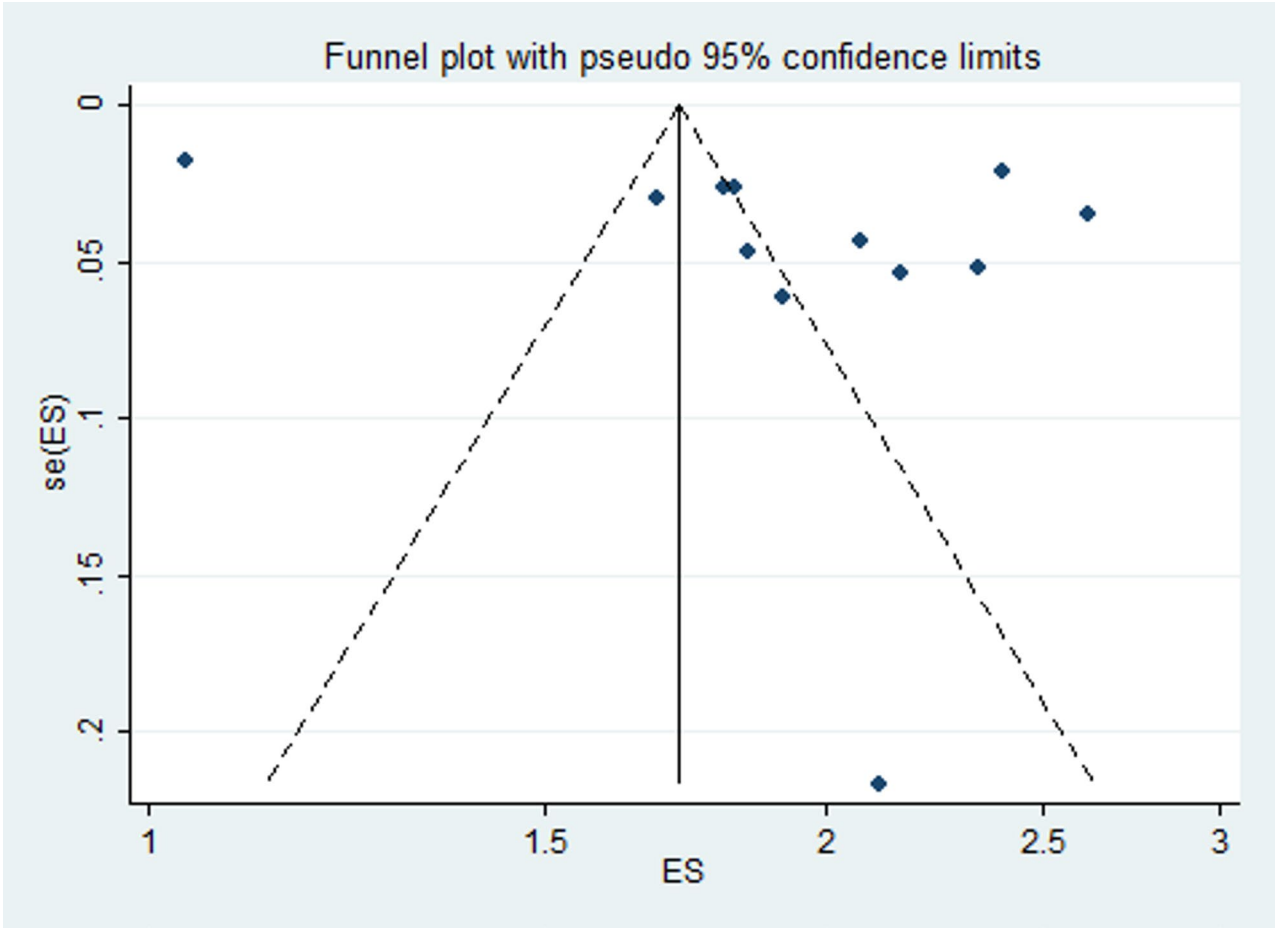



**Fig. 6** Funnel plot for studies on self-efficacy after curricular interventions

professional development. In this sense, they represent a significant advance in teaching-learning processes in the health field by integrating educational technologies and student-centered assessment models [62].

The focus on leadership training in health education highlights initiatives aimed at teacher training and academic management, especially in contexts with limited resources. Programs such as Health Education Advanced Leadership for Zimbabwe (HEALZ) have proven effective in training educational leaders, promoting sustainability and strengthening curricular innovations. Similarly, the Ukwanda Rural Clinical School in South Africa integrates academic leadership with community practice in rural areas, expanding the inclusion of students and teachers in socially complex territories. These experiences reinforce the importance of teacher leadership in institutional transformation, especially when integrating humanistic content, equity-centered approaches, and reflective practices. Evidence indicates that curricula led by structured leadership tend to be more responsive to social demands, promoting collaborative, inclusive educational environments aligned with the ethical and social commitment of health education to social needs [63–65].

The humanistic education axis stands out for its emphasis on the comprehensive training of students, going beyond technical skills to foster empathy, cultural sensitivity, and ethical responsibility. Initiatives such as the Summer Institute, which promotes interprofessional learning in socially vulnerable communities, and the Senior Mentoring program, which connects medical students with elderly people in the community, highlight the transformative potential of engaging with social reality, favoring the development of bonds and recognition of the human complexity involved in care. Projects focused on ethical education and palliative care, such as those that use plays based on real end-of-life experiences, encourage critical reflection on suffering, active listening, and acceptance. Curricula structured around references such as The Nine Abilities and Problem-Based Learning (PBL) models focused on interpersonal communication have proven effective in developing relational skills and patient-centered attitudes. These findings reinforce that humanistic education should not be treated as

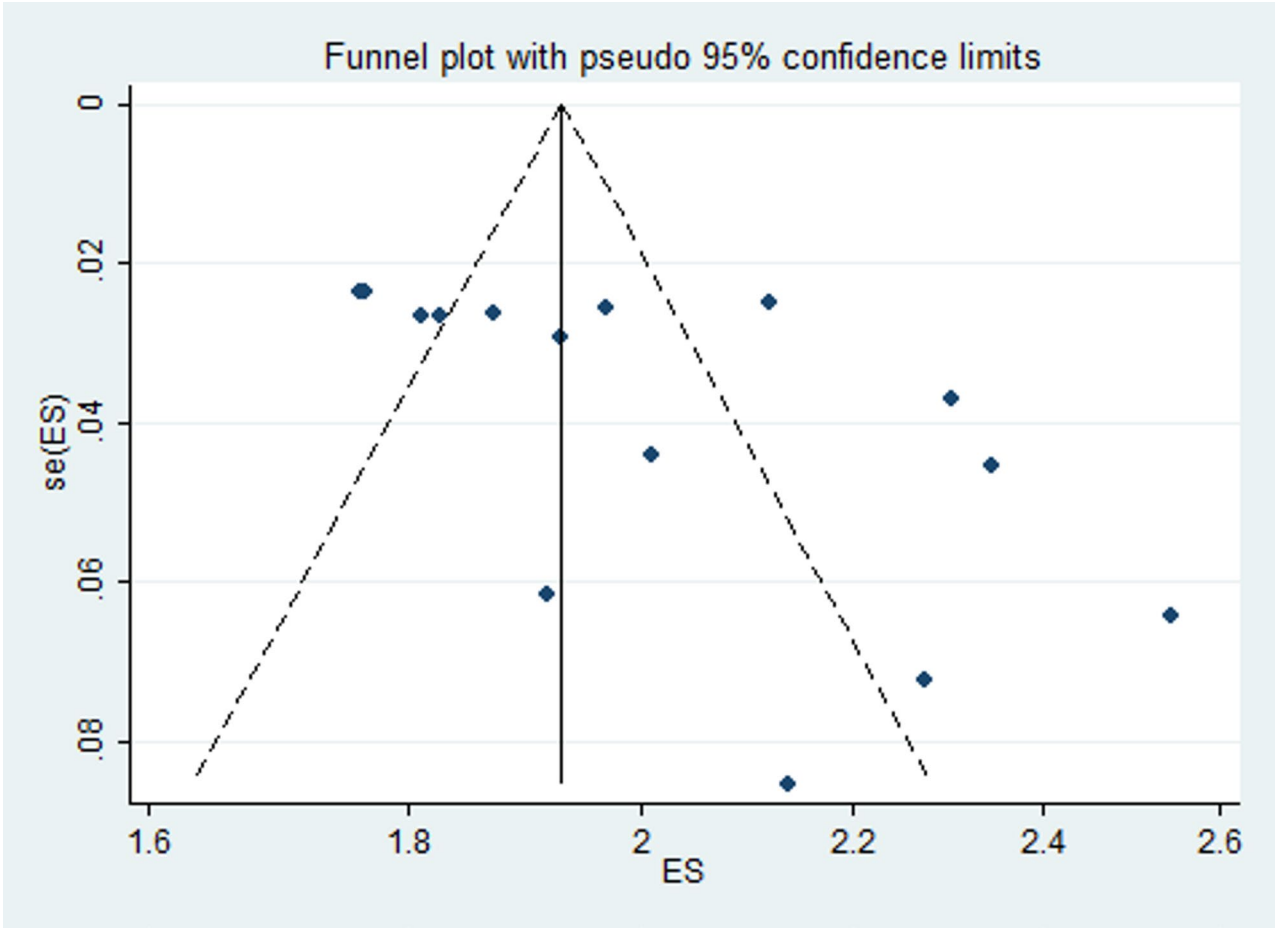


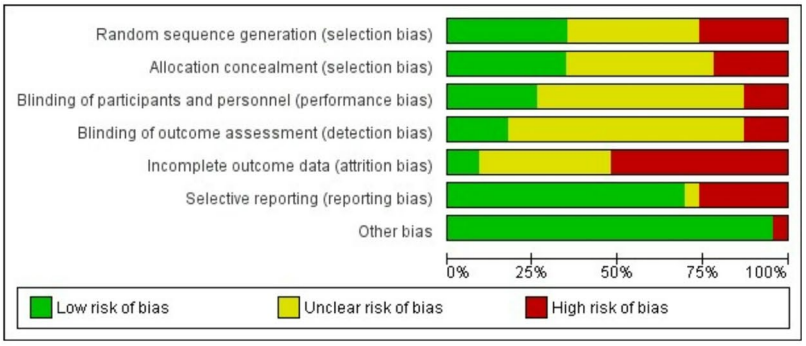

**Fig. 7** Funnel plot for academic performance after curricular interventions

supplementary content, but rather as a structuring axis of training, essential for addressing ethical, social, and emotional dilemmas in clinical practice [50, 66–69].

The focus on digital education highlights the strategic role of technology in health training, expanding access to knowledge, personalizing learning, and integrating technological skills into clinical practice. Programs that are entirely online, with interactive modules and adaptive assessments, have proven effective in adapting content to different learning styles and institutional contexts [26, 70, 71]. The introduction of virtual microscopy as an alternative to traditional slides exemplifies how digitization can make teaching more accessible and dynamic, especially in institutions with structural and laboratory limitations [72]. In addition, familiarity with digital environments helps prepare students for the practice of telemedicine through the use of electronic medical records, remote care simulations, and artificial intelligence tools. These experiences reinforce digital competence as one of the pillars of contemporary health education, aligning with the transformations of an increasingly technological, interconnected, and data-driven health system [26, 73, 74].

Curricular innovations have proven effective in fostering clinical skills, critical thinking, empathy, interprofessional work, and adaptation to digital technologies. Strategies such as simulations, problem-based learning (PBL), community practices, and approaches focused on cultural diversity strengthen student autonomy and person-centered care. Studies indicate that competency-based learning improves clinical performance [75] and that PBL contributes significantly to critical thinking and self-directed learning [76]. An integrative review of the Brazilian literature reinforces that curricular innovations are strategic elements for critical and humanistic training in health [77].

Studies such as those by Mukhalalati et al. (2024) and Kashi et al. (2024) indicate that innovative learning environments—especially those that promote student engagement in curricular decisions and institutional policies—significantly impact the development of professional identity [78, 79]. Interprofessional training, when structured by integrated curricula, has proven effective in



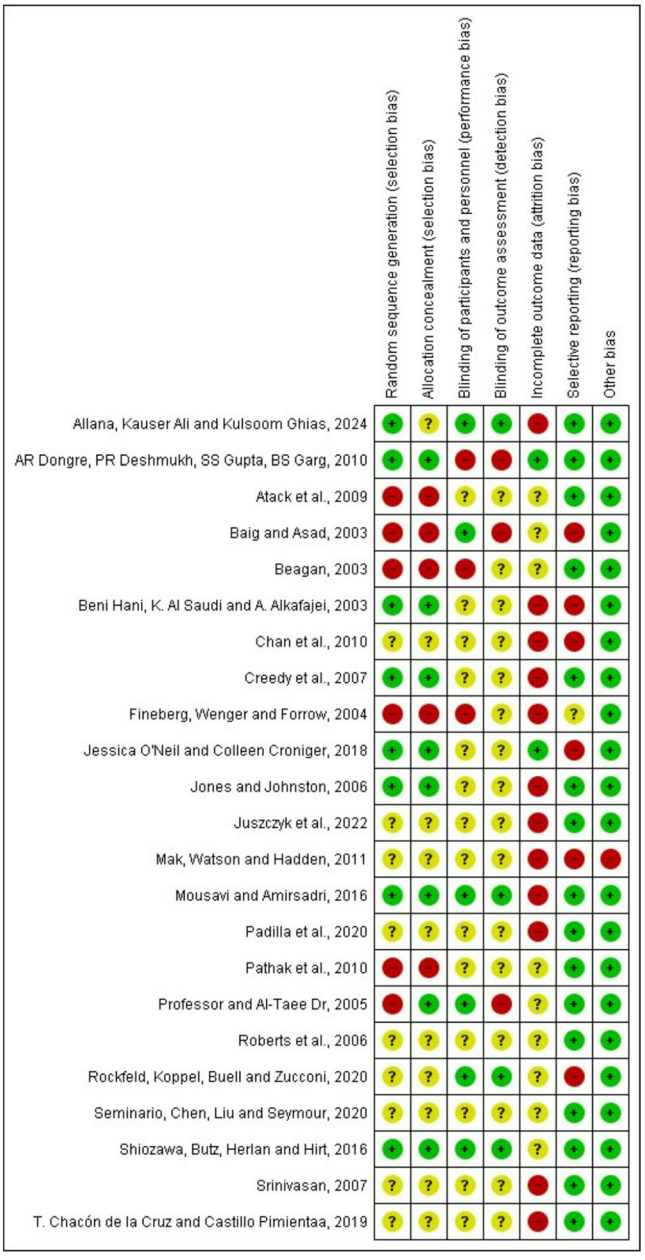




**Fig. 8** Assessment of individual bias risk of studies included in the meta-analysis

promoting collaborative skills essential to health practice [80]. Learning styles and attitudes toward digital technologies also influence student receptivity, highlighting the importance of pedagogical personalization, as discussed by Pagels et al. (2025) [81]. In addition, the integration of evidence-based medicine and clinical decision-making has emerged as a central component of training, strengthening the critical thinking and autonomy of future health professionals [82].

The review conducted by Carr et al. (2021) highlights that institutions that incorporate values of humanism and cultural sensitivity promote educational environments based on empathy, respect, and ethics, which are fundamental to the training of person-centered professionals [83]. In this context, structured teaching of the Humanities in Health contributes to broadening students' understanding of the social, cultural, and ethical aspects of care.

Evidence from practical and collaborative experiences, such as those described by Lazari et al. (2023) in experiential study groups and by Boonmak et al. (2022) in large-scale clinical simulations, indicates a positive impact on students' motivation, engagement, and perception of clinical competence [84, 85]. Additionally, the scoping review conducted by Nagel et al. (2024) reinforces the importance of interprofessional experiential learning as an effective strategy in health education [86].

In the field of systematic reviews, the findings of Wu et al. (2024) demonstrate that simulation-based learning significantly improves knowledge retention and self-efficacy in specific clinical contexts [87]. In turn, recent studies highlight that the use of digital technologies and the encouragement of self-directed learning, as in Gellisch et al. (2024) and Khan et al. (2025), strengthen students' preparation for clinical practice in complex and technologically mediated environments [88, 89].

Despite advances, the implementation of curricular innovations still faces structural and regulatory barriers that compromise their effectiveness and sustainability. The lack of institutional support, especially in contexts with traditional organizational structures, hinders the financing, consolidation, and continuity of educational innovation proposals [90–92]. In addition, regulatory restrictions and inflexible public policies hinder the updating of curricula and the incorporation of interprofessional and technological approaches. Experiences in Kenya and the Middle East reveal how resistance from regulatory boards and bureaucratic obstacles still limit significant reforms [93, 94].

A second set of challenges relates to teacher resistance, often associated with fear of losing autonomy, insecurity about new methodologies, or work overload. Qualitative studies indicate that many teachers report difficulties in migrating from an expository model to active approaches, especially when there is no adequate technical and pedagogical support [95]– [96]. Lack of time and specific training also emerge as recurring obstacles, leading to partial or uncommitted implementation of innovative practices [97–99]. This gap in preparation reduces the effectiveness of interventions and compromises the learning experience of students.

Finally, there is a notable absence of robust metrics for evaluating the impacts of innovations. The predominance of self-reported studies, with small samples and a scarcity of longitudinal data, limits the generalization of findings and hinders the continuous improvement of programs [100, 101]. Reviews point out that the lack of accurate and systematic indicators inhibits the replication of successful experiences and compromises feedback on pedagogical practices [102, 103]. More consistent evaluation models, combining qualitative and quantitative methods, are recommended to more accurately capture the effects of innovations in professional health education [104, 105].

This study has relevant limitations that should be considered when interpreting the results. Most of the included studies used small samples, without control groups and focusing on single institutions, which compromises the generalization of the findings. In addition, the use of self-reports as the main data collection strategy is recurrent, which can introduce desirability and subjectivity biases, affecting the objectivity of the conclusions. The scarcity of quantitative data to complement qualitative analyses also limits the analytical power of the interventions. The meta-analysis showed high heterogeneity, explained by methodological and contextual differences and the non-blinded nature of the educational interventions. Despite this, most studies presented a low risk of reporting bias and satisfactory methodological transparency, which lends robustness to the findings and supports the evidence that curricular innovations are promising strategies for improving health education, provided they are adequately contextualized.

Additionally, the use of active methodologies, interprofessional learning, and integration with real-life practice scenarios is widely recognized as an effective approach to health education. Evidence from systematic reviews confirms that interventions focused on interprofessional approaches favor the development of collaborative skills, while active methodologies are highly recommended strategies for improving students' learning and clinical competence [106, 107].

In this sense, future research should explore the longitudinal impact of curricular innovations, evaluating not only immediate results but also the effects on the professional practice of graduates. It is also recommended that research be expanded to diverse educational contexts, covering different cultures, health systems, and levels

of institutional development, in order to strengthen the external validity of the evidence and contribute to the construction of training models with global applicability.

In summary, this systematic review and meta-analysis identified consistent evidence of the effectiveness of curricular interventions in seven thematic areas—clinical simulation, interprofessional education, diversity and equity, assessment and feedback, educational leadership, humanistic education, and digital teaching. These findings demonstrate that innovative strategies, when well contextualized, favor the development of technical, collaborative, and socio-emotional skills in undergraduate health students. The combination of active methodologies, practical experiences, and student-centered learning environments proves particularly promising for strengthening the quality of professional training and the responsiveness of curricula to contemporary health demands.

## Conclusion

The findings of this systematic review and meta-analysis reinforce that curricular innovations have significant potential to improve training in undergraduate health courses, with positive impacts on students' self-efficacy, academic performance, and satisfaction—key indicators of educational quality. Although the results are promising, they should be interpreted with caution, considering the heterogeneity of the studies and their methodological limitations. This review contributes to supporting decisions by educators and managers regarding the adoption of innovative pedagogical practices, especially in a scenario of health system transformation. Longitudinal and multicenter studies using mixed methods are recommended to investigate the effects of these innovations on the professional practice of graduates, considering different cultural, institutional, and regulatory contexts.

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-08306-0.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

**Acknowledgements**

We would like to thank the team that is part of the University Teaching Innovation Program at the Federal University of Viçosa (PRODUS) for their logistical and technical support during the construction of this study. All the authors were involved in preparing the manuscript and all read and approved the final manuscript, under the guidance of professors and researchers Dr. Rosângela Minardi Mitre Cotta (Department of Nutritional Sciences, Federal University of Viçosa, Brazil), Dr. Tiago Ricardo Moreira (Department of Medicine and Nursing, Federal University of Viçosa, Brazil) and Dr. Ramón López Martín (Faculty of Philosophy and Educational Sciences, University of Valencia, Spain).

**Authors' contributions**

MMLP contributed to the literature, designed the study, analyzed the data and wrote the manuscript. VKRM, TISN, LAM and ESF collected and analyzed the data. RMMC, TRM, RLM, supervised the data analysis and contributed to revising the manuscript for final approval. All authors read and approved the final manuscript.

**Funding**

Not applicable.

**Data availability**

Data are provided in the manuscript or in supplementary information files.

## Declarations

**Ethics approval and consent to participate**

This systematic review and meta-analysis was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the number CRD42024556510. As this was a literature review, it did not require the approval of a Research Ethics Committee. All methods were carried out in accordance with the relevant guidelines and regulations, such as PRISMA.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare no competing interests.

**Author details**

[1]Department of Nutrition and Health, Universidade Federal de Viçosa, Viçosa, Brazil
[2]Department of Medicine and Nursing, Viçosa, Brazil
[3]Faculty of Philosophy and Educational Sciences, University of Valencia, Valencia, Spain

Received: 10 March 2025 / Accepted: 11 November 2025
Published online: 06 December 2025

**References**

1. Isidoro FGR, Côrtes M, da Ferreira CJW, D'Assunção FR, Gontijo ADM. ED. Interprofessional training in undergraduate health programs: a systematic review of educational strategies. Rev bras educ med. 2022;46(3):e 113. https://doi.org/10.1590/1981-5271v46.3-20220030
2. Vale JH, de O, Bichara CNC, Ferreira IP, Vale MGM do, Sena MRD, Freitas JJ da, Nascimento Júnior S, Coelho JCM. HR. Integrated curriculum in health courses: an integrative review with emphasis on interprofessional training. Pedagogical Cad. July 23, 2024 [cited January 15, 2025];21(7):e6002. Available at: https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/article/view/6002
3. Harden RM, Crosby JR. The eight roles of the medical teacher: the purpose and function of a teacher in the healthcare professions. 4th ed. Edinburgh: Elsevier; 2024.
4. Sagarra -RomeroL, Ramón-Arbués E, Huércanos -Esparza I, et al. Cultural competence of undergraduate student nurses: a multicenter study. Rev Latino-Am Nurs. 2024;32:e4230. https://doi.org/10.1590/1518-8345.7070.4230.
5. Benevides R, Miranda ES, Abrahão AL, Pereira S. Interprofessional education in health courses at a public university. Saude Debate. 2023;47(139):905–17. https://doi.org/10.1590/0103-1104202313913.
6. Machado C, Oliveira JM, Malvezzi E. Repercussions of the 2014 National curriculum guidelines on the pedagogical projects of new medical schools. Interface (Botucatu). 2021;25:e200358.
7. Gomes Junior FS, Takenami I, Cecon RS, Silva AL, Palácio MAV. Health education in medical training: an analysis based on pedagogical projects and scientific literature. Cienc Educ (Bauru). 2024;30:e24050.
8. Prevedello AS, Góes FSN, Cyrino EG. Interprofessional education in health training in brazil: a scoping review. Rev Bras Educ Med. 2022;46(3):e110.
9. Thomas DC, Kern DE, Hughes MT. Active learning strategies in undergraduate medical education: a systematic review. Acad Med. 2021;96(4):552–60.

10. Souza RS, Ely LI, Toassi RFC. Interprofessional health education: lessons learned from an innovative experience of integration between people, curricula, and professions. Pro-Posições. 2022;33:e20200011.
11. Yogui JOS, Magalhães TM, Bivanco -Lima D. Teaching the Person-Centered clinical method in undergraduate medical education: a narrative review. Rev Bras Educ Med. 2024;48(4):e120.
12. Lombardo L, Ehlers J, Lutz G. Mindset and reflection—How to sustainably improve intra- and interpersonal competences in medical education. healthcare. 2023;11(6):859. Available at: https://doi.org/10.3390/healthcare11060859.
13. Çakmakkaya OS, Meydanlı EG, Kafadar AM, Demirci MS, Süzer Ö, Ar MC, et al. Factors affecting medical students' satisfaction with online learning: a regression analysis of a survey. BMC Med Educ. 2024;30:e24050. https://doi.org/10.1186/s12909-023-03045-0.
14. Wang Y, Liu C, Zhang H. Digital competence in nursing education: addressing the challenges of online learning. Nurse Educ Today. 2023;117:105–23.
15. Rodríguez ML, Gómez FJ, López DP. Hybrid learning in health training: a systematic review. Rev Colomb Educ Sup. 2022;28(1):15–32. Available at: https://www.scielo.org.co/scielo.php?pid=S2216-09732022000100008.
16. Johnson NR, Chen JT, Phillips AW. Barriers to effective clinical teaching in medical education: A systematic review. Acad Med. 2023;98(4):567–75.
17. Silva AP, Mendes CE, Ferreira LH. Curricular reform in health courses: what is the role of beliefs? Rev Bras Educ Med. 2021;45(2):1–12.
18. Klasen JM, Lingard LA, Huwendiek S. The integration of workplace-based assessment and active learning strategies in health professions education: A systematic review. MedEduc. 2022;56(3):279–89.
19. Souza DL, Silva MJ, Pereira AL. Active teaching-learning methodologies in the training of health professionals: current debates. Cien Saude Colet. 2020;25(1):1–10.
20. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. https://doi.org/10.1136/bmj.n71.
21. The Joanna Briggs Institute. The Joanna Briggs Institute reviewers' manual 2015 : methodology for JBI scoping reviews. Adelaide: Joanna Briggs Institute; 2015.
22. Galvão T, Pansani T, Harrad D. Key reporting items in systematic reviews and meta -analyses: the PRISMA recommendation. Epidemiol Health Serv. 2015;24:335–42. https://doi.org/10.5123/S1679-. 49742 01500 02000 17.
23. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315(7109):629–34. https://doi.org/10.1136/bmj.315.7109.629.
24. Tsou KI, Cho SL, Lin CS, Sy LB, Yang LK, Chou TY, et al. Short-term outcomes of a near-full PBL curriculum in a new Taiwan medical school. Kaohsiung J Med Sci. 2014;30(7):375–84. https://doi.org/10.1016/j.kjms.2014.04.002.
25. Bradley C, Noonan M. A questionnaire survey of students' perceptions of nurse tutor teaching in a clinical skills learning program. BMC Nurs. 2018;17:16. https://doi.org/10.1186/s12912-018-0283-3.
26. Goolsby CA, Goodwin TL, Vest RM, Peterson EC, Odom SD. Hybrid simulation improves medical student procedural confidence during EM clerkship. Mil Med. 2015;60:52.
27. Allana AA, Ali SK, Ghias K. Bioethics curriculum for undergraduate medical students: an evaluation study utilizing mixed methods approach. BMC Med Edu C. 2024;24(1):385. https://doi.org/10.1186/s12909-024-05376-4.
28. Gray J, Williams D, Phillips S. Research odyssey: the evolution of a research partnership between baccalaureate nursing students and practicing nurses. Nurse Educ Today. 2010;30(2):178–82. https://doi.org/10.1016/j.nedt.2009.07.008.
29. D'Alessandro PR, Frager G, Theatre. An innovative teaching tool integrated into core undergraduate medical curriculum. Arts Health. 2014;6(3):191–204. https://doi.org/10.1080/17533015.2013.822398.
30. Heise BA, Johnsen VJ, Himes D. The course council: an example of student-centered learning. J Nurs Educ. 2010;49(2):109–11. https://doi.org/10.3928/01484834-20091023-08.
31. Aponte J, Smith S, Wall S, McDonough C, Ballentine M, Derouin A, et al. A school of nursing-wellness center partnership: creating collaborative practice experiences for undergraduate US senior nursing students. J Interprof Care. 2016;30(4):538–40. https://doi.org/10.3109/13561820.2016.1160047.
32. Creedy DK, Mitchell M, Seaton-Sykes P, Cooke M, Patterson E, Purcell C, et al. Evaluating a Web-enhanced bachelor of nursing curriculum: perspectives of third-year students. J Nurs Educ. 2007;46(10):460–7. https://doi.org/10.3928/01484834-20071001-06.
33. Mousavi S, Kargar M, Poursina F, Sharifnia SH. Objective structured clinical examination in undergraduate pharmacy students: time to switching to an alternative exam for clerkship courses. Curr Pharm Teach Learn. 2016;8(5):679–85. https://doi.org/10.1016/j.cptl.2016.05.007.
34. Baig L, Asad S, Ali SK, Gazzaz ZJ. Introducing problem-based learning in a medical school with a traditional/conventional curriculum. J Pak Med Assoc. 2006;56(9):430–3.
35. Srinivasan M, Wilkes M, Stevenson F, Nguyen T, Slavin S. Comparing problem-based learning with case-based learning: effects of a major curricular shift at two institutions. Acad Med. 2007;82(1):74–82. https://doi.org/10.1097/01.ACM.0000249963.93776.aa.
36. Al- Dabbagh SA, Al- Taee WG. Evaluation of a task-based, community oriented teaching model in family medicine for undergraduate medical students in Iraq. Educ Health (Abingdon). 2005;18(2):166–79. https://doi.org/10.1080/13576280500145648.
37. Cohen Fineberg IC, Wenger NS, Brown-Saltzman K, Redinbaugh EM, Arnold RM, Billings JA, et al. Interdisciplinary education: evaluation of a palliative care training intervention for pre-professionals. Acad Med. 2004;79(8):769–76. https://doi.org/10.1097/00001888-200408000-00011.
38. Filies GC, Dube R, Van Wyk J. Student readiness for interprofessional learning at a local university in South africa: a cross-sectional study. Afr J Health Prof Educ. 2021;13(4):186–90.https://doi.org/10.7196/AJHPE.2021.v13i4.1470.
39. Dongre AR, Deshmukh PR, Gupta SS, Garg BS. An evaluation of ROME Camp: forgotten innovation in medical education. Educ Health (Abingdon). 2010;23(1):363.
40. Goolsby CA, Goodwin TL, Vest RM. Hybrid simulation improves medical student procedural confidence during EM clerkship. Mil Med. 2014;179(11):1223–7. https://doi.org/10.7205/MILMED-D-14-00072.
41. Berman N, Fall LH, Smith S, Levine DA, Potts M, Siegel B, et al. Integration strategies for using virtual patients in clinical clerkships. Acad Med. 2009;84(7):838–43. https://doi.org/10.1097/ACM.0b013e3181a8c668.
42. Miller PM, Ravenel MC, Mauldin MP, Sulkowski S, Lowndes A, Thomas SE. An online alcohol and oral health curriculum for dental students. J Dent Educ. 2014;78(1):16–23. https://doi.org/10.1002/j.0022-0337.2014.78.1.tb05652.x.
43. Atack L, Parker K, Rocchi M, Maher J, Dryden T. The impact of an online interprofessional course in disaster management competence and attitude towards interprofessional learning. J Interprof Care. 2009;23(6):586–98. https://doi.org/10.3109/13561820902886238.
44. Thacker N, Wallis J, Winning J. Capable of being in uncertainty': applied medical humanities in undergraduate medical education. MedHumanit . 2022;48(3):325–34. https://doi.org/10.1136/medhum-2020-012127.
45. Cooper MB, Chacko M, Christner J. Incorporating LGBT health in an undergraduate medical education curriculum through the construct of social determinants of health. MedEdPORTAL. 2018;14:10781. https://doi.org/10.15766/mep_2374-8265.10781.
46. Sopoaga F, Connor JL, Dockerty JD, Adams J, Anderson L. Training medical students in Pacific health through an immersion program in new Zealand. NZ Med J. 2012;125(1349):37–45. PMID: 22327157.
47. Moch SD, Cronje RJ. Part II. Empowering grassroots evidence-based practice: a curricular model to foster undergraduate student-enabled practice change. J Prof Nurs. 2010;26(1):14–22. https://doi.org/10.1016/j.profnurs.2009.03.003.
48. Al-Dabbagh SA, Al-Taee WG. Evaluation of a task-based community oriented teaching model in family medicine for undergraduate medical students in Iraq. BMC Med Educ. 2005;5:31. https://doi.org/10.1186/1472-6920-5-31.
49. Chan SSS, Chan W, Cheng Y, Fung OWM, Lai TKH, Leung AWK, et al. Development and evaluation of an undergraduate training course for developing International Council of Nurses disaster nursing competencies in China. J Nurs Scholarsh. 2010;42(4):405–13. https://doi.org/10.1111/j.1547-5069.2010.01363.x.
50. Cohen Fineberg H, Kavanagh M, Knaus WA, Mulvihill MN, Sherman M, Phillips R, et al. Interdisciplinary education: evaluation of a palliative care training intervention for pre-professionals. Acad Med. 2004;67:33–8.
51. Roberts E, Richeson NA, Thornhill JT, Corwin SJ, Eleazer GP. The Senior Mentor Program at the University of South Carolina School of Medicine: an innovative geriatric longitudinal curriculum. Gerontol Geriatr Educ. 2006;27(2):11–23. https://doi.org/10.1300/J021v27n02_03.
52. Fink LD. Creating significant learning experiences: an integrated approach to designing college courses. 2nd ed. San Francisco: Jossey-Bass; 2011.
53. Rockfeld J, Koppel J, Buell A, Zucconi R. An interactive lifestyle medicine curriculum for third-year medical students to promote student and patient wellness. MedEdPORTAL. 2020;16:10972. https://doi.org/10.15766/mep_2374-8265.10972.

54. Srinivasan M, Wilkes M, Stevenson F, Nguyen T, Slavin S. Comparing problem-based learning with case-based learning: effects of a major curricular shift at two institutions. Acad Med. 2007;82(1):74–82. https://doi.org/10.1097/01.ACM.0000249963.93776.aa.
55. Sinz E, Rodgers DL, Giedraitis M, Vaitkaitis D. A novel algorithm-driven hybrid simulation learning method to improve endotracheal intubation skill acquisition: a randomized controlled trial. BMC Anesthesiol. 2022;22(1):42. https://doi.org/10.1186/s12871-021-01557-6.
56. Zargaran A, Houlden R, O'Neill P, Schaffer S, Chang V, Kafai Golahmadi A, Hirniak J, Turki M, Zargaran D. Undergraduate simulation training in emergency medicine during the COVID-19 pandemic: a course evaluation. Injury. 2022;53(10):3191–4. https://doi.org/10.1016/j.injury.2022.07.003.
57. Gaubert S, Blet A, Dib F, Ceccaldi PF, Brock T, Calixte M, De Macédo L, Dujardin T, Jean-Louis L, Leghima D, et al. Positive effects of lumbar puncture simulation training for medical students in clinical practice. BMC Med Educ. 2021;21(1):18. https://doi.org/10.1186/s12909-020-02452-3.
58. Jensen CB, Norbye B, Dahlgren MA, Iversen A. Making it real in interprofessional clinical clerkships: patient-centeredness in collaborative learning of student teams. Adv Health Sci Educ Theory Pract. 2023;28(3):687–703. https://doi.org/10.1007/s10459-022-10182-y.
59. Hulme A, Sangelaji B, Walker C, Fallon T, Denham J, Martin P, et al. Effectiveness of a student-led interprofessional health clinic in regional Australia for preventing and managing chronic diseases. J Interprof Care. 2024;38(5):893–906. https://doi.org/10.1080/13561820.2024.2380436.
60. Ang W, Verpooten L, De Winter B, Bombeke K. Diversity awareness in medical education: an innovative training with visual reflection tools. Perspect Med Educ. 2023;12(1):480–7. https://doi.org/10.5334/pme.1080.
61. Encandela JA, Batten JN, Shea JA, Rodriguez TE. Principles and practices for developing an integrated medical school curricular sequence about sexual and gender minority health. Teach Learn Med. 2020;32(1):52–61.
62. World Federation for Medical Education. WFME Global Standards for Quality Improvement : Basic Medical Education. Copenhagen: World Federation for Medical Education. 2020. Available at: https://wfme.org/publications/wfme-global-standards-for-quality-improvement/.
63. Hamner JB, Wilder B, Byrd L. Lessons learned: integrating a service-learning community-based partnership into the curriculum. Nurs Outlook. 2003;51(2):65–70.
64. Aagaard E, Lescano AG, Laughlin AL, Miner CA, Parry BA. Health education advanced leadership for Zimbabwe (HEALZ): developing the infrastructure to support curriculum reform. Ann Glob Health. 2007;60:42.
65. Schalkwyk SC, Couper ID, Blitz J, De Villiers MR. Going rural: driving change through a rural medical education innovation. Rural Remote Health. 2018;47:8.
66. Branch WT, Frankel R, Hafler JP, Suchman AL, Weissmann P, Lipsitz S, et al. A Multi-Institutional longitudinal faculty development program in humanism supports the professional development of faculty teachers. Acad Med. 2013;73:993.
67. Roberts E, Richeson NA, Thornhill JT, Corwin SJ, Eleazer GP. The senior mentor program at the university of South Carolina school of medicine: an innovative geriatric longitudinal curriculum. Gerontol Geriatr Educ. 2006;27(2):11–23. https://doi.org/10.1300/J021v27n02_03.
68. Duffy FD, Rhodes R, Wilson L, Jackson A, Berger E. Changing the culture of a medical school by orienting students and faculty toward community medicine. Acad Med. 2014;47:446.
69. Mallory JL. The impact of a palliative care educational component on attitudes toward care of the dying in undergraduate nursing students. J Prof Nurs. 2003;53:104–36.
70. Ota H, Yamaguchi S, Seki M, Sugimoto T, Ishikawa H, Nakanishi M. Evaluating a blended online learning model among undergraduate nursing students: A quantitative study. CIN: Comput Inf Nurs. 2017;35(2):77–84.
71. Atack L, Parker K. The impact of an online interprofessional course in disaster management competence and attitude towards interprofessional learning. J Interprof Care. 2009;47:74.
72. Stewart JE, Cowell CS, Edwards J, Trapp A. Microscope use in clinical veterinary practice and potential implications for veterinary school curricula. J Vet Med Educ. 2014;41(1):52–8.
73. Powers BW, Jain SH, Shrank WH. The interprofessional student hotspotting learning collaborative: a three-year multicenter experience. J Prof Nurs. 2020;80:42.
74. Dumenco L, George P, Taylor JS, Dollase R. Curriculum innovation at the Warren Alpert Medical School of Brown University. Med Health R I. 2012;95(10):317–27.
75. Imanipur M, Ebadi A, Monadi Ziarat H, Mohammadi MM. The effect of competency-based education on the clinical performance of healthcare professionals: A systematic review and meta-analysis. Int J Nurs Pract. 2022;28(1):e13003. https://doi.org/10.1111/ijn.13003.
76. Manuaba IBAP, No Y, Wu CC. The effectiveness of problem-based learning in improving critical thinking, problem-solving, and self-directed learning in first-year medical students: A meta-analysis. PLoS ONE. 2022;17(11):e0277339. https://doi.org/10.1371/journal.pone.0277339.
77. Silva RA, Souza MC. Curricular innovation in the training of health professionals: an integrative review. Rev Bras Educ Med. 2023;47(1):e2023123.
78. Mukhalalati B, Aly A, Yakti O, Elshami S, Daud A, Awaisu A, et al. Examining the perception of undergraduate health professional students of their learning environment, learning experience and professional identity development: a mixed-methods study. BMC Med Educ. 2024;24(1):886. https://doi.org/10.1186/s12909-024-05875-4.
79. Neshastesaz Kashi H, Goharinezhad S, Soleimanpour S, et al. Mapping student engagement in health professions education policy and decision-making: a scoping review. BMC Med Educ. 2024;24:325. https://doi.org/10.1186/s12909-024-05283-8.
80. Karlsson EA, Kvarnström S, Kvarnström M. Exploring a revised interprofessional learning curriculum in undergraduate health education programs at Linköping university. BMC Med Educ. 2024;24:466.
81. Pagels L, Schindler O, Luedtke K. Overview of student styles, content, learning effects, and attitudes toward digitally enhanced physical therapy education—a scoping review. BMC Med Educ. 2025;25(176). https://doi.org/10.1186/s12909-025-06750-6.
82. Simons M, Fisher G, Spanos S, Zurynski Y, Davidson A, Stoodley M, Rapport F, Ellis LA. Integrating evidence-based medicine training and shared decision-making: a qualitative study of junior physicians and consultants. BMC Med Educ. 2024;24(418). https://doi.org/10.1186/s12909-024-05409-y.
83. Carr SE, Noya F, Phillips B, Harris A, Scott K, Hooker C et al. Health Humanities curriculum and assessment in health professions education: a scoping review. BMC Med Educ. 2021;21(568). Available at: https://bmcmededuc.biomedcentral.com/articles/https://doi.org/10.1186/s12909-021-03012-3
84. Lazari EC, Mylonas CC, Thomopoulou GE, Manou E, Nastos C, Kavantzas N, et al. Experiential student study groups: perspectives on medical education in the post-COVID-19 period. BMC Med Educ. 2023;23(1):42. https://doi.org/10.1186/s12909-023-04006-9.
85. Boonmak P, Suraseranivongse S, Pattaravit N, Boonmak S, Jirativanont T, Lertbunnaphong T, et al. Simulation-based medical education in Thailand: a cross-sectional online national survey. BMC Med Educ. 2022;22(1):298. https://doi.org/10.1186/s12909-022-03369-9.
86. Nagel DA, Penner JL, Halas G, Philip MT, Cooke CA. Exploring experiential learning within interprofessional practice education initiatives for pre-licensure healthcare students: a scoping review. BMC Med Educ. 2024;24(1):139. https://doi.org/10.1186/s12909-024-05114-w.
87. Wu Z, Huang Y, Lyu L, Huang Y, Ping F. The effectiveness of simulation-based learning versus non-simulation-based learning in endocrinology education: a systematic review and meta-analysis. BMC Med Educ. 2024;24:1069.
88. Gellisch M, Morosan-Puopolo G, Brand-Saberi B, Schäfer T. Adapting to new challenges in medical education: a three-step digitization approach for blended learning. BMC Med Educ. 2024;24(1):585. https://doi.org/10.1186/s12909-024-05503-1.
89. Khan EH, Sethi A, Junaid SM, Khattak T, Khattak M. Readiness for self-directed learning among undergraduate medical students in Khyber Pakhtunkhwa during COVID-19, Pakistan. BMC Med Educ. 2025;25(1):165. https://doi.org/10.1186/s12909-025-06745-3.
90. Al-Balas M, Al-Balas HI, Jaber HM, Obeidat K, Al-Balas H, Aborajooh EA, et al. Distance learning in clinical medical education amid COVID-19 pandemic in Jordan: current situation, challenges, and perspectives. BMC Med Educ. 2020;20(1):341. https://doi.org/10.1186/s12909-020-02257-4.
91. Gebremickael A, Mulu A. Implementation status of nationally harmonized modular, integrated, competency-based medical curriculum in ethiopia: opportunities and challenges. BMC Med Educ. 2024;24:799.
92. Banerjee Y, Tuffnell C, Alkhadragy R. Mento's change model in teaching competency-based medical education. BMC Med Educ. 2019;19(1):472. https://doi.org/10.1186/s12909-019-1896-0.
93. Sharkas GF, El- Masry R, Abdel- Ghany S, El Baz A, Abou -Elsaad T, Kassab AA, et al. Satisfaction of academic medical staff with the integrated medical curriculum: an exploratory multinational survey. BMC Med Educ. 2024;24:1483.
94. Shikuku DN, Bar-Zeev S, Ladur AN, Allott H, Mwaura C, Nandikove P, et al. Experiences, barriers, and perspectives of midwifery educators, mentors, and

students implementing the updated emergency obstetrics and enhanced pre-service newborn care curriculum in kenya: a nested qualitative study. BMC Med Educ. 2024;24:950.
95. El- Awaisi A, Wilby KJ, Wilbur K, El Hajj MS, Awaisu A, Paravattil B. A middle Eastern journey to integrate interprofessional education into the health curriculum: a SWOC analysis. BMC Med Educ. 2017;17:15.
96. Najjuma JN, Muhumuza A, Santorino D, Sekyere SO, Ocheke AN, Yiltok SJ, et al. Barriers and facilitators to interprofessional simulation-based learning in a Ugandan medical school: a qualitative study. BMC Med Educ. 2024;24(1):1528. https://doi.org/10.1186/s12909-024-06521-9.
97. Brooks JV, Hughes D. Inverting the expert: faculty educators' sensemaking during the transition to an active learning curriculum. BMC Med Educ. 2024;24:85.
98. Sudacka M, Adler M, Durning SJ, et al. Why is it so difficult to implement a longitudinal clinical reasoning curriculum? A multicenter interview study on the barriers perceived by European health professions educators. BMC Med Educ. 2021;21:575. https://doi.org/10.1186/s12909-021-02960-w.
99. Regmi K, Jones L. A systematic review of the factors – enablers and barriers – affecting e-learning in health sciences education. BMC Med Educ. 2020;20(1):91. https://doi.org/10.1186/s12909-020-02007-6.
100. Mueller S, Weichert N, Stoecklein V, Hammitzsch A, Pascuito G, Krug C, et al. Evaluation of the effectiveness of instruction and study habits in two consecutive clinical semesters of the Munich medical curriculum (MeCuM) reveals the need for more time for self-study and a higher frequency of assessment. BMC Med Educ. 2011;11:62.
101. Ali SK, Baig LA. Problems and issues in implementing innovative curricula in developing countries: the Pakistani experience. BMC Med Educ. 2012;12:31.
102. O'Doherty D, Dromey M, Lougheed J, Hannigan A, Last J, McGrath D. Barriers and solutions to online learning in medical education – an integrative review. BMC Med Educ. 2018;18:130.
103. Hertling SF, Back DA, Eckhart N, Kaiser M, Graul I. To what extent has the digitalization of medical education progressed in times of COVID-19? A multinational survey of medical students and teachers in German-speaking central Europe. BMC Med Educ. 2022;22:387.
104. Noorbhai H, Ojo TAM. Health and e-Learning in health sciences curricula: a South African study of health sciences staff perspectives on utilization, constraints, and future possibilities. BMC Med Educ. 2023;23:189.
105. Mergen M, Graf N, Meyerheim M. Review of the current status of virtual reality integration in medical education - a scoping review. BMC Med Educ. 2024;24:788.
106. Aldriwesh MG, Alyousif SM, Alharbi NS. Undergraduate teaching and learning approaches for interprofessional education in the health professions: a systematic review. BMC Med Educ. 2022;22:13.
107. Zhang SL, Ren SJ, Zhu DM, Liu TY, Wang L, Zhao JH, Fan XT, Gong H. Which new teaching strategy is most recommended in medical education? A systematic review and network meta-analysis. BMC Med Educ. 2024;24:1342.

## Publisher's Note