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Integrating digital health into medical curricula: A review of current practices and future directions

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Abstract

This literature review critically examines the integration of digital health education within medical school curricula. Despite advancements toward patient-centered care, a significant gap persists in adequately preparing future healthcare professionals for the digital age. Through a systematic analysis of recent literature, this review explores the current state of digital health education, revealing substantial deficiencies in content and literacy. Key benefits such as improved patient outcomes, healthcare delivery, innovation, and interdisciplinary collaboration are highlighted. Conversely, the review identifies major challenges, including faculty readiness, curricular integration, resource limitations, and resistance to change. Pedagogical strategies like blended learning, problem-based learning, simulation, and continuous feedback mechanisms are discussed as means to enhance digital health education. The review also addresses assessment methods and student perceptions, underscoring the need for hands-on experience and integration of digital health into clinical practice. Recommendations for future directions include developing partnerships with technology companies, creating standardized digital health competencies, and updating curricula to include ethical considerations of digital technologies. This comprehensive overview elucidates the importance of equipping medical students with digital competencies to navigate the evolving healthcare landscape effectively.

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Introduction

In the rapidly evolving healthcare landscape, medical education has made significant strides toward patient-centered care and inter-professionalism (O'Brien *et al.*, 2018). These advancements reflect the growing emphasis on patient safety and quality of care. However, despite these commendable efforts, the current medical education curriculum still lags behind in embracing the digital age. One glaring gap in the existing curricula is the lack of adequate digital health teaching, which is vital for preparing future healthcare professionals to navigate the challenges and opportunities presented by digital technologies.

Experts in medical education have recognized the urgent need to integrate digital health into the curriculum to enhance student learning and equip them with the necessary skills for the digital era. (Zainal *et al.*, 2022) As the field of digital health continues to revolutionize healthcare delivery, the evidence of its benefits becomes increasingly evident and well-documented (Bhavnani, 2020; Cancela *et al.*, 2021; Silva *et al.*, 2022). Notably, the use of digital health has led to improved patient access to health information, safer clinical processes, reduced adverse events, fewer ambulatory-sensitive hospitalizations, and better care coordination and health service planning (Aapro *et al.*, 2020; Biggs *et al.*, 2019; Hall *et al.*, 2012; Imison *et al.*, 2016; Powell and Torous, 2020; Slevin *et al.*, 2019; Tehrani, 2017).

Embracing digital health in medical education is not merely a matter of staying up-to-date with technological advancements. Instead, it represents a strategic approach to building a sustainable healthcare system that revolves around patient-centered care. Despite its undeniable benefits, incorporating digital health into medical education remains challenging, as very few medical professionals are currently trained in this critical area (Car *et al.*, 2019; Lupton, 2014; Machleid *et al.*, 2020).

To address this gap and ensure that the medical workforce is adequately prepared to leverage digital technologies for patient care, it is essential to integrate digital health into medical education and training in a phased manner. This integration will empower medical students with the necessary knowledge and skills to effectively utilize digital health tools and systems in their future practice, ultimately benefiting both patients and healthcare providers.

In this literature review, we aim to explore the importance of incorporating digital health into medical education and delve into the benefits, challenges, and potential strategies for successful implementation. By examining the existing body of knowledge on digital health education in medical schools, we seek to shed light on the way forward in preparing the next generation of healthcare professionals for the digital revolution in healthcare.

Materials and methods

This section outlines the systematic methodology adopted for the literature review. The aim is to ensure a comprehensive, objective, and reproducible analysis of the available literature on digital health education in medical schools.

Research question
What are the key challenges and opportunities of integrating digital health education into medical school curricula?

Research question refinement
Initial definition
The research commenced with a broad question: "What is the current state and future directions of digital health education in medical schools?"

Refinement process
The question was refined through preliminary searches and discussions among team members, leading to a more focused question: "What are the challenges, opportunities, and best practices in integrating digital health education into medical school curricula?"

Database and source selection
Databases used
A range of academic databases were utilized, including PubMed, Scopus, Web of Science, and Google Scholar.

Rationale for selection
These databases were chosen for their comprehensive coverage of peer-reviewed journal articles, conference proceedings, and academic publications in medical and educational fields.

Search strategy
Keywords and phrases
A combination of keywords related to "digital health education," "medical school curriculum," "challenges," "opportunities," and "best practices" were used. Boolean operators (AND, OR) were applied to refine the search.

Search filters
Filters such as publication date (last 10 years), language (English), and document type (peer-reviewed articles) were applied.
Inclusion and Exclusion Criteria

Inclusion criteria
Publication type: Peer-reviewed journal articles and conference proceedings.
Time frame: Last 10 years to focus on recent developments.
Focus: Studies addressing digital health in medical school curricula.
Level of education: Undergraduate and graduate medical education.

Exclusion criteria
Language: Non-English publications.
Non-academic content: Opinion pieces, editorials, news articles.
Incomplete data: Conference abstracts, incomplete studies.
Irrelevant focus: Studies on other healthcare professionals or continuing medical education.

Data extraction and analysis
Extraction process
Relevant data, including study objectives, methodologies, findings, and conclusions, were extracted using a standardized form.

Analysis approach
A thematic analysis was conducted to identify common themes, trends, challenges, and best practices in digital health education.

Quality assessment
Criteria
The quality of studies was assessed based on their methodology, sample size, relevance to research questions, and bias.

Process
Two reviewers independently evaluated each article, and discrepancies were resolved through discussion.

Ethical considerations
Ethical compliance
Ensured all data used adhered to ethical standards of research, with proper acknowledgment of sources.

Result and Discussion
Digital health education in medical school curricula
Machleid *et al.* (2020) revealed a significant deficiency in digital health-related content in medical education across Europe, coupled with a notable lack of digital health literacy among medical students. In a separate endeavor, Khurana *et al.* (2022) identified 40 essential digital health topics that should be integrated into medical curricula, encompassing a broad range of knowledge, skills, and attitudes.

A comprehensive review of 32 undergraduate medical curricula from Peruvian universities (17 public and 15 private) indicated a surprising gap in digital health education. Only 46.8% of these programs included courses on information and communication technology (ICT), and a mere 9.3% offered specific courses on health informatics. Remarkably, none of these courses adhere to the guidelines recommended by the International Medical Informatics Association (IMIA) (Juli and Ayala, 2022). The study also found that these courses predominantly targeted early-stage medical students (first to third year) and varied significantly in duration, ranging from a single hour to an extensive three-year period (Tudor Car *et al.*, 2021). The variation in integration levels suggests a lack of consensus or a standardized approach. There's an apparent disconnect between the rapidly advancing digital health field and the more slowly evolving medical education curricula.

Benefits and opportunities of digital health education

Digital health education plays a crucial role in enhancing the clinical skills of medical students. As observed by Zainal *et al.* (2022), students with digital health proficiency demonstrate improved diagnostic accuracy, patient management, and adaptability to various digital health tools in clinical settings (Zainal *et al.*, 2022). The integration of digital health into medical education ensures that future healthcare professionals are better equipped to utilize emerging technologies effectively, thereby enhancing the quality of patient care.

Improved healthcare delivery

According to Silva *et al.* (2022), digital health education contributes to more efficient and effective healthcare delivery. Students trained in digital health are prepared to engage in telemedicine, electronic health records management, and data-driven decision-making, which are increasingly crucial in modern healthcare environments (Silva *et al.*, 2022).

The use of digital tools in healthcare has been linked to improved patient outcomes, reduced medical errors, and enhanced access to healthcare services, particularly in remote or underserved areas.

The introduction of digital health education encourages a culture of innovation and continuous learning among medical students and healthcare professionals. Bhavnani *et al.* (2020) highlight that familiarity with digital health technologies motivates healthcare providers to explore new ways of improving patient care and healthcare systems (Bhavnani, 2020). This culture of innovation is essential for keeping pace with the rapidly evolving field of healthcare technology.

Digital health education opens opportunities for interdisciplinary collaboration, as noted by Tudor Car *et al.* (2021) (Table 1). Medical students gain insights into the roles of data scientists, IT professionals, and healthcare administrators, fostering a collaborative approach to patient care and healthcare management. Such interdisciplinary learning environments prepare students for the collaborative nature of modern healthcare, where diverse expertise is required to address complex health issues.

Table 1. Benefits and opportunities

Key points	Details/Examples
Improved patient outcomes	Utilizing digital tools for superior patient care
Enhanced healthcare delivery	Streamlining services through digital means
Culture of innovation	Promoting continuous learning and proactive health approaches
Interdisciplinary collaboration	Fostering teamwork across healthcare specialties
Improved access	Expanding healthcare reach via digital platforms

The benefits and opportunities presented by digital health education are vast and multifaceted. By enhancing clinical skills, improving healthcare delivery, fostering innovation, and encouraging interdisciplinary collaboration, digital health education is poised to impact the future of healthcare significantly. As the healthcare landscape continues to evolve, the integration of digital health into medical education becomes increasingly vital.

Challenges and barriers to implementing digital health education

A primary challenge, as noted by Zainal *et al.* (2022), is the readiness of faculty members to teach digital health subjects. Many educators lack the necessary training and expertise in digital health, leading to a gap in effective teaching methodologies (Zainal *et al.*, 2022).

Continuous professional development is essential, but often, there is insufficient institutional support for such initiatives, hindering educators' ability to stay abreast of digital health advancements.

According to Tudor Car *et al.* (2021), integrating digital health into an already crowded medical curriculum is a significant challenge. There is a struggle to find a balance between introducing digital health topics and covering traditional medical content (Car *et al.*, 2019).

The lack of standardized guidelines or frameworks for digital health education complicates this integration, leading to inconsistent teaching approaches across different medical schools.

Access to the necessary technological infrastructure is a substantial barrier. As Machleid *et al.* (2020) point out, many institutions lack the resources to provide state-of-the-art digital health tools for training purposes (Machleid *et al.*, 2020). Furthermore, budget constraints and the cost of updating technological resources also pose significant challenges for many medical schools.

Bhavnani *et al.* (2020) highlight the natural resistance to change as a key barrier (Bhavnani, 2020). Both educators and students often prefer traditional methods of teaching and learning, making the adoption of new digital approaches challenging. Overcoming this resistance requires a cultural shift within the institution, promoting an environment that is open to innovation and technological advancements.

Table 2. Challenges and barriers

Key points	Details/Examples
Faculty readiness	Training educators in digital health methodologies
Curriculum integration	Fitting new digital content into existing programs
Standardization issues	Creating universal digital health education standards
Resource limitations	Overcoming financial and technological constraints
Resistance to change	Adapting to new educational paradigms

The challenges and barriers to implementing digital health education are multifaceted, involving issues related to faculty training, curriculum development, resources, student engagement, and institutional culture (Table 2). Addressing these challenges requires a concerted effort from educational institutions, healthcare systems, and policy-makers to provide the necessary support, resources, and frameworks for the effective integration of digital health into medical education.

Furthermore, research by Alhur and Alhashash (2022) reveals that students specializing in digital health or health informatics in Saudi Arabia face numerous challenges (Alhur and Alhashash, 2022). Alhur's subsequent study in 2023 also indicates that internships in digital health or health informatics are fraught with issues (Alhur, 2023).

Pedagogical approaches and best practices
A significant trend in digital health education is the adoption of blended learning models. Studies by Tudor Car *et al.* (2021) have highlighted the effectiveness of combining traditional classroom instruction with digital learning tools (Car *et al.*, 2019). This approach not only enhances the learning experience but also familiarizes students with the digital tools they will encounter in their professional practice. Also, Problem-Based Learning (PBL), as detailed by Walpole *et al.* (2017), is particularly effective in the digital health education (Walpole *et al.*, 2017). It encourages students to apply their theoretical knowledge to real-world scenarios, thereby improving their analytical and decision-making skills in digital health contexts.

Simulation-based education, as discussed by Machleid *et al.* (2020), offers a practical platform for students to apply digital health knowledge in a controlled, risk-free environment (Machleid *et al.*, 2020). This method has been found to significantly improve the clinical skills of students, preparing them for real-life medical situations involving digital health technologies.

Silva *et al.* (2022) emphasize the importance of an interdisciplinary approach in digital health education (Vlačić *et al.*, 2021). By integrating courses with computer science, data analytics, and health informatics, medical students gain a broader perspective, enhancing their ability to work collaboratively in diverse healthcare teams.

According to Bhavnani *et al.* (2020), continuous feedback mechanisms are essential in digital health education. These systems help in adapting teaching methods to the evolving needs of students and the healthcare sector(Bhavnani, 2020).

Partnerships with digital health companies can provide students with exposure to the latest technologies and industry best practices. Additionally, equipping educators with the necessary skills and knowledge in digital health is crucial. Regular faculty development programs can ensure that teachers remain at the forefront of digital health advancements.

Table 3. Pedagogical approaches and best practices

Key points	Details/Examples
Blended learning	Merging traditional and digital methodologies
Problem-Based learning (PBL)	Focusing on real-world health problems
Simulation-Based education	Employing practical simulations
Interdisciplinary learning	Encouraging learning across disciplines
Continuous feedback	Implementing regular assessment mechanisms

Effective pedagogical approaches in digital health education are diverse and evolving (Table 3). Blended learning, PBL, simulation-based education, and interdisciplinary learning have emerged as key strategies. Continuous feedback and industry partnerships further enhance the learning experience. As the field of digital health continues to grow, these educational practices will need ongoing refinement to keep pace with technological advancements.

Assessment and evaluation of digital health education

The assessment of digital health education involves various methods tailored to measure both the acquisition of knowledge and the development of digital competencies. According to Tudor Car *et al.* (2021), multiple-choice examinations, practical skill tests, and OSCEs (Objective Structured Clinical Examinations) are commonly used. These methods evaluate students' understanding of digital tools and their ability to apply this knowledge in clinical scenarios (Tudor Car *et al.*, 2021). However, there is an ongoing debate about the effectiveness of traditional examination formats in assessing digital literacy skills.

Evaluation strategies are crucial in understanding the impact and effectiveness of digital health education programs. Silva *et al.* (2022) highlight the use of course feedback surveys and focus groups as primary tools for curriculum evaluation (Silva *et al.*, 2022). These methods provide insights into student satisfaction, perceived relevance, and areas for improvement. Additionally, long-term follow-up studies, as suggested by Powell and Torous (2020), are essential for assessing the impact of digital health education on clinical practice(Powell and Torous, 2020).

One of the main challenges in this area, as identified by Slevin *et al.* (2019), is keeping pace with rapidly evolving digital technologies (Slevin *et al.*, 2019). The dynamic nature of digital health requires continuous updates to assessment and evaluation strategies. Furthermore, the lack of standardized competencies in digital health education complicates the development of uniform assessment criteria.

Some innovative approaches in assessment include simulation-based assessments and peer-review mechanisms, offering more practical and interactive evaluation methods. For instance, Walpole *et al.* (2017) emphasize the potential of simulation environments to assess decision-making and problem-solving skills in a digital context (Walpole *et al.*, 2017).

Table 4. Assessment and evaluation

Key points	Details/Examples
Multiple-choice exams	Testing theoretical knowledge
Practical skill tests	Assessing hands-on abilities
OSCEs	Evaluating clinical skills in structured settings
Course feedback surveys	Gathering student feedback
Focus groups and studies	Conducting in-depth analyses and long-term tracking

The assessment and evaluation of digital health education are critical components in ensuring the effectiveness of such programs. While traditional methods are still prevalent, there is a growing need for innovative, practical, and dynamic assessment strategies that align with the evolving nature of digital health. Future research should focus on developing standardized competencies and exploring new methods of assessment that can accurately reflect students' proficiency in digital health (Table 4).

Student perceptions and experiences

The incorporation of digital health education into medical curricula is not only a matter of curriculum design but also of how students perceive and experience these changes. Understanding student perspectives is crucial for effective implementation and improvement of digital health education. This literature review aims to synthesize current findings on medical students' perceptions and experiences with digital health education.

Studies indicate varied responses from medical students regarding digital health education. Evbuomwan *et al.* (2020) found that while students recognize the importance of incorporating Information and Communication Technology (ICT) into their curricula, there is apprehension about the adequacy of their training and preparedness for future practice (Evbuomwan *et al.*, 2020). This highlights a gap between curriculum objectives and student confidence in their digital health competencies.

The way digital health education is delivered significantly affects student perceptions. According to Tudor Car *et al.* (2021), students favored blended learning approaches that combined traditional teaching methods with digital tools, as these were seen to enhance understanding and engagement (Tudor Car *et al.*, 2021). The use of interactive platforms and real-life case studies was particularly appreciated for its practical relevance.

Despite acknowledging the necessity of digital health education, students expressed concerns related to the curriculum's content and structure. A study by Walpole *et al.* (2017) revealed apprehensions about the potential overshadowing of fundamental clinical skills and the pace at which technological advancements are introduced in the curriculum. Students also voiced the need for more hands-on experience with digital tools within clinical settings (Walpole *et al.*, 2017).

Students expressed a desire for more integrated and clinically relevant digital health content, as reported by Machleid *et al.* (2020). They sought an education that not only provided theoretical knowledge but also prepared them for the practical application of digital technologies in the patient care (Machleid *et al.*, 2020).

Student perceptions and experiences are critical in shaping and refining digital health education. Current literature suggests that while students acknowledge the importance of digital health, they seek more practical, integrated, and clinically relevant training.

Addressing these needs requires curricular adjustments that balance digital competency with core medical skills and ensure that students are well-equipped for the evolving digital healthcare landscape (Table 5).

Table 5. Student perceptions and experiences

Key points	Details/Examples
Importance recognition	Acknowledging the value of digital health
Preparedness concerns	Addressing readiness for digital health practices
Preference for blended learning	Favoring a mix of traditional and digital methods
Curriculum content concerns	Seeking integrated, clinically relevant content

Integration of digital health into clinical practice
The integration of digital health technologies into clinical practice is a critical step in modernizing healthcare. As medical schools incorporate digital health into their curricula, it is essential to understand how this translates into actual clinical settings. This literature review aims to explore the transition of digital health education from academic theory to practical application in healthcare environments.

A significant focus of current research is on how well digital health education prepares medical students for real-world clinical applications. Studies by Silva *et al.* (2022) have shown that while students are receiving theoretical knowledge about digital tools, there remains a gap in hands-on practical experience. These disconnect raises concerns about the readiness of new graduates to utilize digital health technologies effectively in patient care.

The integration of digital health into clinical practice is not without its challenges. According to Bhavnani *et al.* (2020), one of the main barriers is the lack of standardization across different healthcare settings, leading to inconsistencies in the use and understanding of digital tools among healthcare professionals (Bhavnani, 2020). Additionally, there is often resistance to change among established practitioners, as noted by Cancela *et al.* (2021), which can hinder the adoption of new technologies (Cancela *et al.*, 2021).

To bridge the gap between education and practice, innovative strategies are being explored. Tudor Car *et al.* (2021) emphasize the importance of simulation-based training and interdisciplinary learning experiences to better equip students for the digital demands of clinical practice (Tudor Car *et al.*, 2021). Furthermore, ongoing professional development and training for current healthcare workers are crucial for the effective integration of digital health, as suggested by Walpole *et al.* (2017).

The successful integration of digital health into clinical practice has significant implications for the future of healthcare. It promises to enhance patient care, improve healthcare efficiency, and foster a more data-driven approach to medicine. However, as Machleid *et al.* (2020) point out, this requires a collaborative effort between educational institutions, healthcare providers, and technology developers to ensure a seamless transition of digital health from the classroom to the clinical practice (Machleid *et al.*, 2020).

Future directions and recommendations

Future curricula should involve partnerships with technology companies to ensure that medical students are exposed to the latest digital health tools and trends. Incorporate learning modules that bring together students from medical, IT, and data science backgrounds to foster a more holistic understanding of digital health applications.

Develop a standardized set of digital health competencies that medical students should acquire, as suggested by experts like Machleid *et al.* (2020). Moreover, curricula should be dynamic, allowing for the rapid incorporation of new technologies and methodologies in digital health.

Enhanced use of simulation in teaching digital health tools, as proposed by Tudor Car *et al.* (2021), can provide hands-on experience in a controlled environment. Implement real-world case studies to demonstrate the practical applications and implications of digital health technologies.

Introduce clinical rotations in settings that are highly digitalized, providing students with firsthand experience of using digital tools in patient care. Regular workshops by digital health professionals can keep students updated on the latest developments and best practices.

Motivate medical students to engage in research projects focused on digital health to foster a deeper understanding and innovation. Develop continuing education programs for healthcare professionals to stay updated with the ever-evolving digital health landscape.

Integrate courses on the ethical implications of digital technologies in healthcare, including privacy, data security, and patient autonomy. Educate students on how healthcare policies and regulations impact the development and use of digital technologies.

Conclusion

This literature review highlights the essential need for digital health education in medical schools. As healthcare continues to evolve, the traditional medical curriculum must adapt to include the necessary digital skills. The challenges faced in this endeavor are significant. Faculty may lack the skills to teach digital health, curricula are already packed, and there is no common standard for what digital health education should entail. Moreover, there's often resistance to moving away from traditional teaching methods.

Yet, the benefits of integrating digital health into medical education are clear. It can improve how future doctors diagnose and manage patient care, make healthcare delivery more efficient, and promote ongoing learning and teamwork across different health fields.

Teaching methods that mix traditional learning with digital tools, problem-solving in real-life situations, practicing in simulations, and learning from different disciplines are promising. These approaches can make students more comfortable and skilled with the digital tools they'll use in their careers.

Also, feedback from students shows they see the value in learning digital skills but want more practical training. They want to feel ready to use these skills effectively in real-world healthcare settings.

Looking ahead, medical schools should work with tech companies to ensure students get to use the latest digital tools. Curricula should be flexible to keep up with new technologies. Training should include ethical considerations around using digital technologies in healthcare, like protecting patient privacy. Medical schools have an opportunity to better prepare students for the digital side of healthcare. By doing so, they'll help ensure that new doctors are ready to provide the best care with the latest tools available.

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