INVITED EDITORIAL

The future is here: medical graduates need to be ready for digital health

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Digital technology has long been an important part of effective healthcare delivery, evolving steadily to support clinical practice. In recent years, digital health has become central to improving efficiency, quality, safety, and accuracy across clinical processes. Advances in artificial intelligence (AI), combined with other digital technologies are creating both new opportunities and challenges that medical graduates must be prepared for. Opportunities include improved diagnostic accuracy, greater precision in personalised treatment plans, enhanced clinical decision support, streamlined recordkeeping, and more efficient administrative processes. At the same time, AI is empowering patients with greater knowledge about both routine and complex health issues, enabling them to take a more active role in decision-making. To support their active engagement, many patients increasingly expect doctors to be proficient in these rapidly emerging digital health technologies that include AI, health apps, telemedicine, wearable devices, and other remote assessment tools.[1]

While offering many benefits, these rapid advances in digital health technologies also present notable challenges, including heightened concerns about data security, patient privacy, ethical issues, and potential algorithmic bias. Therefore, it is essential for clinicians to understand these technologies thoroughly and be able to use them safely and effectively to optimise patient care and system performance. At graduation, new doctors should be competent with current technologies and equipped with the skills to adapt to new and evolving digital technologies that will inevitably arise. Therefore, there is an urgent need for better and more visible integration of digital health education into the core curriculum of primary medical degree programmes to prepare a future-ready medical workforce.

Digital health education fulfils multiple key roles in medical training. Primarily, it equips students with the ability to use digital technologies to effectively enhance patient care, by supporting more accurate diagnoses and decision-making while optimising workflow efficiency. In parallel, it supports the broader acquisition of the knowledge, skills, and attitudes essential for competent medical practice. Recent advances in AI can play a vital role in both aspects by enabling personalised learning experiences tailored to students' needs.

The need to include digital health education in medical training has been acknowledged for some time. Although some progress has been made, it remains inconsistent and insufficient in both scale and speed to keep pace with rapid technological advancement. This raises growing concerns that graduates are being left underprepared for the continuously changing digital environment.

In this opinion piece, we examine several important aspects of digital health education for medical students. We begin by clarifying key terminology around digital health, then discuss the drivers behind the digital health revolution. Next, we explore reasons for the longstanding limited focus on digital health education that has left medical graduates potentially underprepared for rapid technological advances, and how this is now prompting medical accreditation bodies to address this. We also address common assumptions about digital natives - medical students presumed to be naturally proficient with digital technologies - and explain why additional training is needed to develop comprehensive digital competence in the clinical workplace. We then review leading expert opinions and international consensus efforts that seek to define essential digital health competencies for medical students. We highlight challenges in applying these frameworks broadly, before discussing findings from our own local research which identify what we consider to be the minimum essential digital health educational requirements for future doctors in Aotearoa New Zealand. Recognising that curricular change takes time, we also offer some practical guidance for medical students on building critical digital health skills, particularly in AI, through accessible online resources. Finally, we examine some of the institutional approaches to AI education in medical schools, outline current limitations and offer some cautionary advice regarding the risks associated with AI integration in healthcare education and practice.

Digital health terminology

The use of technology in healthcare has been described using various labels and definitions over the decades, including terms such as 'medical informatics,' 'health informatics,' and 'clinical informatics.' More recently, interchangeable terms like 'digital health' and 'eHealth' have emerged. In this article, we use the broad umbrella term "digital health," which is widely adopted globally and encompasses nearly all activities involving technology in healthcare practice.[2-3] In this context, we focus primarily on the use of digital technology by doctors and other healthcare professionals in delivering healthcare. This typically includes telehealth, electronic health records (EHR), clinical decision support systems (CDSS), patient portals, e-prescribing, and e-ordering, as well as more advanced technologies such as artificial intelligence (AI), machine learning (ML), and decision-support systems.

The technology revolution

Although AI has been used in healthcare for some time, the unexpected public release of the generative AI (GenAI), chat-based tool, ChatGPT, by OpenAI in 2022 caught many medical educators off guard.[4] ChatGPT and similar chat-based applications, such as Claude by Anthropic and Gemini by Google, are built on large language models (LLMs), which are reshaping many aspects of clinical and academic life. GenAI is already capable of performing certain tasks at or above human levels. It is part of a broader suite of disruptive technological advancements that some scholars identify as the Fourth Industrial Revolution (4IR). This revolution also encompasses big data, blockchain, wearables, the Internet of Things (IoT), robotics, genome editing, augmented reality, 3D printing, and biotechnology.[5] These technologies are driving significant change, some at a faster pace than

others, and this momentum is unlikely to slow anytime soon. Surprisingly, despite its advanced functions, the current level of capability within artificial intelligence is often described as "narrow AI",[4] a term that may seem counterintuitive. Commentators predict that incremental advancements over the next decade will ultimately lead to machines surpassing human intelligence, a milestone known as Artificial General Intelligence (AGI).[4] This is expected to be far more powerful than current GenAI and bring significantly greater opportunities and challenges due to its advanced human like abilities. These include 'multimodality', which means integrating different kinds of sensory inputs and outputs. It will also have 'generality', the capacity to learn and reason across any cognitive task and 'autonomy' which allows it to act without supervision. Finally, it will have greater 'self-learning' capabilities which will enable it to continuously improve and adapt on its own.[4] While these fast-emerging capabilities offer tremendous potential, they also introduce new risks, including increased security vulnerabilities, data privacy concerns, and potential ethical breaches. These challenges are of particular concern to future doctors, who will need the skills and judgment to address them effectively.

Recognising the digital health gap

Although some medical schools have incorporated elements of digital health education,[6] for most it remains limited or intermittent, with a substantial number of medical schools offering little formal training in this area. The COVID-19 public health emergency created an urgent need for fast-track telehealth training to support remote health care delivery.[7] The urgent shift to telehealth demonstrated clear benefits, including continued patient care and remote medical education, but also revealed significant challenges largely driven by funding and training barriers that limited its full potential for both providers and patients.[8] No sooner had the urgent demand for telehealth begun to diminish than generative AI emerged, intensifying the need to broaden and modernise digital health education. Unlike the relatively transient surge of telehealth during COVID-19, GenAI is poised to become a lasting and integral part of clinical practice, underscoring the continuing imperative to equip learners for this rapidly evolving digital landscape.

Historically, when medical schools have offered digital health education, it has mostly been as optional electives rather than as an essential component of the core curriculum.[9] Core education has typically reflected the needs of the "information age" where computers are harnessed to store and process information. Topics of learning have mainly focused on electronic record keeping via Electronic Health Records (EHRs) and patient management systems. However, medical education now needs to extend beyond this into the "AI age" and address aspects of human computer interactions. Examples of new skills will include the capacity to critically appraise and leverage autonomous decision-making based on a multitude of data sources: a shift which needs new approaches and skills, such as the ability to interface effectively between patients, machines, and medicine.[10]

The need to address digital health education for doctors is not new. Fifteen years ago, a Lancet Commission report criticised professional health curricula for failing to prepare graduates to keep pace with the challenges posed by technological innovation.[11] A recent follow-up conference echoed this concern, emphasising that graduates must be equipped to respond effectively to unexpected upheavals.[12] The Commission report and more recent conference clearly foreshadowed the unpreparedness revealed by the COVID-19 pandemic, as well as the emerging challenges posed by transformative technologies such as generative AI. These technological advancements represent an ongoing and critical phase of healthcare transformation, underscoring the imperative that medical schools need to take decisive action now to address the digital health education gap and ensure that future clinicians are adequately prepared to adapt to ongoing technological advancements.

The need to include more digital health education for medical students is clear, but meaningful change has been slow. Barriers impeding progress include limited curriculum space, insufficient faculty expertise, infrastructure and system access challenges, institutional resistance, and bureaucratic inertia.[9,13] Many of these obstacles are not new,[14] but medical accreditation bodies are increasingly acknowledging the need for digitally literate doctors. The Australian Medical Council (AMC), which works collaboratively with the Medical Council of New Zealand (MCNZ), has recently released new accreditation standards that medical degree programmes must meet to be eligible for a graduate to be registered as a medical practitioner. The latest standards include 'digital literacy' as a necessary competence.[15] In the foreseeable future medical schools must include digital health learning outcomes as an achievement by graduation as an accreditation requirement. While this approach may appear to depend more on mandates than on motivation, it may be the lever to overcome obstacles to the effective integration of digital health education.

Transforming tech-savvy digital natives into digitally competent doctors

As medical schools begin to offer more digital health education, it is important to consider learners' needs carefully. Many educators and institutions assume that digital native medical students, having grown up surrounded by technology, possess an inherent aptitude and therefore require minimal training with digital health tools upon entering the workplace. This external expectation can create a false sense of security. While many digital natives excel in consumer-level and social media skills with proficiency far surpassing their digital immigrant counterparts, these abilities alone are insufficient to meet the complex demands of the clinical workplace. To make matters more complex, research suggests that medical trainees tend to overestimate or underestimate their own skills, consistent with the Dunning-Kruger effect.[16] While this presents a challenge, with adequate training digital natives are well positioned to apply their skills to patient care.[17] Consider this: if medical students are trained to use stethoscopes, sphygmomanometers, and scalpels effectively, why would the same not apply to one of the most powerful tools in our history?[18] In addition to technology systems and tools, digital health education must equip graduates with essential practice-relevant knowledge of data security, privacy, confidentiality, ethics, policies, and regulations. It should also address professional competencies such as managing reputation, ensuring accountability, and maintaining professional identity within the digital healthcare environment. Within this context, cultural safety considerations are especially important in Aotearoa New Zealand, where Māori data is regarded as a treasured resource (taonga) requiring special understanding and adherence to relevant ethical and governance principles for its use.[19] When the full scope of required digital health learning is considered, it becomes evident that inherent digital nativeness alone is insufficient. The next logical step is to identify the essential content and effective teaching methods that address challenges faced by both medical students and faculty.

Existing frameworks and expert recommendations

Defining the specific digital competencies expected of graduate doctors remains a challenge. Although numerous frameworks have been proposed by experts and health sector organisations, no universally accepted digital health framework for health professional education exists. A common challenge with many proposed frameworks is their extensive list of learning outcomes, which risks overwhelming an already crowded medical curriculum. Such frameworks can be impractical and may fail to engage students who are still primarily focused on mastering traditional clinical skills and patient care, rather than on emerging competencies required for the current and future digital health environment.

By way of an example, a recent international consensus exercise involving 211 medical curricular and digital health experts from 79 countries aimed to identify the minimum mandatory digital health learning outcomes for medical students.[20] The group agreed on 33 mandatory

learning outcomes spanning 19 competences, while also proposing 145 additional discretionary learning outcomes to address the wide range of digital health topics. One key consideration from the international consensus to address the challenge of limited curriculum space is to prioritise foundational concepts and skills that prepare medical students for clinical practice, rather than focusing on technical details likely to evolve over time. For example, graduates should understand AI's strengths and limitations in diagnostics without needing to explain the underlying machine learning techniques. While such consensus recommendations provide valuable guidance, we believe that understanding and incorporating the local context is the most crucial consideration in defining the minimum digital health competencies for our medical students. We have addressed local needs by conducting a study to identify the minimum essential digital health competency domains tailored to the needs of medical students in Aotearoa New Zealand.

The essential competencies: a study at Otago Medical School

To provide a clear local framework for digital health education we aimed to identify the minimum essential digital health competency domains from the perspectives of learners, educators, and content experts for the University of Otago medical programme.[21] We sought to identify the content and educational interventions most effective in achieving the learning outcomes necessary to prepare medical graduates for the contemporary Aotearoa New Zealand digital clinical environment. We undertook student focus groups as well as semi-structured interviews with medical educators from the medical school and digital sector experts from primary care, the Ministry of Health New Zealand (Manatū Hauora) and Health New Zealand (Te Whatu Ora). Data from student focus group interviews revealed considerable variation in aptitude, confidence, and interest in technology. This suggests any future curriculum development should be aware of and accommodate this diversity in students' technological skills and engagement. The thematic analysis of the data identified four core competence domains as the minimum essential learning outcomes:

1. Understand the Local Digital Health Ecosystem and Landscape,
2. Safe, Secure and Ethical Information Literacy and Management,
3. Proficiency in Digital Health Tools and Associated Technologies, and
4. Scholarly Research and Evidence-based Practice.

Our participants told us that digital health education is most likely to be effective when it focuses on a clinically relevant core set of competencies fully integrated into the medical curriculum. They highlighted the importance of adapting these competencies to the specific environment and accommodating the diverse skills and interests of students to promote engagement and learning. Additionally, students expressed a preference for practical, hands-on learning approaches over didactic methods. By prioritising a minimum set of essential, practice-oriented digital health competencies tailored to our local needs, this approach helps reduce less relevant content and ease the burden on an already crowded curriculum. Our study reaffirms the critical role of contextual relevance in designing effective digital health education.

Building digital health skills in AI while the curriculum evolves

Implementing curricular redesign will take time. Meanwhile, there are steps that students can take to develop their digital health competencies. AI offers a unique opportunity to serve both as a powerful learning tool and as a key subject of study. AI chatbots, for instance, can help boost confidence and build proficiency in using technology and related digital health tools, tailored to individual learning needs. They also encourage critical thinking, enhance decision-making skills, and promote a deeper understanding of AI's strengths and limitations.[22] Students can use chatbots to create medical case vignettes and virtual patient simulations featuring simulated conversations. These tools offer realistic, risk-free environments where learners can practice history-taking, clinical reasoning, diagnostic decision-making, and communication skills, all while receiving immediate feedback.[23] One example where students can gain familiarity and develop competence with such tools is the AI patient actor app by the Geisel School of Medicine, which is freely available online.[24]

As students gain confidence and experience with AI, they can begin creating simple, customisable AI learning applications that are easy to share. To support this development, extensive guidance and resources are available online from a variety of reputable sources. These include prompt templates for medical education designed to generate case vignettes, virtual patients, multiple-choice questions, and script concordance test items using ChatGPT.[25] Students can also benefit from free online training on AI fundamentals by exploring reputable educational platforms, such as Harvard's Professional and Lifelong Learning site or edX, which provide a variety of free AI courses. While these courses may not focus specifically on medical education, many include content relevant to AI's use in healthcare, helping future doctors understand its applications and implications.

Institutional approaches, limitations and risks of AI

Medical educational institutions have differed in their responses and policies regarding AI use. Some have been more proactive and readily embraced its inevitability, while others have adopted a more reactive and cautious stance. To avoid being caught off guard again in this technological revolution, experts have urged a shift away from the 'AI-check-and-catch-the-students' phase toward a more proactive strategy that fosters the responsible and constructive use of AI in healthcare[4] Equally important and an essential part of learning about AI involves understanding its limitations and risks, particularly when evaluating the trustworthiness of its responses. Although LLMs are becoming increasingly more accurate and capable, the risk of producing confident-sounding but incorrect information, often referred to as 'hallucinations' or 'confabulations',[4] underscores the importance of verifying AI-generated content. It is also important to recognise the ethical and legal risks associated with using AI chatbots, or any technological tools in medical education, particularly regarding patient data privacy and security. Furthermore, it is essential to avoid overreliance on simulated learning, which may impede the development of critical thinking, hands-on experience, and effective communication skills vital for clinical practice.[26]

The digital future has never been closer or more exciting and health care has never been as complex and challenging. In this landscape, curricular change can seem daunting but the need is urgent. Our educational institutes are responding. Medical students have always needed to have ownership of their own learning and can support and potentially lead initiatives in digital health education. We hope you take on this challenge and we wish you well for the digital rollercoaster which is just leaving the platform.

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