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The Digital Health Competencies in Medical Education Framework
An International Consensus Statement Based on a Delphi Study

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Abstract

IMPORTANCE Rapid digitalization of health care and a dearth of digital health education for medical students and junior physicians worldwide means there is an imperative for more training in this dynamic and evolving field.

OBJECTIVE To develop an evidence-informed, consensus-guided, adaptable digital health competencies framework for the design and development of digital health curricula in medical institutions globally.

EVIDENCE REVIEW A core group was assembled to oversee the development of the Digital Health Competencies in Medical Education (DECODE) framework. First, an initial list was created based on findings from a scoping review and expert consultations. A multidisciplinary and geographically diverse panel of 211 experts from 79 countries and territories was convened for a 2-round, modified Delphi survey conducted between December 2022 and July 2023, with an a priori consensus level of 70%. The framework structure, wordings, and learning outcomes with marginal percentage of agreement were discussed and determined in a consensus meeting organized on September 8, 2023, and subsequent postmeeting qualitative feedback. In total, 211 experts participated in round 1, 149 participated in round 2, 12 participated in the consensus meeting, and 58 participated in postmeeting feedback.

FINDINGS The DECODE framework uses 3 main terminologies: domain, competency, and learning outcome. Competencies were grouped into 4 domains: professionalism in digital health, patient and population digital health, health information systems, and health data science. Each competency is accompanied by a set of learning outcomes that are either mandatory or discretionary. The final framework comprises 4 domains, 19 competencies, and 33 mandatory and 145 discretionary learning outcomes, with descriptions for each domain and competency. Six highlighted areas of considerations for medical educators are the variations in nomenclature, the distinctiveness of digital health, the concept of digital health literacy, curriculum space and implementation, the inclusion of discretionary learning outcomes, and socioeconomic inequities in digital health education.

CONCLUSIONS AND RELEVANCE This evidence-informed and consensus-guided framework will play an important role in enabling medical institutions to better prepare future physicians for the ongoing digital transformation in health care. Medical schools are encouraged to adopt and adapt this framework to align with their needs, resources, and circumstances.

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Key Points

Question What digital health competencies are essential and relevant for medical education globally?

Findings In this international consensus statement, a geographically diverse panel of 211 experts identified 19 competencies grouped into 4 digital health domains that medical graduates should acquire. Six additional areas for medical educators to consider were highlighted.

Meaning The Digital Health Competencies in Medical Education framework is intended to facilitate the systematic design, development, and introduction of digital health curricula in medical education worldwide.

+ Invited Commentary

+ Supplemental content

Author affiliations and article information are listed at the end of this article.

Introduction

Digital health is the use of information and communication technologies in health care to promote better health and well-being. It encompasses (among others) electronic health records, clinical decision support systems, telemedicine, mobile apps, wearable devices, data analytics, and, increasingly, artificial intelligence. The application of digital health has rapidly grown worldwide over the past 4 decades, and accelerated particularly during the COVID-19 pandemic.[1-3] However, many physicians feel inadequately prepared to use digital health technologies safely and effectively in their work.[4,5] According to the Stanford Medicine 2020 Health Trends Report,[6] 44% of physicians considered their education to be inadequate for new health care technologies. This report is consistent with findings from multiple countries showing that many medical students and junior physicians do not feel equipped to use digital health technologies and are keen to receive more training in this field.[7-12] The deficiency of digital health competencies (DHCs) among health workforce hampers the opportunity to seize the full potential of these technologies to improve health outcomes.[13]

Effective training in digital health is vital for delivering safe, efficient, and high-quality health care.[13] In the UK, the Topol Review on health care digitalization[14] emphasized the improvement of health-workforce digital literacy by developing appropriate skills, attitudes, and behaviors, which are essential for better health information management and accelerated digital health care transformation.[15] The World Health Organization (WHO) European Region digital health action plan (2023-2030) echoed these recommendations by highlighting the importance of digital health education, given that less than one-third of its member states reported having a digital health education strategy.[16,17] Most medical schools do not include digital health education and training in their curricula.[18-20] This omission can be attributed to numerous challenges, such as, among others, an already dense medical school curricula, shortage of teaching faculty with digital health expertise, lack of appropriate infrastructure and technology resources for digital health education, the dynamic and rapidly evolving nature of digital health, as well as the need for clarity as to what a digital health curriculum should entail and how such courses should be taught.[21-23] While some schools included digital health education and training, the curricula lack comprehensiveness and are often delivered in the form of elective courses.[11,24-28] There is a clear and urgent need for integration of digital health education into all medical school programs.

Digital health education and training should follow a clearly defined framework of DHCs.[29] Several frameworks have been developed in recent years for various health professionals, including nurses,[30-33] physicians,[18,34,35] allied health professionals,[36] and health informatics specialists.[29,37,38] Notable examples include the Health Information Competency framework,[39] developed in 2014 by experts from the EU and the US, and the International Medical Informatics Association framework, published in 2000[40] and most recently revised in 2023.[41] These frameworks outline health informatics learning objectives for all types of health care professionals at different stages of education, from bachelor to doctorate level.[41,42] While useful, these frameworks focus mainly on more traditional biomedical informatics–related competencies and do not cover all aspects of digital health. Other existing digital health frameworks largely focus on nursing staff in high-income countries settings,[29] limiting their adoption in preregistration medical education (which can be both undergraduate or postgraduate) and in low- and middle-income countries. There are several country-specific national medical curricula that incorporate digital health learning objectives.[43-46] However, these curricula vary widely and overlook more recently introduced digital health tools such as symptoms checkers and conversational agents (eg, chat bots).

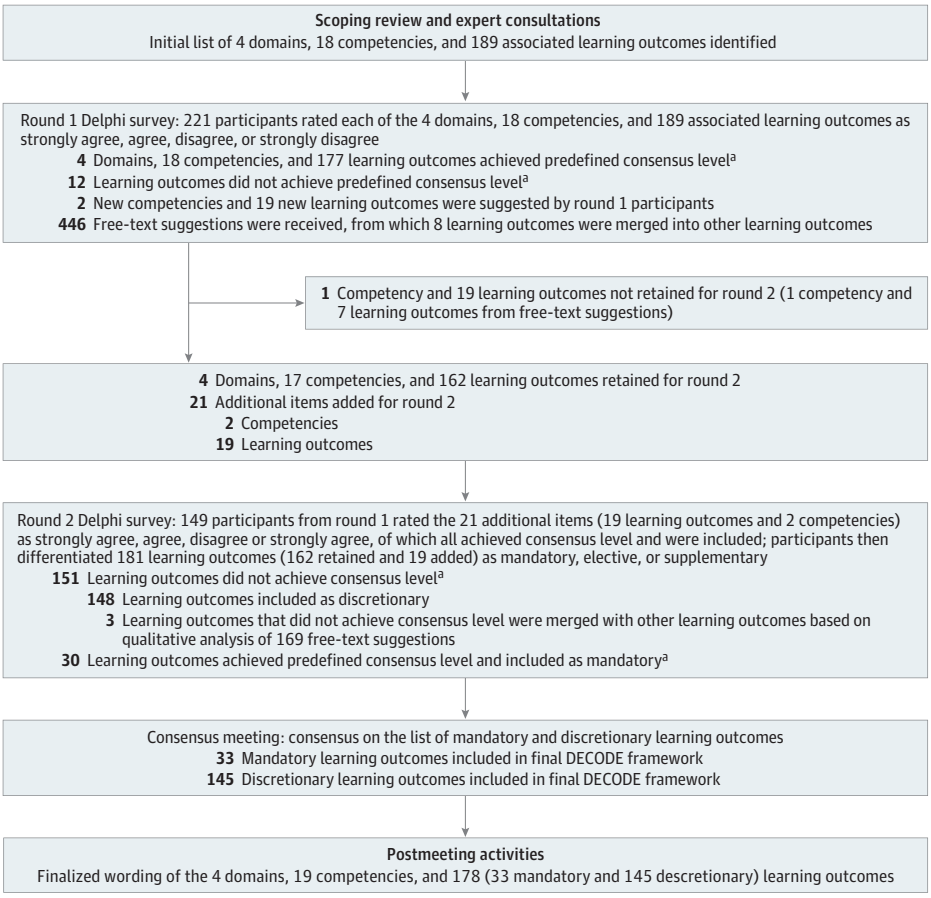
Research on what constitutes the basis of digital health education is ongoing. Two recently published digital health frameworks for medical students outlined 27 artificial intelligence–specific competencies[47] and 40 digital health topics,[48] respectively. Nevertheless, these 2 frameworks involved experts from a single country in their development, which may limit their wider use. Given that physicians are one of the principal decision-makers in clinical care, integration of digital health

solutions into health care practice would require their endorsement and active use. Improving the DHCs of medical students and physicians could help overcome barriers to more widespread adoption and use of digital health solutions.[13,29] Therefore, there is a need for a comprehensive and actionable international DHC framework for medical education. To this end, we carried out an international Delphi study, with the aim of developing an evidence-informed, consensus-guided applicable set of competencies and associated learning outcomes that can be adapted for the design and development of digital health curricula in medical schools globally.

Methods

The development of the DHC in Medical Education (DECODE) framework involved 5 stages: (1) mapping exercise based on a scoping review[29] to identify potential competencies; (2) iterative expert consultations and piloting of the initial list of competencies and learning outcomes; (3) a 2-round modified Delphi survey for consensus on framework structure, terminology, domains, competencies, and learning outcomes; (4) a consensus meeting to refine wordings; and (5) postmeeting activities for additional qualitative feedback and recommendations. The process is illustrated in the **Figure**. The modified Delphi method, used to establish consensus among a panel of experts, was chosen because it provides opportunity for experts to discuss and interact in a final meeting.[49] The expert consensus process was overseen by a group of subject matter experts (J.C., Q.C.O., T.E.F., S.J.K., I.S., K.K.F.T., A.H.S., C.G.P., and R.A.) in medical education and digital health research. This study was approved by Nanyang Technological University institutional review board

Figure. Flow Diagram of the Expert Consensus Process



DECODE indicates the Digital Health Competencies in Medical Education framework.

[a] Rated by 70% or more of participants.

and followed the Accurate Consensus Reporting Document (ACCORD) reporting guideline for consensus methods in biomedicine developed via a modified Delphi.

Identification of the Initial Set of Relevant DHCs

Multiple steps were used to create the list of digital health domains, competencies, and learning outcomes. The initial list of domains, competencies, and learning outcomes was based on findings from a 2020 scoping review of relevant international medical literature,[29] which analyzed existing DHC frameworks used by health care professionals, considering their geographical applicability (ie, local or organizational, regional, national, and international), health care settings (eg, acute care, emergency care, and primary care), and the nomenclature used for competency areas (eg, health information technology and telemedicine). A total of 30 DHC frameworks and 28 common digital health domains were identified, and a varied focus across health professions was noted with only 1 framework developed specifically for preregistration medical education.

The core group reviewed the complete list of competencies and outcomes identified from the scoping review.[29] Four digital health researchers screened competencies against predefined eligibility criteria (eTable 1 in the Supplement). During the screening process, they identified gaps in the learning outcomes. Additional literature appraisal and review of existing medical education curriculum frameworks were carried out to address these gaps by adding new domains and competencies and formulating new learning outcomes. Through iterative rounds of internal discussion, an initial framework structure was agreed upon and included terminology, domains, competencies, and associated learning outcomes. The resulting list was used to build the questionnaire for the round 1 survey of the Delphi study. Subsequently, 2 pilots were carried out. The survey questionnaire and the identified list of domains, competencies, and learning outcomes were distributed among the core group for an extensive review. The survey questionnaire was revised for clarity and streamlined, while the terminologies, domains, competencies, and associated learning outcomes in the list were adjusted, modified, regrouped, and improved with the relatively newer areas of digital health.

Two-Round Delphi Survey

An iterative sampling method was used to create a diverse expert panel for the Delphi study. The eligibility criteria for inclusion in the panel are detailed in eAppendix 1 in the Supplement. Detailed information on the purpose of the study and the roles of each panelist were provided before written informed consent was obtained online. Only those who completed the round 1 Delphi survey were invited to round 2. Round 1 of the Delphi survey, which took place between December 2022 and April 2023, had 3 sections: (1) framework structure and terminology, (2) relevance of digital health domains, and (3) relevance of DHCs and learning outcomes for medical education. Feedback was sought from experts on the framework's structure and terminology via free text, while the relevance of domains, competencies, and learning outcomes were determined via a Likert scale parsed as strongly agree, agree, disagree, and strongly disagree. For an item to be included in the DHC framework, a prespecified combined rating (agree and strongly agree) of at least 70% of the participants (excluding blank votes and abstentions) had to be achieved. Expert agreement percentage is commonly used as the cutoff for consensus in Delphi,[50] with studies using different thresholds ranging from 67% to 80%.[51-53] Qualitative analysis of the free-text suggestions was performed independently by 2 reviewers (O.C.O. and T.E.F.), and discrepancies were resolved through discussion with a third reviewer (J.C.). Suggestions were categorized into common ideas and synthesized. In round 2 of the survey (between June and July 2023), experts reviewed changes made from round 1 feedback and indicated agreement. Analysis of free-text responses from round 1 suggested for learning outcomes to be categorized to aid curriculum differentiation and definition. Experts were asked whether learning outcomes should be mandatory, elective, or supplementary for the digital health curriculum. We defined mandatory outcomes as essential for all medical students, elective outcomes as important but not universal, and supplementary outcomes as providing

additional, context-specific knowledge, skills, or behaviors. In addition, experts were asked to rate the relevance of new competencies and outcomes proposed by participants in round 1. Details of the recruitment process and the 2-round Delphi survey are described in the eMethods in the Supplement.

Consensus Meeting and Postmeeting Activities

A virtual consensus meeting was held in September 2023 and involved 12 participants (16 invited) who had taken part in rounds 1 and 2, and 2 members of the core group (meeting chair and notetaker). They were selected to represent a range of roles within medical education, diverse medical fields, and global geographic locations. One invited panelist who was unable to attend provided detailed written feedback, which was considered. To facilitate the discussion, the consensus meeting agenda and the revised draft of the DHC framework were sent to the invited panelists prior to the meeting. Following the presentation of the results, the consensus meeting panelists participated in focused discussions, deliberating on the appropriateness of inclusion of each competency and its associated learning outcomes, the descriptions, and wordings. Items with a marginal percentage of agreement (ie, 60.0%-69.9%) were highlighted and discussed. Consensus was reached through discussion. The revised document, listing the agreed domains, competencies, and learning outcomes, was circulated to panelists for confirmation and minor wording suggestions. This process aimed to ensure that the document accurately reflected decisions made during the consensus meeting. Apart from the consensus meeting panelists, the final document was distributed to all participants who completed both rounds of the Delphi survey to seek their qualitative feedback and inquire their interest in implementing the framework at their medical schools.

Results

Delphi Survey and Consensus Meeting

In total, 211 individuals participated in round 1 of the survey, and 149 participated in round 2 (70.6% of participants from round 1). Survey participants were from 79 countries and territories in round 1 and 68 countries in round 2, with representation from all 6 WHO regions and all 4 World Bank country income groups (eFigure in the Supplement). Of those who took part in both rounds (149 participants), 63 (42.6%) were based in high-income countries and 19 (12.8%) in low-income countries (World Bank country income classification).[54] Almost two-thirds of the participants (91 participants [61.1%]) reported clinical medicine as their primary professional background. The majority reported having a teaching role (125 participants [83.9%]) and/or research role (109 participants [73.2%]), while one-half of them had a clinical role (76 participants [51.0%]). The majority (140 participants [94.0%]) also worked in a university, and more than one-half of them (83 participants [55.7%]) worked in a clinical setting. Approximately one-third (47 participants [31.5%]) reported holding an institutional leadership position, such as president or chancellor of university, dean or vice dean of medical school, or chief medical officer of hospital. The characteristics of participants in each Delphi Survey round are reported in **Table 1**.

From an initial list of 4 domains, 18 competencies, and 189 learning outcomes, after round 1, 4 domains, 18 competencies, and 177 learning outcomes achieved the predefined level of consensus (ie, ≥70%) and were subsequently retained for round 2 (Figure). Twelve learning outcomes that did not reach the a priori consensus level were removed from the list. A total of 446 free-text suggestions were received. These pertained to framework structure, description of competencies, wording of learning outcomes, overlapping items, and suggestions for new items. Following qualitative analysis, 1 competency and 7 learning outcomes associated with this competency were removed, 16 learning outcomes were reorganized and merged (into 8 learning outcomes), 64 learning outcomes were reworded, and 2 new competencies and 19 new learning outcomes were added.

Table 1. Characteristics of Participants in Each Round of Delphi Survey

Characteristics, round	Participants, No. (%)	
	Round 1 (n = 211)	Round 2 (n = 149)
Retention rate, %	NA	70.6
Survey completion		
Full	177 (83.9)	141 (94.6)
Partial[a]	34 (16.1)	8 (5.4)
Country (and territory) of primary affiliation[b]		
African Region	33 (15.6)	28 (18.8)
Region of the Americas	22 (10.4)	13 (8.7)
South-East Asian Region	16 (7.6)	11 (7.4)
European Region	78 (37.0)	50 (33.6)
Eastern Mediterranean Region	23 (10.9)	13 (8.7)
Western Pacific Region	38 (18.0)	33 (22.1)
Other[c]	1 (0.5)	1 (0.7)
Country income classification[d]		
High-income	96 (45.5)	63 (42.6)
Upper middle-income	42 (19.9)	31 (20.9)
Lower middle-income	46 (21.8)	35 (23.6)
Low-income	27 (12.8)	19 (12.8)
Designation[e]		
University leader (eg, president, vice president, rector)	11 (5.2)	8 (5.4)
Dean of medical school or faculty	32 (15.2)	25 (16.8)
Vice dean of medical school or faculty	11 (5.2)	11 (7.4)
Head of department or director of center	38 (18.0)	35 (23.5)
Professor	66 (31.3)	48 (32.2)
Associate professor	37 (17.5)	31 (20.8)
Assistant professor	16 (7.6)	15 (10.1)
Lecturer	19 (9.0)	17 (11.4)
Program director for medical education	17 (8.1)	13 (8.7)
Digital health researcher	29 (13.7)	28 (18.8)
Clinician	54 (25.6)	50 (33.6)
Chief medical officer	2 (0.9)	2 (1.3)
Chief medical informatic officer or chief information officer	3 (1.4)	2 (1.3)
Other	15 (7.1)	11 (7.4)
NA	11 (5.2)	0
Primary professional discipline		
Clinical medicine	NA	91 (61.1)
Public health	NA	9 (6.0)
Basic sciences	NA	17 (11.4)
Computer science	NA	2 (1.3)
Engineering	NA	2 (1.3)
Other	NA	28 (18.8)
Current role[e]		
Teaching role	NA	125 (83.9)
Clinical role	NA	76 (51.0)
Research role	NA	109 (73.2)
Other	NA	29 (19.5)
Place of employment[e]		
University	197 (93.4)	140 (94.0)
Hospital	73 (34.6)	70 (47.0)
Private health practice	13 (6.2)	13 (8.7)
Governmental organization	20 (9.5)	20 (13.4)
Nonprofit organization (eg, nongovernmental organization or charity)	7 (3.3)	7 (4.7)
For-profit organization (eg, digital health start-up)	2 (0.9)	1 (0.7)
NA	3 (1.4)	0

Abbreviation: NA, no available data.

[a] Completion of at least 1 full section.

[b] According to World Health Organization regions.[55] There were 79 countries and territories in round 1 and 68 in round 2.

[c] Non–World Health Organization member.

[d] Based on the World Bank.[54]

[e] Participants may select more than 1 answer.

In round 2, all newly added items reached the predefined level of consensus and were included in the framework. Of the 162 learning outcomes retained from round 1 and the 19 newly added learning outcomes, 30 attained more than 70% agreement rates for the mandatory category, while 151 did not reach the 70% agreement rate for any single category (ie, mandatory, elective, or supplementary). These 151 learning outcomes were labeled as discretionary. Qualitative analysis of 169 free-text suggestions led to rewording of 14 learning outcomes and merging of 6 learning outcomes into 3. Following differentiation of learning outcomes in round 2, 30 learning outcomes emerged as mandatory and 148 as discretionary. In-depth deliberations during the consensus meeting led to panelists reclassifying 4 discretionary learning outcomes with a marginal percentage of agreement (ie, 60.0%-69.9%) as mandatory and 1 mandatory learning outcome with marginal percentage agreement (ie, 70.0%-79.9%) as discretionary. After the consensus meeting, 58 of those who received the framework responded with qualitative feedback. In addition, 29 of them (50.0%) expressed willingness to adopt the DECODE framework at their medical schools, 6 (10.3%) would consider adoption with conditions, 7 (12.1%) mentioned a need for further discussion, 6 (10.3%) indicated barriers or being noncommittal to adoption, and 10 (17.2%) did not provide a direct response to this inquiry. Results of the 2-round modified Delphi survey are shown in the Figure. Detailed results of round 1 and round 2 are presented in eTable 2 and eTable 3 in the Supplement.

Final DECODE Framework

The hierarchy of the DECODE framework had 3 main terminologies: domain, competency, and learning outcome. We defined competency as a statement describing a specific ability, or set of abilities, requiring specific knowledge, skill and/or behavior, and learning outcome as the intended aggregate learner end point for a program.[56-58] After the 2-round Delphi survey and the consensus meeting, a total of 4 domains, 19 competencies, 33 mandatory learning outcomes, and 145 discretionary learning outcomes were included in the final DECODE framework (eAppendix 2 in the Supplement). The competencies were organized into 4 domains: professionalism in digital health, patient and population digital health, health information systems, and health data science (**Box**). Detailed descriptions of the domains are presented in **Table 2**. Each competency has a description and a set of associated learning outcomes, which can be mandatory or discretionary. All 178 learning outcomes were labeled as relating to medical graduates' knowledge (119 learning outcomes [66.8%]), skill (35 learning outcomes [19.7%]), or behavior (24 learning outcomes [13.5%]). In this framework, 13 of the 19 competencies have both mandatory and discretionary learning outcomes, while the remaining 6 have only discretionary learning outcomes.

Additional Considerations for Medical Educators

During the Delphi survey and consensus meeting, several areas of debate arose. These discussions suggest highly relevant topics that stakeholders in medical education and health care should consider when developing or implementing digital health curricula in medical institutions. These include variations in nomenclature, distinctiveness of digital health, the concept of digital health literacy, curriculum space and implementation, inclusion of discretionary learning outcomes, and socioeconomic inequities in digital health education (**Table 3**).[59-75] A list of additional resources can be found in eAppendix 3 in the Supplement.

Discussion

The DECODE framework was developed through a rigorous, multistage international consensus process. The framework is based on findings of a scoping review,[29] expert consultations, a 2-round Delphi survey, a consensus meeting, and postmeeting qualitative feedback. The consensus process garnered an international panel of experts with diverse professional backgrounds, leadership roles in medical education, and geographical locations to ensure the framework's applicability and relevance to a global audience. The final DECODE framework comprises 4 domains, 19 competencies, and 33

mandatory and 145 discretionary learning outcomes; this allows institutions engaged in medical education to adapt their digital health curricula to their countries and jurisdiction's specific context and requirements. To our knowledge, this is the first attempt to develop a curriculum for digital health medical education at a global scale.

Box. Definitions, Domains, and Competencies Within the Digital Health Competencies in Medical Education Framework

Definitions

Competency: A statement describing a specific ability, or set of abilities, requiring specific knowledge, skill, and/or behavior.[56,57]

Learning outcome (LO): The intended aggregate learner end point for a program.[56,58]

Domains and Competencies

Domain 1: Professionalism in Digital Health

1.1 Professionalism, ethical, legal, and regulatory considerations in digital health (9 LOs)

The medical school graduate demonstrates adherence to digital health professional, ethical, legal, and regulatory standards when handling health information.

1.2 Digital identify, safety, and security (8 LOs)

The medical school graduate can maintain appropriate professional digital identity, apply concepts of digital intelligence to health care, and recognize their own critical role in cyber-risks and cyber-threats.

Domain 2: Patient and Population Digital Health

2.1 Digital health literacy (7 LOs)

The medical school graduate recognizes the importance of digital health literacy of the population and associated health inequalities.

2.2 Personal health records (6 LOs)

The medical school graduate recognizes the role of personal health records in patient-centered care.

2.3 Telehealth (12 LOs)

The medical school graduate recognizes the scope, capabilities, and limitations of telehealth and demonstrates remote consulting skills.

2.4 Digital diagnostics (15 LOs)

The medical school graduate recognizes the scope, abilities, and limitations of digital diagnostics and demonstrates their efficient use relevant to the field of practice.

2.5 Sensors, wearables, and internet of medical things (9 LOs)

The medical school graduate can identify the scope of wearables and internet of medical things in patient care and recognize their limitations.

2.6 Health apps and digital therapeutics (8 LOs)

The medical school graduate demonstrates knowledge of health apps and digital therapeutics.

2.7 Internet-based health interventions (6 LOs)

The medical school graduate can describe different designs and areas of clinical applications of internet-based health interventions.

2.8 Digital determinants of health (8 LOs)

The medical school graduate can describe various digital determinants of health and recognize their impact on digital health equity.

Domain 3: Health Information Systems

3.1 Data governance and data management (13 LOs)

The medical student graduate can manage health data efficiently in accordance with respective health care data governance standards.

3.2 Foundation and principles of health information systems (8 LOs)

The medical school graduate demonstrates secure and efficient operation and management of health data using health information systems.

3.3 Electronic health records (19 LOs)

The medical school graduate demonstrates appropriate use of electronic health records, electronic prescribing, and other electronic health record–related clinical software relevant for the area of practice and geographic region.

3.4 Health information exchange (5 LOs)

The medical school graduate demonstrates the ability to operate electronic health information exchange in a manner that optimizes safe and effective patient- and population-centered care.

3.5 Human-centered design in digital health (6 LOs)

The medical school graduate can apply human-centered design and system thinking when creating or evaluating digital health solutions for patients and health professionals.

Domain 4: Health Data Science

4.1 Public health informatics (11 LOs)

The medical school graduate can describe the application of informatics in the public health field.

4.2 Artificial intelligence in health care (19 LOs)

The medical school graduate can identify the scope of data analytics, artificial intelligence, and machine learning in health care, as well as describe how solutions based on these may be used to achieve the best patient, population, and health system outcomes.

4.3 Computational thinking in medicine (4 LOs)

The medical school graduate can apply the principles of computational thinking to medicine.

4.4 Precision medicine (5 LOs)

The medical graduate can describe the concepts of precision medicine, its intersection with digital health, and its applications and relevance for public health and health of an individual patient.

A key strength of this study is the systematic approach preceding the Delphi survey that generated an initial list of competencies and learning outcomes through a scoping review.[29] Next, there was a high number of participating nations with representations from both lower middle–income and low-income countries within the expert panel. Because priorities in digital health training of future physicians in these settings may differ, the involvement of experts from these countries enhanced the framework's broader applicability and led to advocacy for elevating and incorporating digital health equity within the competencies (eg, digital determinants of health). The substantial presence of institutional leadership among Delphi participants enriched the framework with their strategic insights, ensured its alignment with broader educational and organizational needs, and may facilitate its adoption within their respective institutions.

There are several barriers to adopting a universal DHC framework. Our group identified the following categories: geographic heterogeneity, variation in resources between regions and between institutions in the same region, variance in local needs within a given institution, and the zero-sum nature of the curriculum (ie, adopting new content requires removal of other content). We will continue to explore these issues and pragmatic approaches to adoption in future work. These may include an implementation guide (similar to the WHO Patient Safety Curriculum Guide, which outlines methods of curriculum delivery for each domain and competency), methods of assessment, and regularly updated core curricular content that could be used and adapted in each school.[76] Development of an accompanying framework for evaluating the implementation and impact of the DHC framework on student competencies and patient care could also assist in refining and validating the competencies over time. The recommended DHCs, currently absent from standardized licensing examinations, need to be included and assessed in the future.[77,78]

Limitations

This study has some limitations. First, the preliminary scoping review that this study was based on only included literature published in English.[29] Second, the study was conducted in English due to

Table 2. Description of Domains

Domain	Importance	Description
Professionalism in digital health	The use of digital technologies in health care poses important professional, legal, and ethical implications, and demands a high level of medical professionalism.	This domain encompasses themes that are related to professionalism in digital health, which is described as the ability of health professionals to understand, develop, and demonstrate appropriate professional behavior when using digital technologies. Learning outcomes within this domain prepare medical graduates to become competent and responsible digital health users with an awareness of cybersecurity and ethical, legal, and regulatory guidelines and demonstrate digital intelligence. Mastery of this domain will allow them to incorporate technologies in their daily practice without compromising data of their patients.
Patient and population digital health	A widespread availability of internet, mobile, and wearable technologies empowers patients and healthy individuals to be active participants (ie, digital health consumers) in the process of making choices about their health, rather than being recipients of services. This trend allows for person-centered care; the prerequisites for that include a focus on patient in informatics, promotion of digital health literacy, and patient education.	This domain focuses on equipping medical students with knowledge and skills in telehealth, health apps, digital therapeutics, wearables, sensors, remote monitoring, and point-of-care and self-testing. It enables them to communicate, counsel, provide care, and motivate self-management in patients in the context of digital health technologies. It also expands on the types of data that can be collected through digital technologies available to patients and how this may lead to better diagnoses and treatment decisions in the future. Additionally, it ensures medical students are aware of digital health literacy of patients, the broader digital determinants of health, the digital divide, and associated health inequalities.
Health information systems	Physicians, among other health care professionals, are key stakeholders in collecting, storing, monitoring, accessing, and sharing patient health data. Accurate and safe handling of health data extends beyond the quality and safety requirement of an individual patient's care. Clinical decision support systems, computerized physician order entries, and other information technology solutions embedded within health information systems leverage existing health data and enhance patient care by providing automation and decision support.	Competencies in this domain prepare medical students to be competent users of health information systems and health information exchange who are aware of the design and development process of such systems. It ensures that medical students are compliant with the standards of data governance policies. Furthermore, it focuses on clinical documentation skills and electronic prescribing methods.
Health data science	The growth of digitally captured, processed, and stored health data has been drastic, creating opportunities to address challenges in medicine, public health, and biomedical sciences. In addition to data from electronic health records, patient-generated data (eg, wearables) and genome sequencing contribute substantially to the health data pool. One of the promises of this trend is the use of multiple modalities to support personalized medicine.	This domain covers competencies in health data application fields such as population health informatics, computational thinking, artificial intelligence in health care, and precision medicine. It ensures medical students understand the scope of health data, the impact of data on health care, and how to apply data for the optimization of patient care at both the population and individual levels.

research team's language limitations and English being a commonly use language in medical publications; this limited participation to English speakers. Third, the absence of a neutral option in the Likert scale may have inadvertently forced the respondents to select either a positive or negative response despite their ambivalence; this could have introduced response bias. Fourth, akin to any

Table 3. Additional Considerations for Implementation of the DECODE Framework

Considerations	Elaboration
Variations in nomenclature used	The consensus panel concurred that the interpretation of the nomenclature used within this framework may vary due to geographical, language, and other differences. There are several terminology schemes used in curriculum and instructional design in medical education globally, and these vary depending on the region, location, and organization. The panel acknowledged that different medical education institutions and accrediting bodies globally use a range of terms in curriculum design and a number of documents guide medical educators in different countries, such as the UK General Medical Council guidance for medical schools (*Outcomes for Graduates*),[59] the Association of American Medical Colleges Medical Schools Objectives Project,[60] and the *Review of Accreditation Standards for Primary Medical Programs* by the Australian Medical Council.[61] One of the challenges in creating digital health competencies for a global audience is the need to use meaningful terminology, given the diverse national and local approaches to curriculum design, terminology, and practices. The use of terms such as *competencies*, *outcomes*, and *objectives* is widespread, but the way these terms are defined, used, and understood varies around the world. This variation emphasizes the need for clarity, refinement, and consensus around language in the field of digital health. The consensus panel agreed that the use of working definitions in the preface of the framework would help circumvent these issues.
Distinctiveness of digital health	The consensus panel highlighted the need for a focused approach to distinguish digital health from its nondigital counterparts during the curriculum development process. This emphasis arises from the recognition that some fundamental principles, such as data privacy and security, have already existed in the predigital era and are not exclusive to digital health. The focus of the curriculum should therefore be the distinctive challenges and nuances introduced by the digital transformation of health care, as opposed to using digital as an adjective for preexisting concepts. Placing too much emphasis on general concepts applicable to both digital and nondigital contexts risks diluting the distinctiveness of digital health. Nevertheless, the consensus panel expressed concern about the potential oversight of these critical domains if not adequately covered in a specific digital health curriculum. Given the pervasiveness of digitalization in health care, digital health curricula might become the default standard for anything related to data. The assumption that this curriculum would cover data-related domains comprehensively could possibly lead to displacement and neglect of these essential aspects of data handling in other educational domains, such as population health.
Concept of digital health literacy	The consensus panel acknowledged that digital health literacy (of health consumers) is a concept that is not universally agreed upon and is difficult to measure and therefore challenging to operationalize. In published literature, the terms *digital health literacy*, *digital literacy*, and *eHealth literacy* have been used to denote a common or substantially similar concept,[62-64] and these terms are sometimes used interchangeably.[65] While some argue that digital health literacy is the convergence of digital literacy and health literacy,[66] which are 2 different constructs, they are nonetheless equally important in the context of digital health. Health and digital literacy are both well-established determinants of health.[67-69] More recently, digital health literacy was acknowledged as a superdeterminant of health with civic, digital, and health literacies as its 3 building blocks.[70] This speaks to the importance of digital health literacy as a concept that should be understood and considered by all who practice modern medicine because it affects patients' access to digital health services,[71] health-related behaviors,[72] and health outcomes.[73] For the purpose of this study, we built upon existing definitions of digital health literacy and defined it as the skills to seek, select, appraise, understand, and apply health information from electronic sources, health care–related digital technologies, and digital health services.[62-65]
Curriculum space and implementation	From the curriculum implementation perspective, several experts raised concerns on the challenges in incorporating all competencies within this framework into the existing crowded medical curricula and the potential pushback that might arise. The conundrum lies within balancing the enthusiasm to cover all relevant domains with the practicality of curriculum implementation to ensure that all essential items are effectively integrated into the curriculum. This could be achieved by focusing on foundational concepts and skills that will support medical students through clinical practice in lieu of technical skills that are likely to change as technology evolves. For example, a medical graduate should be able to recognize the strengths and limitations of artificial intelligence–supported diagnostics compared with conventional methods but not be expected to reiterate the detailed mechanism and techniques used in machine learning. One of the suggestions is for discretionary learning outcomes to be addressed through alternative educational activities such as continuing medical education programs. Other suggestions include vertical integration of the framework into preexisting curricula and step-by-step incremental introduction over time. The use of an integrated or cross-domain curriculum approach, such as in planetary health, may also facilitate implementation by expanding existing content to accommodate digital health domains.[74]
Inclusion of discretionary learning outcomes	Discretionary learning outcomes are important while not being mandatory. There was consideration that some of these might already be addressed in other facets of medical curricula, such as within the purview of public health or bioinformatics. This is also relevant for institutions that offer dual-degree programs such as MD-MBA (business), MD-JD (law), MD-MPH (public health), and MD-PhD, where some aspects of the DECODE framework might be covered in the combined degree program but not within the medical curriculum. For instance, digital determinants of health, given its interdisciplinary nature, could be a part of the MPH curriculum within the MD-MPH program. As such, introducing these competencies might result in redundancy. However, the presumption that certain competencies might already be encompassed elsewhere or an optimistic anticipation of their coverage within other curricula poses the risk of inadvertent oversight of these competencies. Therefore, within the scope of this study, we included all domains deemed pertinent to the domain of digital health, irrespective of their potential intersection with other disciplines, to provide medical educators globally with a comprehensive framework for consideration. Medical educators may find it prudent to include some discretionary learning outcomes as part of the digital health curriculum, especially if they are not currently addressed in other domains of the existing curriculum.
Socioeconomic inequities in digital health education	Issues pertaining to digital health equity and socioeconomic inequities in access to digital diagnostic platforms and their applicability in LMICs were raised by experts in both the Delphi survey and the consensus meeting. In resource-constrained settings, implementation of digital diagnostics remains difficult due to various barriers related to cost, trained personnel, regulation, and infrastructure.[75] Because many of these platforms are not readily available in LMICs, it poses a challenge to discuss their practical application during teaching. With limited exposure and little hands-on practice, medical students may have difficulty grasping the use of these platforms. In addition, educators who lack clinical experience in using digital diagnostics may not be confident and competent to educate students on these technologies. Nevertheless, several experts recognized the tremendous potential of digital diagnostics in LMICs, highlighting that regions with the scarcest resources stand to gain substantially from the remote capabilities of digital diagnostics. Notwithstanding the potential benefits of digital diagnostics, the discourse around the feasibility and costs associated with setting up these platforms for educational purposes, along with how learners can effectively demonstrate the requisite competencies, is likely to persist for years to come. With most of its associated learning outcomes included as discretionary, our findings aptly reflect the present state of digital diagnostics, wherein most experts acknowledged its relevance in medical education but did not consider it mandatory across all settings. This was also observed in other competencies, including wearables, sensors, and the internet of medical things (competency 2.5), internet-based health interventions (competency 2.7), and health information exchange (competency 3.4).

Abbreviations: DECODE, Digital Health Competencies in Medical Education; JD, juris doctor; LMIC, low- and middle-income countries; MBA, master of business administration; MD, doctor of medicine; MPH, master of public health; PhD, doctor of philosophy.

Delphi approach, this study faces potential biases, such as selection bias from purposive sampling. Although the research team tried to minimize sampling bias by adopting a multimethod sampling approach to create a sizeable panel with geographical and disciplinary diversity, the results may not capture fully the context specificities and need of all countries. A further criticism of the Delphi approach lies in its potential constraint when experts are confined to voting on a predetermined list. Although the research team attempted to identify all possible options through the preliminary work (scoping review, iterative expert consultations, and piloting) leading up to the initial item list, exhaustiveness of the list could not be guaranteed. To mitigate this, free-text responses were allowed in the survey for experts to propose additional items, which has proven to be invaluable.

Conclusions

This multistage international consensus process has produced a comprehensive DHC framework for preregistration medical education. This framework will play an enabling role in assisting individual medical institutions in developing and introducing digital health learning outcomes and appropriate learning opportunities into curricula for medical students. Adaptable to each country's specific needs and contexts, this approach ensures both relevance and flexibility in curriculum design. The international composition of the Delphi expert panel provided a balanced perspective on digital health technologies and digital health inequities, leading to the segregation of learning outcomes into mandatory and discretionary categories to enhance their applicability in diverse educational settings. Interdisciplinary collaboration within or across departments is encouraged when coordinating its implementation. Integration of this framework into curriculum design can assist in better preparing future physicians for the ongoing digital transformation in health care. We envisage that curricula developed from this framework will be taught in an integrated manner throughout the study years. It is critically important that similar international collaborative effort should be undertaken for other health professionals, such as nurses, midwives, therapists, health technologists, and, among others, health managers, and we envisage contributing to such endeavors. Our subsequent work will also focus on making teaching resources available widely as public goods. Going forward, this framework will need reviewing and updating to reflect the latest developments and evidence-advancement in digital health.

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SUPPLEMENT.

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