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Review

Artificial Intelligence Education Programs for Health Care Professionals: Scoping Review

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Abstract

Background: As the adoption of artificial intelligence (AI) in health care increases, it will become increasingly crucial to involve health care professionals (HCPs) in developing, validating, and implementing AI-enabled technologies. However, because of a lack of AI literacy, most HCPs are not adequately prepared for this revolution. This is a significant barrier to adopting and implementing AI that will affect patients. In addition, the limited existing AI education programs face barriers to development and implementation at various levels of medical education.

Objective: With a view to informing future AI education programs for HCPs, this scoping review aims to provide an overview of the types of current or past AI education programs that pertains to the programs' curricular content, modes of delivery, critical implementation factors for education delivery, and outcomes used to assess the programs' effectiveness.

Methods: After the creation of a search strategy and keyword searches, a 2-stage screening process was conducted by 2 independent reviewers to determine study eligibility. When consensus was not reached, the conflict was resolved by consulting a third reviewer. This process consisted of a title and abstract scan and a full-text review. The articles were included if they discussed an actual training program or educational intervention, or a potential training program or educational intervention and the desired content to be covered, focused on AI, and were designed or intended for HCPs (at any stage of their career).

Results: Of the 10,094 unique citations scanned, 41 (0.41%) studies relevant to our eligibility criteria were identified. Among the 41 included studies, 10 (24%) described 13 unique programs and 31 (76%) discussed recommended curricular content. The curricular content of the unique programs ranged from AI use, AI interpretation, and cultivating skills to explain results derived from AI algorithms. The curricular topics were categorized into three main domains: cognitive, psychomotor, and affective.

Conclusions: This review provides an overview of the current landscape of AI in medical education and highlights the skills and competencies required by HCPs to effectively use AI in enhancing the quality of care and optimizing patient outcomes. Future education efforts should focus on the development of regulatory strategies, a multidisciplinary approach to curriculum redesign, a competency-based curriculum, and patient-clinician interaction.

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KEYWORDS

machine learning; deep learning; health care providers; education; learning; patient care

Introduction

Background

The widespread and rapid adoption of artificial intelligence (AI) technologies in health sciences, education, and practices introduces new ways of delivering patient care [1]. AI encompasses a broader term within computer science, which includes technologies that can incorporate human-like perception, intelligence, and problem-solving into complex machines [2]. Big data in health care, along with high-performance computing power, has enabled the use of AI, machine learning (ML), and deep learning, in particular, to improve clinical decision-making and health sector efficiency [3]. More recently, AI-enabled technologies have continued to emerge, predominantly in the medical fields of radiology, anesthesiology, dermatology, surgery, and pharmacy [4-7]. Although AI is not likely to replace clinical reasoning, Mesko [8] predicts that AI will influence all specialties in varying degrees, depending on the nature of the practice (eg, the degree of repetitive tasks involved and whether the tasks are data driven). However, the efficacy of AI-enabled technologies in health care depends on the involvement of health care professionals (HCPs) in developing and validating these technologies. Therefore, HCPs should play a role in this transformation and be involved in every aspect of shaping how AI adoption will affect their specialties and organizations.

Recommendations for HCP involvement are emerging. For instance, in the field of medical imaging, West and Allen [9] recommend that HCPs be involved in (1) implementing data standards and following them in practice, (2) prioritizing use cases of AI in medicine, (3) determining the clinical impact of potential algorithms, (4) describing and articulating the needs of the profession for data scientists and researchers, and (5) participating in the translation of practice needs from human language into machine language. As these technologies emerge, it is essential for HCPs and educators to have the competencies required to rapidly develop and incorporate these changes into their practices and disciplines.

At the individual level, a lack of AI literacy is a significant barrier to the adoption and use of AI-enabled technologies to their full capacity in various medical specialties. In AI education programs specifically, there are barriers to implementation at various levels of medical education (undergraduate, postgraduate, practice-based education, or continuing professional development). For instance, health informatics plays a valuable role in modern medicine; yet, it is not the focus of most medical school curricula [2]. Technology experts are often consulted to provide training on the use of electronic clinical tools, but this does not support the level of skill required to understand how it could be used to enhance patient interactions and improve care [10]. Another example exists within radiology residency programs, where the lack of awareness as well as lack of knowledge of implementing and using AI were cited as barriers to its adoption [11,12]. Incorporating AI fundamentals into health professionals' curricula is essential, and it would be useful to balance this knowledge with providing patient-centered care by empowering future HCPs to consider AI in the context of their own clinical judgment. The combination of trust in their own judgment and basic statistical knowledge will be useful in understanding how to best apply new AI-driven technologies in clinical practice [13]. AI needs to be considered within the context of HCPs' broader skill sets, priorities, and ultimate goals in health care; this includes encouraging patient-centered, compassionate care in clinical practice [13,14].

Martec's Law refers to the idea that technology changes occur much more rapidly, and in fact exponentially, compared with the ability of organizations to adopt these technologies [1]. Therefore, organizations need to promote innovative technologies proactively and empower their professionals to be adequately trained to successfully implement AI-based tools in their practice [1]. A concerted, deliberate approach is required to incorporate these new technologies, both effectively and compassionately, at an individual level and within the culture and operations of an organization [1].

A number of potential barriers to implementing these technologies exist; the 3 main limitations identified include regulatory, economic, and organizational culture issues [15]. Regulatory approval [16] is needed to adopt AI technologies in clinical settings, and potential liabilities in using these technologies for patient care must be considered, as well as the safety, efficacy, and transparency of AI algorithms for clinical decision-making [17,18]. Regulatory issues can also come into play when it comes to accessing data for AI adoption; multi-institution data sharing is required for algorithm improvement and validation, as well as the accompanying research ethics board and regulatory approvals [18]. To further improve adoption, these technologies will also have to be economical, supported by adequate funding [18], and seem as valuable to the organization itself. At an organizational level, the use of AI should align with the goals and strategic plans of an organization; organizations will need to assess how well the AI technology will integrate into existing systems, including data warehouses and electronic health records [18]. It may be difficult to generalize a particular AI model across different clinical contexts to a degree that would prove valuable at an organizational level while still working seamlessly and being clinically useful at the individual level [15]. Furthermore, when choosing to adopt AI technologies, organizations can either collaborate with outside vendors or create the technologies in-house, which will require the use of additional human and material resources [15].

Objective

Deficits in AI education may be contributing to a lack of capacity in health care systems to fully integrate and adopt AI technologies to improve patient care, despite calls for AI integration as part of the National Academy of Medicine's Quintuple Aim Model [19]. It is important to equip health care organizations and their stakeholders to have the cognitive, psychomotor, and affective skills to harness AI in enhancing and optimizing the delivery of care. This will also involve supporting AI education initiatives that are widely available for all types of HCPs. To support future AI education development, dissemination, and evaluation, it is important to assess the current situation within AI adoption in health care and further understand the extent of AI education implementation, including who is receiving AI training or education, what content is covered, how it is delivered, and whether this reflects what experts believe that AI education curricula should include. Therefore, this scoping review aims to establish a foundational understanding of education programs on AI for HCPs by determining the following:

1. What were the most effective educational approaches to enabling HCPs to harness AI in enhancing and optimizing health care delivery?
   - What curricular content was delivered?
   - What was the scope of content that should be delivered?
   - What learning objectives were used in these approaches, using the taxonomy for learning formulated by Bloom [20]?
2. What were the enablers or barriers that contributed to the success of these programs and the implementation of AI curricula in health care education programs?
3. What outcomes were used to assess the effectiveness of the education programs, using the Kirkpatrick-Barr Framework [21]?

Methods

Overview

This scoping review followed the Arksey and O'Malley [22] guidelines and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Extension for Scoping Reviews checklist [23,24]. The objective of this scoping review is to examine and summarize the extant literature on AI education and training for HCPs.

Stage 1: Search Strategy

A health sciences librarian (MA) developed strategies for Ovid MEDLINE All, Ovid Embase, Ovid APA PsycINFO, Ovid Emcare Nursing, Ovid Cochrane Database of Systematic Reviews, Ovid Cochrane Central Register of Controlled Trials, EBSCO ERIC, and Clarivate Web of Science using appropriate subject headings and keywords for AI and health professions education. As a result of the widespread use of terms relating to health professions and education in health sciences literature, the decision was made to focus the searches on health professions education concepts to reduce *noise* in the results sets. Searches for these subject headings were limited to where they were the major subject heading (the most important subject heading in the database record for an item). Keywords for these concepts were only searched in the study titles, the author-assigned keywords, heading words, and journal titles, depending on the content and field availability of the database. No language or date limits were applied. The searches were run and the results were downloaded on July 7, 2020. For the complete strategies, see Multimedia Appendix 1. If the search results included conference abstracts and proceedings, a subsequent search to find any corresponding follow-up studies was conducted in Google Scholar. Finally, *pearl growing*, also known as a *hand comb* process, was conducted where all cited works in the included studies from the initial screening underwent a 2-stage screening process (title and abstract scan as well as full-text review).

Stage 2: Study Selection

The 2-stage screening process consisted of (1) title and abstract scan and (2) full-text review. Study eligibility was determined by 2 independent reviewers, and a third reviewer was involved to resolve any conflict when consensus was not reached between the 2 reviewers. For a study to be included for full-text review and to be chosen for subsequent inclusion, the title and abstract at each stage needed to have the following attributes:

1. It discussed an actual training program or educational intervention or potential training program or educational intervention and the desired content to be covered.
2. It focused on AI.
3. It was designed or intended for HCPs (at any stage of their career).

A pilot review of 20% (595/2973) of the MEDLINE citations was conducted to establish interrater reliability. The interrater reliability threshold had a Cohen κ value of 0.70, indicating substantial agreement. Additional batches of 50 citations were reviewed until the threshold was met.

Stage 3: Data Collection

A standardized charting form was developed to capture the following domains: article details, study details (if publication was an empirical study), education program details, and implementation factors. The subdivisions of the domains for the data extraction are outlined in Table 1.

Table 1. Data charting: domains and subdomains.

Domain	Subdomain
Article details	Article type, year, and country
Study details	Study design, participants, intervention, comparator, primary outcomes, and secondary outcomes
Education program details	Name, setting, participants, program delivery and curriculum, program instructors (discipline), program length, and instructor training
Implementation factors	Implementation enablers or facilitators, implementation barriers, and recommendations

Stage 4: Synthesizing and Reporting the Results

To collate, summarize, and report on the included studies in this review, a narrative synthesis approach was used [25]. This included a numeric summary using descriptive statistics to report each domain (article details, study details, education program details, and implementation factors). For program curriculum under education program details, curriculum topics were inductively coded. Once a list of topics was generated, they were then grouped by domain using the taxonomy for learning formulated by Bloom. There are 3 domains: (1) cognitive, which refers to knowledge that learners should have, (2) psychomotor, which refers to skills learners should demonstrate and master, and (3) affective, which refers to attitudes learners should develop and incorporate into their practice [20].The study outcomes were deductively coded using the Kirkpatrick-Barr Framework [21] of educational outcomes. This framework was selected because it provided a standardized method of categorizing the type of educational outcomes reported by each study. The implementation factors subdomain was thematically analyzed by 2 independent reviewers using a priori codes. The reviewers compared coding schemes and iteratively determined overarching themes to frame their findings. For content validation, the project team members, patients, and experts in the fields of medical education and AI provided feedback on the thematic analysis.

Results

Search Results

The initial database search yielded 13,449 results; once duplicates were removed, the titles and abstracts of 10,094 (75.05%) unique citations were identified. From the 10,094 unique citations, we identified 41 (0.41%) articles [2,5,13,26-63], where 13 unique, existing programs [32,35,39,43,49,50,59,61-63] were mentioned in 10 (24%) articles, and the remaining 31 (76%) articles [2,5,13,26-31,33,34,36-38,40-42,44-48,51-58,60] discussed the desired or recommended curricular content. The article selection process is presented in Figure 1. Of the 10 articles that discussed an existing program, 8 (80%) were commentaries [32,43,49,50,59,61-63], 1 (10%) was a case report [39], and 1 (10%) was an empirical study [35]. Tables 2 and 3 describe the characteristics of the articles and programs included in this review.

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram of the scoping review results. AI: artificial intelligence; CPD: continuing professional development.

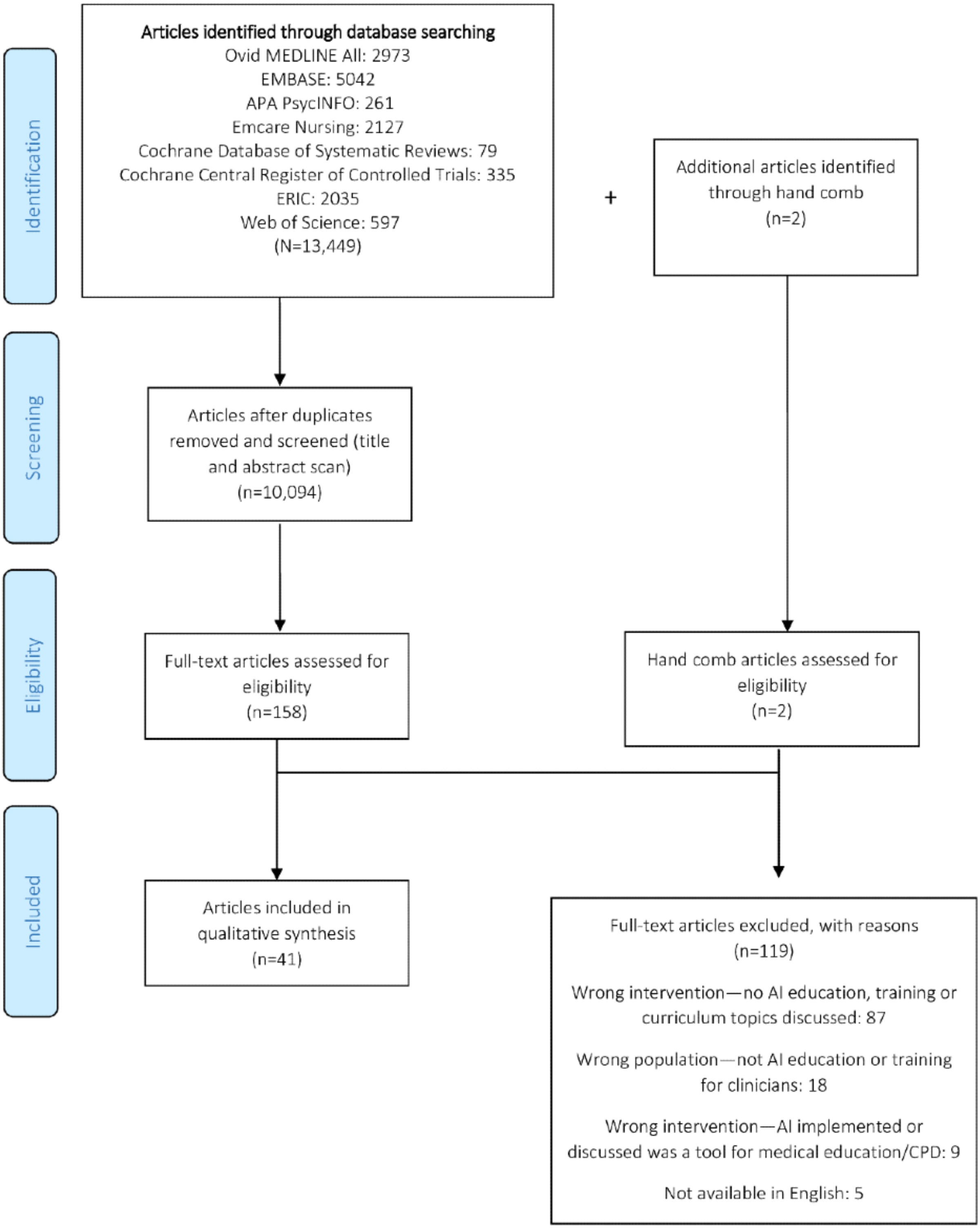


Table 2. Summary of article characteristics (N=41).

Characteristics	Frequency, n (%)	References
Study type		
Commentary	30 (73)	[13,26-30,32-34,36,38,41-45,47,49-53,55,56,58-63]
Review	6 (15)	[2,5,40,48,54,57]
Empirical study	3 (7)	[31,35,37]
Case report	1 (2)	[39]
Best Evidence Medical Education Guide	1 (2)	[46]
Publication year		
2013	1 (2)	[39]
2016	3 (7)	[35,56,61]
2017	2 (5)	[31,50]
2018	8 (20)	[5,28,32-34,42,47,53]
2019	16 (39)	[13,26,27,29,30,38,40,44-46,48,49,52,57,59,62]
2020	11 (27)	[2,36,37,41,43,51,54,55,58,60,63]
Country		
United States	23 (56)	[2,26,28-32,34,35,42,44,45,47,49-52,54,55,59,61-63]
Canada	4 (10)	[13,27,33,43]
United Kingdom	2 (5)	[37,56]
Other	12 (29)	[5,36,38-41,46,48,53,57,58,60]

Table 3. Summary of program characteristics (N=13).

Characteristic	Frequency, n (%)	References
Program type		
Workshop	2 (15)	[49,50]
Fellowship	3 (23)	[32,59]
Biomedical informatics course	2 (15)	[35,39]
Data science course	2 (8)	[59,61]
Joint course-based program	1 (8)	[59]
Educational summit	1 (8)	[62]
Certificate program	1 (8)	[43]
Artificial Intelligence Journal Club	1 (8)	[63]
Program setting		
Medical school	6 (46)	[39,43,59,61,62]
Academic hospital	4 (31)	[32,35,59]
National	1 (8)	[49]
International	2 (15)	[50,63]
Program length		
>1 year	2 (15)	[43,61]
>1 month	2 (15)	[39,63]
>1 day	1 (8)	[50]
≤1 day	2 (15)	[49,62]
Not reported	6 (46)	[32,35,59]
Program audience		
Health care professionals	12 (92)	[32,35,39,43,49,50,59,61-63]
Researchers or clinician scientists	2 (15)	[59,62]
Health care administrators	1 (8)	[62]
Other health disciplines	1 (8)	[63]
Continuum of learning[a]		
Undergraduate medical education	5 (39)	[39,43,59,62]
Postgraduate medical education	8 (62)	[32,35,49,50,62,63]
Program objectives[b]		
Cognitive or psychomotor	10 (77)	[32,35,39,43,49,50,59,61,63]
Affective	1 (8)	[39]
Both	2 (15)	[59,62]
Program methods		
Didactic	9 (69)	[32,35,39,43,49,50,59,61,62]
Workshop	2 (15)	[49,50]
Case-based	2 (15)	[49,50]
Discussions	2 (15)	[49,62]
Experiential learning	5 (39)	[43,49,59]
Web-based	3 (23)	[39,61,63]
Number of methods used		
1 method	5 (39)	[32,35,59,63]

Characteristic	Frequency, n (%)	References
2 methods	5 (39)	[39,43,59,61,62]
≥3 methods	2 (15)	[49,50]
Study outcomes[c]		
Level 1	3 (23)	[39,49,50]
Level 2a	3 (23)	[49,50,62]
Level 2b	2 (15)	[35,62]
None	8 (62)	[32,43,59,61,63]

[a]There are no continuing medical education programs.

[b]Categorized based on the domains identified in the taxonomy for learning formulated by Bloom [20].

[c]Categorized based on the education outcomes identified in the Kirkpatrick-Barr Framework [21].

What Was the Mode of Delivery?

Summaries of the individual programs can be found in Table 4. Of the 13 programs, 8 (62%) originated from the United States [32,35,49,50,59,61-63], 1 (8%) from Canada [43], 1 (8%) from France [59], and 1 (8%) from Mexico [39]. The typology described by Strosahl [64] was used to classify the educational method. Of the 13 programs, 9 (69%) had a didactic approach [32,35,39,43,50,59,61,62] in combination with discussions [62] (1/13, 8%), web-based [39,61] (2/13, 15%), workshop and case-based [50] (1/13, 8%), and experiential learning [43] (1/13, 8%). Of the 13 programs, 10 (77%) were taught in an academic setting [32,35,39,43,59,61,62].

Table 4. Summary of program details.

Program name or first author; country; host institution; specialty; program length	Program setting				Curriculum delivery methods					
	Medical school	Academic hospital	National	International	Didactic	Workshop	Case-based	Discussion	Experiential learning	Web-based
Artificial Intelligence Journal Club; United States; American College of Radiology; Radiology; monthly for 1 hour [63]				✓						✓
Educational Summit; United States; Duke University Medical Center; NS[a]; <1 day [62]	✓				✓			✓		
Health Care by Numbers; United States; New York University; NS; 3 years [61]	✓				✓					✓
Joint course-based program; France; Gustave Roussy with École des Ponts ParisTech and CentraleSupélec; NS; NR[b] [59]	✓				✓					
Fellowship; United States; Emory University School of Medicine; Radiology; NR [59]		✓							✓	
Fellowship; United States; Hospital of the University of Pennsylvania; Imaging Informatics; NR [59]		✓							✓	
Elective courses; United States; Carle Illinois College of Medicine; NS; NR [59]	✓				✓				✓	
Introduction to Comparative Effectiveness Research and Big Data Analytics for Radiology; United States; New York University School of Medicine; medical imaging; 2 days [50]				✓	✓	✓	✓			
Kinnear; United States; University of Cincinnati; NS; <1 day [49]			✓			✓	✓	✓	✓	
Computing for Medicine certificate program; Canada; University of Toronto, Faculty of Medicine; NS; 2 years [43]	✓				✓				✓	

Program name or first author; country; host institution; specialty; program length	Program setting				Curriculum delivery methods					
	Medical school	Academic hospital	National	International	Didactic	Workshop	Case-based	Discussion	Experiential learning	Web-based
The National Autonomous University of Mexico, Faculty of Medicine, biomedical informatics education; Mexico; University of Mexico's Faculty of Medicine; NS; 2 one-semester courses [39]	✓				✓					✓
Formalized bioinformatics education; United States; Baylor Scott and White Medical Center; medical imaging; NR [35]		✓			✓					
National Cancer Institute–Food and Drug Administration Information Exchange and Data Transformation fellowship in oncology data science; United States; National Cancer Institute; medical imaging; NR [32]		✓			✓					

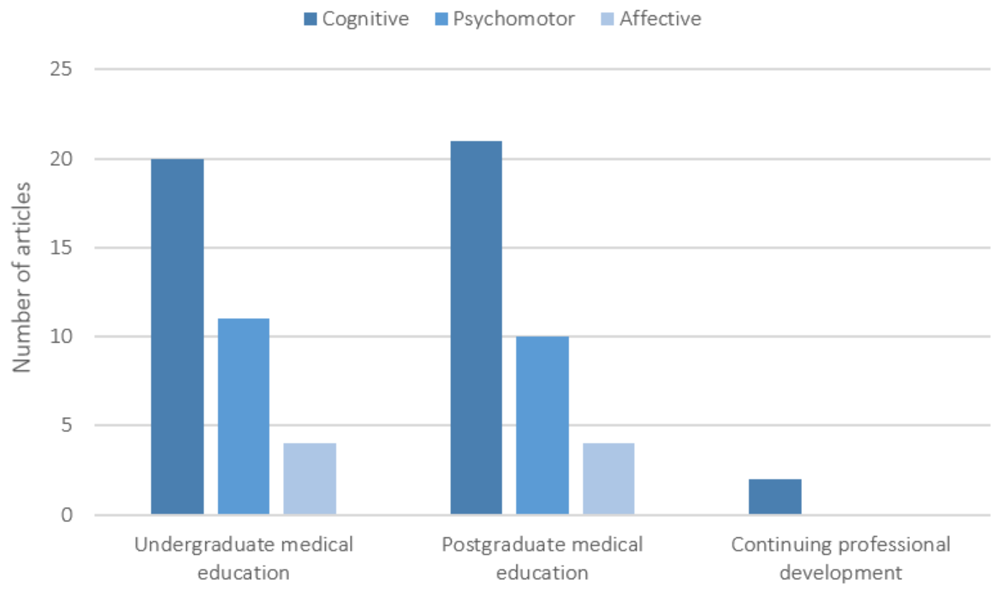
[a]NS: specialty not specified.

[b]NR: not reported.

Target Audience

There were 3 types of HCPs identified in the 41 reviewed papers: physicians [41,43,46,52,59,63] (6/41, 15%), nurses [31,52] (2/41, 5%), and radiology technologists [5] (1/41, 2%). In addition, 2 specific specialties were identified: medical imaging [5,26,32-34,37,42,48,50,51,55,58,63] (13/41, 32%) and cardiology [56,61] (2/41, 5%), with others not being specified [2,13,27-31,35,36,38-41,43-47,49,52-54,57,59,60,62] (26/41, 63%). Figure 2 illustrates the type of curriculum topics covered in the continuum of learning for clinicians, which includes undergraduate medical education [2,13,28-30,33,35-37,39-41,43,44,47,53,57,61,62] (20/41, 49%), postgraduate medical education [5,26,32-35,41,42,48-51,54-58,62,63] (19/41, 46%), and continuing professional development [5,57] (2/41, 5%). Other nonclinical professionals include researchers [5,27,33,59,62] (5/41, 12%), health care administrators [27,33,45,52,62] (5/41, 12%), and computer and data scientists [27,33,52,63] (4/41, 10%).

Figure 2. Number of articles in each curriculum topic domain grouped by target audience.



What Content Was Covered?

From these papers, the program curriculum and desired or recommended content mentioned included topics on using AI, interpreting AI, and explaining results from AI, as framed by McCoy et al [43]. A description of each curricular topic can be found in Table 5.

Of these 16 curricular topics, 9 (56%) fell under cognitive domain, 6 (38%) under psychomotor domain, and 1 (6%) under affective domain, and most of them were mentioned both by papers that discussed current education programs and commentaries that discussed what HCPs should be learning. The curricular topics were categorized into the 3 domains identified in the taxonomy for learning formulated by Bloom [20]. Table 6 displays the curricular topics that were unique to 24% (10/41) of the papers [32,35,39,43,49,50,59,61-63] that described what AI programs currently teach, 76% (31/41) of the papers [2,5,13,26-31,33,34,36-38,40-42,44-48,51-58,60] that described what AI programs should teach as part of their curriculum, and those that outlined both what was taught and what should be taught.

Table 5. Curriculum focus and objectives.

Themes (framed by McCoy et al [43]) and topic	Description	Number of studies	References
Using AI[a]			
Fundamentals of AI	An overview of all stages of model development, translation, and use in clinical practice. Specifically, this would cover nomenclature and principles such as data collection and transformation, algorithm selection, model development, training and validation, and interpreting model output	20	[5,26,27,32,34,36,37,39-41,43,46,47,51,52,55,57-59,62]
Fundamentals of health care data science	Fundamental understanding of the environment supported by AI. This includes an overview of biostatistics, big data, data streams available, and how algorithms and machine learning use and process data	20	[5,13,26-36,41,42,45,49,51,52,54]
Fundamentals of biomedical informatics	An overview of essential concepts such as nomenclature (information and knowledge taxonomy), structure and function of computers, information and communications technology, standards in biomedical informatics, and technology evaluation	1	[39]
Multidisciplinary collaboration	Learning how to partner and communicate with experts in engineering and data science to ensure clinical relevance and accuracy of AI systems	13	[26,29,31,33,43,45,51-54,57,58,62]
Applications of AI	Providing examples of AI that have been implemented in health care settings to understand the impact of technologies that incorporate AI	11	[2,32,39,40,44-46,51,52,55,57]
Implementation of AI in health care settings	Understanding how to embed AI tools into clinical settings and workflows. Specifically, this includes requirements for clinical translation and interpretation of model outputs	9	[27,30,32-34,41,45,57,62]
Strengths and limitations of AI	Understanding the value, pitfalls, weaknesses and potential errors or unintended consequences that may occur when using AI tools	13	[26,30,32-34,37,41,45,51,52,55,58,62]
Ethical considerations	Understanding and building awareness of ethics, equity, inclusion, patient rights, and confidentiality when using AI tools	13	[5,26,28-30,33,36,39,41,42,46,54,58]
Legal considerations and governance strategy	Understanding data governance principles, regulatory frameworks, legislation, policy on using data and AI tools, as well as liability or intellectual property issues	7	[27,30,39,41,45,51,58]
Economic considerations	"Understanding of how business or clinical processes will be altered through the integration of AI technologies into health care" [58] as well as commercialization	2	[26,33]
Interpreting results from AI			
Medical decision-making	Understanding decision science and probabilities from AI diagnostic and therapeutic algorithms to then meaningfully apply them in clinical decision-making	8	[13,26,28-31,39,51]
Data visualization	Understanding how to present and describe outputs from AI tools	4	[27,30,52,54]
Product development projects	Hands on experience to develop, test, and validate AI algorithms with real medical data	2	[52,54]
Explaining results from AI			

Themes (framed by McCoy et al [43]) and topic	Description	Number of studies	References
Communicating with patients	Mastering how to communicate results with patients in a personalized and meaningful way and discuss the use of AI in the medical decision-making process	8	[5,28-30,32,36,43,46]
Compassion and empathy	Cultivating and expressing empathy and compassion when communicating with patients	4	[28-30,36]
Critical appraisal	Understanding how to evaluate AI diagnostic and therapeutic algorithms	7	[2,34,40,43,51,54,59]

[a]AI: artificial intelligence.

Table 6. Illustration of the cognitive, psychomotor, and affective domains between what programs currently teach as part of the artificial intelligence (AI) curriculum and what programs should teach.

Competencies	What programs currently teach	Similarities between the current program and recommended program topics	What programs should teach
Cognitive	Informatics	• Fundamentals of AI • Implementation of AI in health care settings • Big data • Data science • Machine learning • Statistics • Multidisciplinary collaboration • Strengths and limitations of AI	• Challenges with AI • AI applications • EHR[a] fundamentals • Predictive analytics • Ethics and legal Issues • Data governance • Economic considerations
Psychomotor	Leadership	• Analytical • Problem solving • Interpretation • Communication • Critical appraisal • Medical decision-making	• Cultivation of compassion and empathy • Product development • Data visualization
Affective	Perception of humanistic AI-enabled care	• Beliefs about how AI will affect future of health careers and patient care	• Change management • Adoption of AI • Create and sustain a culture of trust and transparency with stakeholders and patients

[a]EHR: electronic health record.

Cognitive Domain

Of the 41 papers, 20 (49%) [5,26,32,34,36,37,39-41,43,45-47,50,52,55,57-59,62] highlighted the importance of providing HCPs with a baseline understanding of AI and 10 (24%) [32,35,39,43,49,50,59,61-63] recommended teaching them AI applications. The studies focused on various applications of AI, including diagnostic systems, data gathering, assessment and use, clinical applications, and personalized care. In addition, many of the papers reported that medical curricula should integrate fundamentals of health care data science [5,13,26-36,42,45,49,50,52,54] (19/41, 46%), including, but not limited to, big data and bioinformatics. Matheny et al [45] stated that data science curricula should encompass how to form multidisciplinary development teams to improve the value of AI and to be aware of the ethics, equity, diversity, and inclusion principles at play and the inadvertent ramifications that may result from AI implementation. The studies also focused on statistics, ML with model development, model translation and use in clinical knowledge, data extraction, and applications for visualization of patients. Familiarity with ML vocabulary and a basic understanding of the methodology (algorithms and machine gathering and process of data) were deemed important to understand this rapidly emerging field.

Psychomotor Domain

Most of the papers focused on clinicians being able to effectively analyze the data [2,5,31,34,35,40,43,46,50,54,55,58,59,61,63] (15/41, 37%) to identify trends and efficiency correlations. As highlighted by Balthazar et al [63] and Forney and McBride [55], it is imperative to learn how to evaluate the efficacy and precision of AI applications. This point was reinforced in a review conducted by Park et al [40] that stated medical students should be able to validate the clinical accuracy of algorithms. HCPs will need to become accustomed and understand how to embrace real-time health information to help make decisions in their practice setting [61]. Of the 41 papers, 8 (20%) discussed the significance of understanding and interpreting the findings with a reasonable degree of accuracy, including awareness of source error, bias, or clinical irrelevance [13,28-31,39,47,50]. Moreover, the study findings described problem-solving [35,38,60] (3/41, 7%) as a critical skill, entailing the management and application of several distinct resources. Clinicians will need to become adept in communicating the results and processes [5,28-30,32,36,43,46] (8/41, 20%) with patients in a personalized and meaningful manner. Cultivating and expressing empathy and compassion [28-30,36] (4/41, 10%) when communicating with the patient was emphasized in several studies.

Affective Domain

Of the 41 papers, 8 (20%) stressed that HCPs should have the attitude to harness AI tools effectively to improve outcomes for patients and their communities [27,30,37,52,55,58,59,62]. Wiljer and Hakim [27] asserted the importance of breaking the mass stereotypes about AI as an initial step. It is essential that professionals perceive AI as augmenting their delivery of care, rather than taking over different aspects of the health care system [62]. Forney and McBride [55] stated that clinicians are not as likely to perceive AI as a threat if they are able to see the wide array of AI tools and the impact these tools have on workflow and patient care. Furthermore, Sit et al [37] mentioned that medical students are not as likely to be discouraged from pursuing certain specialties when they are presented with use cases and understand the boundaries of AI tools; almost half of the respondents believed the misconception that because of AI, certain specialists such as radiologists will become obsolete in the near future. Moreover, Brouillette [59] mentioned the need for collaborative programs among medical students, computer science students, and engineering students, where they can better understand each other's disciplines. A few papers recommended that future AI programs should integrate change management and establish a culture of trust and transparency with relevant stakeholders, which will support organizations to more rapidly adopt and implement AI technologies within the health care ecosystem [27,30]. Thus, it is vital to help organizations manage change at a rate in pace with the rapid advancement of technology.

What Were the Critical Implementation Factors?

Enablers

The factors identified as contributing, or potentially contributing, to the success and implementation of these programs include promoting interfaculty collaboration [39,54,57] and working within existing regulatory structures [28,37,39,57]. Not all institutions have clinical faculty who also have experience with data science; hence, there is a need in both practice and teaching for collaboration with data science faculty. Promoting interfaculty collaboration was described in the studies as the sharing of expertise among faculty members, thus creating a multidisciplinary team [39,54,57]. Collaborative teaching by clinical and nonclinical instructors may increase the educational value when preparing future HCPs and also provide data science support to faculty [39,54]. Another facilitator to implementation is working within existing regulatory structures. Curriculum changes require the support of existing accreditation and regulatory bodies [28]. A few papers discussed the need for the integration of mandatory AI coursework and assessments with the current curricula [39,57]. Hence, this could address varying AI literacy levels; enhancing knowledge of AI will increase the likelihood that it will be used in practice settings [37].

Barriers

Overall, 2 major barriers were identified that could potentially impede an organization's implementation efforts: (1) varying levels of AI literacy among faculty in designing curricula [54,57] and (2) lack of infrastructure to integrate AI into the current curriculum [34,39,50,54]. Varying levels of AI literacy among faculty and curriculum leaders was discussed as a major barrier that encumbers the implementation of AI programs. Of the 41 papers, 2 (5%) discussed how faculty have limited knowledge of AI fundamentals (eg, big data or data science) and software, as well as limited time to teach [54,57]. There is a lack of technical expertise to design AI-based curricula [49,57]. Moreover, a few studies voiced concerns about the lack of infrastructure to integrate AI into the curriculum. Some studies highlighted that the existing curricula are comprehensive and complex and additional content on AI will increase the course load [34,50,54]. Academic institutions are faced with several encumbrances such as faculty retirement, staff not being well-versed in AI, and inadequate financial resources [54]. Finally, integrating the AI content into existing curricula can be an impediment for many organizations [39].

What Measures and Outcomes Were Used to Assess the Effectiveness of Education Programs?

Of the 41 papers, 5 (12%) presented the results of their training evaluation [35,39,49,50,62]. As the educational approaches varied across studies, each approach will be briefly discussed (Table 7), followed by the measures and outcomes associated with each educational initiative. Categorized according to the Kirkpatrick-Barr Framework, the outcomes were either level 1 (ie, learner reaction and satisfaction with the education) [39,49,50], level 2a (ie, change in attitude) [49,50,62], or level 2b (ie, change in knowledge or skill) [35,62]. There were no outcomes that could be categorized as level 3 or level 4; thus, the program evaluations did not comment on the change in behavior or affect at the organizational level or on patient outcomes.

Table 7. Summary of the 5 papers that assessed the effectiveness of the education program.

Programs and authors	Measure	Actual outcomes
Educational summit		
Barbour et al 2019, [62]	• Conducted a 5-question before-and-after poll of those attending our educational summit	• Level 2a: Baseline beliefs about how AI[a] will affect the future of health care careers and patient care were similarly positive before and after the event • Level 2a: At arrival, 70% of the attendees felt that AI would make health care less humanistic; 50% left the summit feeling neutral • Level 2a: We did not observe a meaningful shift in attitudes regarding the desire to take a leadership role in developing or implementing AI • Level 2b: At arrival, 40% of the attendees believed that they had a poor baseline understanding of AI's role in health care; 90% left the summit with an enhanced understanding of the topic
Workshops		
Kang et al 2017, [50]	• A survey was designed to capture residents' opinions after their minicourse, covering 5 major areas of interest: 1. How helpful the minicourse was as an introduction to CER[b] and big data research (on a 5-point scale, with 5 indicating very helpful) 2. Whether the residents would likely pursue further educational or research opportunities in CER 3. Whether the residents had prior educational or research exposure to CER 4. Whether a mentor was available for CER at their home institutions 5. The importance of CER and big data research to the field of radiology (on a 5-point scale, with 5 indicating very important)	• Level 1: 90% of the residents reported that the course was helpful or very helpful • Level 1: 94% of the participants felt that the lectures were of high or very high quality • Level 2a: 82% reported that they planned to pursue additional educational or research training in CER or big data analytics after the course • Level 2a: 98% of the respondents felt that health services and big data research are important or very important for the future of radiology
Kinnear et al 2019, [49]	• Evaluations were conducted on a 5-point Likert scale	• Level 1: The average weighted rating on a 5-point Likert scale over the 3 years for the prompt "Overall satisfaction with the session" was 4.32 out of 5 • Level 2a: The participants reported an increase in confidence to use this knowledge to teach residents in the coming academic year
Biomedical informatics course within medical education		
Sanchez-Mendiola et al 2013, [39]	• Administered a program-evaluation anonymous survey to the students at the end of the course, a 41-item questionnaire that explored several aspects of the program	• Level 1: Overall opinion of the students regarding the different elements of the program was good to excellent for educational activities, course resources, and perception of clinical relevance
Sybenga et al 2016, [35]	• Competency of senior residents on the basis of their project results was evaluated by staff during a multidisciplinary conference	• Level 2b: After introductory education in big data analysis concepts, the residents were able to rapidly analyze large sets of data to answer simple questions • Level 2b: The senior residents were able to engage in complex problem solving requiring management and application of multiple seemingly unrelated resources and successfully present these results

[a]AI: artificial intelligence.

[b]CER: comparative effectiveness research.

Discussion

Current State of AI Education Programs

This review identified pivotal knowledge gaps in our understanding of effective AI education programs for HCPs. The gaps identified through this review illustrated the limited AI education and training opportunities available for HCPs and thus emphasized the necessity of curating further AI education programs targeted to HCPs. The existing programs tend to focus only on the development and implementation of AI; yet, it is essential to also prepare HCPs to not only work with AI but also to advance AI for health and clinical decision-making. AI education programs should be designed in a way that enables HCPs to not only safely adopt these technologies, but also to adapt and shift their scope of practice to stay relevant. A significant and meaningful change to AI curricula in health care will only occur by increasing AI literacy among HCPs and by providing them with the ability to leverage relevant digital and data-driven decision-making tools. Although the studies demonstrate that efforts are being made to evaluate the outcomes of AI-related education initiatives, there is a lack of consistency in the measures for a comprehensive assessment of these outcomes. Most of the papers used self-constructed and nonvalidated instruments and delineated their findings in qualitative terms. Given the variety of instruments that have been employed in the studies, the absence of a standard, comprehensive tool impedes the integration and synthesis of findings across the studies. The guiding principles provided in this review will also hopefully inform future development and design of these programs.

Critical Implementation Factors

A lack of infrastructure to integrate AI content into current curricula could hinder the development of these types of programs; some of the programs described embedded their content within existing professional certifying bodies' infrastructure to facilitate content development. The Royal College of Physicians and Surgeons of Canada, in particular, further emphasizes the need for these regulatory strategies, which are currently in process but not yet in practice [65,66]. The promotion of multidisciplinary collaboration was indicated as an enabler of content delivery; yet, varying levels of AI literacy among faculty could impede successful delivery of AI content [54,57]. Curricular adaptations and building an infrastructure for AI technologies could be helpful to HCPs wanting to adopt AI to improve patient care; this includes improvements in the types of health care data available for AI education [67]. Of note, much of the health data generated are often inaccessible to researchers and limited by regulatory or infrastructure-level barriers, including institutional ethics approvals and data-sharing agreements [67]. The use of deidentified data, security, and privacy controls could potentially widen the scope of access; broader collaboration with multidisciplinary experts could also help to establish secure data networks to improve use and access of health care data [67]. Lower levels of AI literacy could be augmented by standardizing competency statements and engaging and training faculty in e-learning, for instance [68-70]. The World Health Organization's Global Strategy on Digital Health further suggests that the barriers to AI adoption need to be addressed at the systems level and all aspects of implementation should be considered.

Our recommendations have been formed into guiding principles that could be used to guide the development of future AI curricula or to incorporate AI education into existing curricula.

Guiding Principles

Principle 1: Need for Regulatory Strategies

Many studies discussed that working within the existing regulatory structure can hinder the implementation of AI education initiatives. Faculty can be inhibitors to changing curricula that were initially developed to prepare students for their national board examinations [28,30]. In addition, teaching approaches may be too outdated to incorporate new and emerging technologies [29] into the changing digital and AI landscape. New regulatory strategies will be required, and organizations will have to prioritize developing a workforce that not only has the knowledge and skills to provide care with these tools, but also the competencies to rapidly learn and adapt. The studies also highlighted that accrediting bodies can be a roadblock to change [27-29]. Wartman and Combs [28] stated that to prepare future care providers for AI-enabled care, there is a need for accreditors to move beyond traditional models (based on fact memorization and clinical clerkships) and be willing to innovate and consider new approaches to lifelong learning.

Principle 2: Multidisciplinary Approach to Design and Delivery

The rapidly evolving nature of the field and the dynamic regulatory, legal, and economic landscape may hinder the implementation of an AI curriculum and thus affect the deployment of AI tools in clinical practice. An initial AI curriculum must be developed iteratively because many of these areas still entail considerable research and advancement [26], ensuring that new knowledge gains and policy changes are reflected within the curriculum. This finding was reinforced in a paper by Wiljer and Hakim [27]. The authors reported that AI applications have not yet developed to a level of complexity and clinical value because many of these applications are currently in the research and development stages.

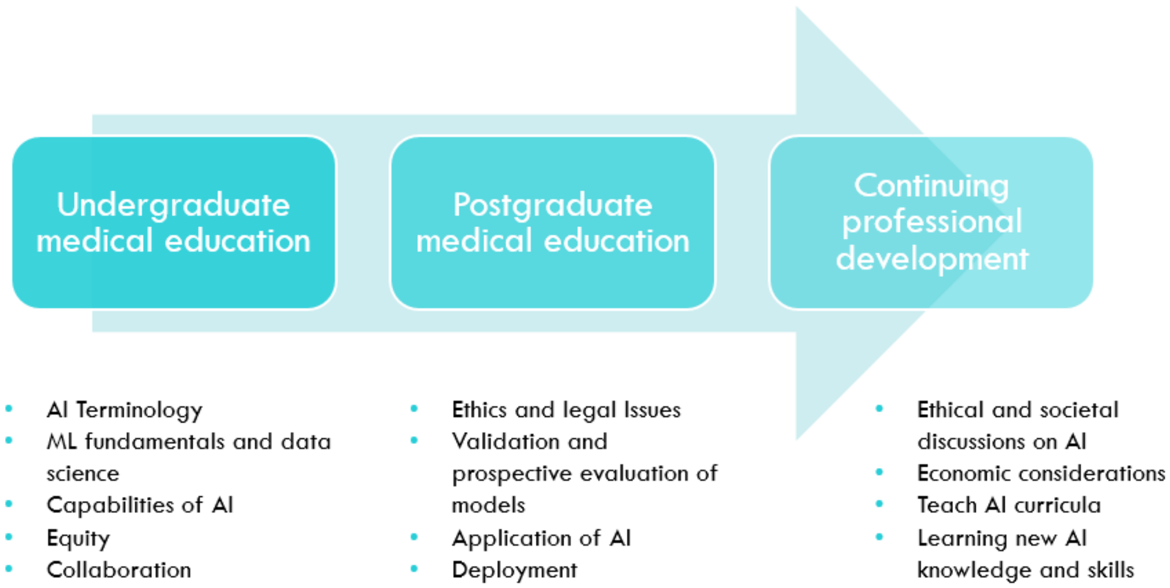
Wiens et al [71] stated that successful ML deployment entails assembling experts and stakeholders from various disciplines, including knowledge experts, decision-makers, and users. The approach to curriculum redesign will need to focus on multiple disciplines and levels of training; curricula should be specialized to the needs of various individuals such as health care researchers, clinicians, and quality improvement teams [44]. Therefore, the development of an AI-based curriculum should involve a multidisciplinary team comprising health system leaders, frontline providers, data scientists, patients, and education experts to ensure accuracy and clinical relevance of the curriculum [57,71]. It is imperative for all stakeholders and experts in the field to work collaboratively to understand and address the potential biases, thus reducing the existing social inequalities and ultimately leading to optimal care for all patients [71].

Principle 3: Competence-Based Curriculum Design

To influence the development of their future practice, it is essential for HCPs to have a foundational level of AI competencies and skills [27]. Education should be designed in a manner that teaches HCPs to work with, and understand, the AI they use in their clinical practice. Furthermore, a level of baseline competencies in AI should allow trainees to make significant contributions to health policy decisions related to their scope of practice [50]. AI will likely contribute significantly to the medical practice of the future; therefore, fundamentals and applications of AI tools and terminologies should be integrated into medical school curricula. Specifically, training current and future physicians on how to use these tools to provide quality health care, while taking into account the limitations and ethical implications of such technologies, will be useful [43]. In addition to medical learners and physicians, medical teachers need to be trained to deliver this innovative AI curriculum content; this is a shift that needs to occur without delay, given the steep learning curve ahead [36]. Paranjape et al [41] recommended a staged approach to educating future care providers about AI and its application in health care that spans from undergraduate to continuing medical education.

On the basis of the findings of this review, an ideal flow of AI concepts could be split across the 3 stages of medical education defined by Oxford Medicine: undergraduate medical education, postgraduate medical education, and continuing professional development (Figure 3) [72]. Undergraduate medical education should be focused on HCPs becoming familiar with AI terminology, the fundamentals of ML and data science, capabilities of AI, and how to identify opportunities and applications in health where AI would be appropriate with a health equity lens. During postgraduate medical education, emphasis should be placed on how to engage in validation and prospective evaluation of models, as well as deployment. Ethical and legal considerations, including governance strategy development, should be explored in more depth. Finally, during continuing professional development, providers should be involved in facilitating ethical and societal discussions, teaching AI courses, and keeping abreast of new AI knowledge and skills as well as teaching methods.

Figure 3. Ideal flow of key concepts for AI education curricula. The terms have been defined in the Results section. AI: artificial intelligence; ML: machine learning.



Principle 4: Patient-Clinician Interaction

In the age of AI-enabled care, HCPs must consider the potential impact of the patient and clinician interaction as well as the strategies for improving the quality of care delivered in a technology-enabled environment [13,27]. Li et al [13] stated that health professions education should teach and cultivate altruism and compassion, unique skills to humans that are integral to the emergence of AI applications. This will ensure that HCPs are not disrupted by novel tools. To equip themselves to use AI in practice, care providers should develop competencies that allow them to differentiate between credible and false information in their delivery of care [40]. Similar to the situation in other industries, the challenge of adopting and implementing AI in health care will lead to winners and laggards [48]. In the successful adoption of AI, HCPs should engage with their patients because these interactions will be important to complement the technical expertise of AI as AI transforms the health care milieu [48].

Limitations

Our scoping review findings should be examined in the context of the following limitations. Because of the nature of the scoping review, the quality of each identified study was not assessed. Given the nature of the topic being investigated, we excluded studies that discussed AI as a tool for medical education or continuing professional development. Only studies in English were included. In addition, the educational approaches varied across the studies; thus, we were unable to conduct formal comparisons among the curricula to determine which were effective. However, reviewing the literature enabled us to identify the gaps in current education programs and provide insights and best practices to guide future education efforts. As this review was inclusive of all types of studies and focused on a breadth of literature, the depth in reporting of education program details was inconsistent and varied based on the scope of the study.

Conclusions

With the inevitable progression of health care digitization, health professions education should foster unique human abilities, which will complement these emerging technologies. This review provided an overview of the current state of AI in health professions education and future directions on preparing care providers for the era of AI in health care. Future education efforts should focus on the development of regulatory strategies, a multidisciplinary approach to curriculum redesign, a competency-based curriculum, and patient-clinician interaction.

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Authors' Contributions

RC led the conceptualization, design, and execution of the review. RC, TJ, and SY collaborated on the numeric and thematic analyses, drafting, and finalization of the manuscript. MA developed the search strategy and conducted the search. In addition to RC, TJ, and SY, DAM, SH, SW, and TT contributed to the identification of papers and screening. DW and ED provided guidance on the conceptualization and design of the study. DW, ED, MS, and WT contributed to the development of ideas that were instrumental in surfacing and maturing many of the concepts contained in this study. They also served as content experts in validating the findings and revising all drafts of this manuscript for important intellectual content and clarity. All authors have revised drafts of this manuscript as well as read and approved the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Database search strategies.
[DOCX File , 43 KB - mededu_v7i4e31043_app1.docx]

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Abbreviations

AI: artificial intelligence
HCP: health care professional
ML: machine learning
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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Original Paper

Replicating Anatomical Teaching Specimens Using 3D Modeling Embedded Within a Multimodal e-Learning Course: Pre-Post Study Exploring the Impact on Medical Education During COVID-19

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Abstract

Background: The COVID-19 pandemic has had significant effects on anatomy education. During the pandemic, students have had no access to cadavers, which has been the principal method of learning anatomy. We created and tested a customized congenital heart disease e-learning course for medical students that contained interactive 3D models of anonymized pediatric congenital heart defects.

Objective: The aim of this study is to assess whether a multimodal e-learning course contributed to learning outcomes in a cohort of first-year undergraduate medical students studying congenital heart diseases. The secondary aim is to assess student attitudes and experiences associated with multimodal e-learning.

Methods: The pre-post study design involved 290 first-year undergraduate medical students. Recruitment was conducted by course instructors. Data were collected before and after using the course. The primary outcome was knowledge acquisition (test scores). The secondary outcomes included attitudes and experiences, time to complete the modules, and browser metadata.

Results: A total of 141 students were included in the final analysis. Students' knowledge significantly improved by an average of 44.6% (63/141) when using the course (SD 1.7%; Z=−10.287; *P*<.001). Most students (108/122, 88.3%) were highly motivated to learn with the course, and most (114/122, 93.5%) reported positive experiences with the course. There was a strong correlation between attitudes and experiences, which was statistically significant (r_s=0.687; *P*<.001; n=122). No relationships were found between the change in test scores and attitudes (*P*=.70) or experiences (*P*=.47). Students most frequently completed the e-learning course with Chrome (109/141, 77.3%) and on Apple macOS (86/141, 61%) or Windows 10 (52/141, 36.9%). Most students (117/141, 83%) had devices with high-definition screens. Most students (83/141, 58.9%) completed the course in <3 hours.

Conclusions: Multimodal e-learning could be a viable solution in improving learning outcomes and experiences for undergraduate medical students who do not have access to cadavers. Future research should focus on validating long-term learning outcomes.

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KEYWORDS

congenital heart disease; cardiac anatomy, pathologic anatomy; education; learning aids; 3D models

Introduction

Background

Congenital heart disease (CHD) occurs in 1 out of every 100 births and is an essential subtopic of study for medical students [1]. One of the fundamental concepts in understanding the physiology of CHD is comprehending the anatomy of the normal heart and how that is different with congenital heart defects. An understanding of the gross anatomy lays the foundation for effective clinical tasks, such as performing physical examinations, evaluating medical images for diagnosis, and performing procedures required for intervention (eg, surgical correction).

Anatomy Education

In the past, medical schools have used several creative approaches to introduce 3D visualization of complex structures into their curricula when cadavers were not available or feasible to use. Technologies discussed in the literature include computer-based learning (eg, videos, animations, multimedia simulation software, 3D models, and 3D computer graphics), 3D printed models, and extended realities (stereoscopic videos, virtual reality, and augmented reality). The tools are valuable teaching and learning aids [2-13] but are underused [14].

Local Context

At our institution located in Canada, between 200 and 300 undergraduate medical students attend a 2-hour session where they use cadaveric specimens to work through the key features of common congenital cardiac abnormalities. Medical students enter this program with a completed undergraduate degree, then undergo 4 years of undergraduate medical studies, followed by a residency. It is widely accepted that cadaveric specimens are the gold standard for anatomy education, providing students with a 3D understanding of the human body, a sense of the relationship between different anatomical features, and an appreciation of the depth, fragility, and variability within the human body [2,15]. However, in pediatric medicine, there is a noteworthy difference with regard to access to cadaveric specimens because of various reasons, including improved outcomes within the affected patient population (9 of 10 patients with CHDs now live to adulthood [1]) and financial, religious, cultural, ethical, and legal considerations related to the acquisition and use of such specimens [16].

In combination with barriers that are well documented in the literature, we were also amid the COVID-19 pandemic, where a return to in-person cadaveric learning sessions was not permitted because of local public health and safety requirements [3,17]. Social distancing measures implemented in our area precluded students from gathering in group learning settings. Without alternatives to in-person cadaveric laboratories, the opportunity to use cadavers for anatomy learning was compromised for an indeterminate length of time. There was an urgent need for alternatives that allowed for 3D spatial visualization of complex structures under these circumstances.

Study Objectives

With this in mind, we created a customized CHD e-learning course that contained interactive 3D models of anonymized pediatric congenital heart defects. The course was implemented for use in first-year undergraduate medicine courses. The aim of this study is to assess whether the e-learning course contributed to improved learning outcomes in a cohort of first-year undergraduate medical students. We hypothesized that students would gain new knowledge from the course. Secondary hypotheses were that students would report positive attitudes and experiences with the course and that student's reported attitudes, experiences, and knowledge would be related, and experiences would be affected by the minimum requirements of individual hardware used to access the course.

Methods

CHD Cases Course Design

Pedagogy

The e-learning course was designed to incorporate pedagogical attributes along 5 parameters: (1) developing content, (2) storing and managing content, (3) packaging content, (4) student support, and (5) assessment [18]. The structure also addressed barriers to implementation identified by conceptual frameworks [19] such as technology compatibility, user design, student motivation, perceived usefulness and ease of use, and access.

This remote e-learning course was also well integrated with Fleming VARK model (visual, auditory, reading or writing, and kinesthetic learners) [20], providing course materials, which are tailored for different ways of learning. Visual learners are supported through the addition of videos, graphics, and animations. Auditory learners are supported through the addition of videos. Reading and writing learners are supported through didactic text within each module. Finally, kinesthetic learners are supported through the opportunity to interact with patient-specific 3D virtual models.

Developing the Course Content

The CHD media was custom designed and developed by the BC Children's Hospital Digital Lab. To ensure that the course was relevant, accurate, and aligned to the aims of the medical school curricula, e-learning objectives and course content were designed by a team of approximately 8 stakeholders, including cardiologists, researchers, medical students, and learning designers. Although increased collaboration requires more time, an interprofessional approach allowed us to combine the expertise of several fields for the development of a creative product. Media included videos of 3D printed models (Figure 1), cadaveric specimens (Figure 2), interactive 3D virtual models (disseminated via Modelo; Figure 3), animations, and graphics (acquired through Shutterstock). The interactive course content was supplemented with text and packaged as an e-learning course using Articulate Rise course authoring software. In addition, 1 faculty member (a pediatric cardiologist) provided overarching medical oversight and clinical quality assurance for the final course content.

Figure 1. Video describing a heart with tetralogy of Fallot using a patient-specific 3D printed model.

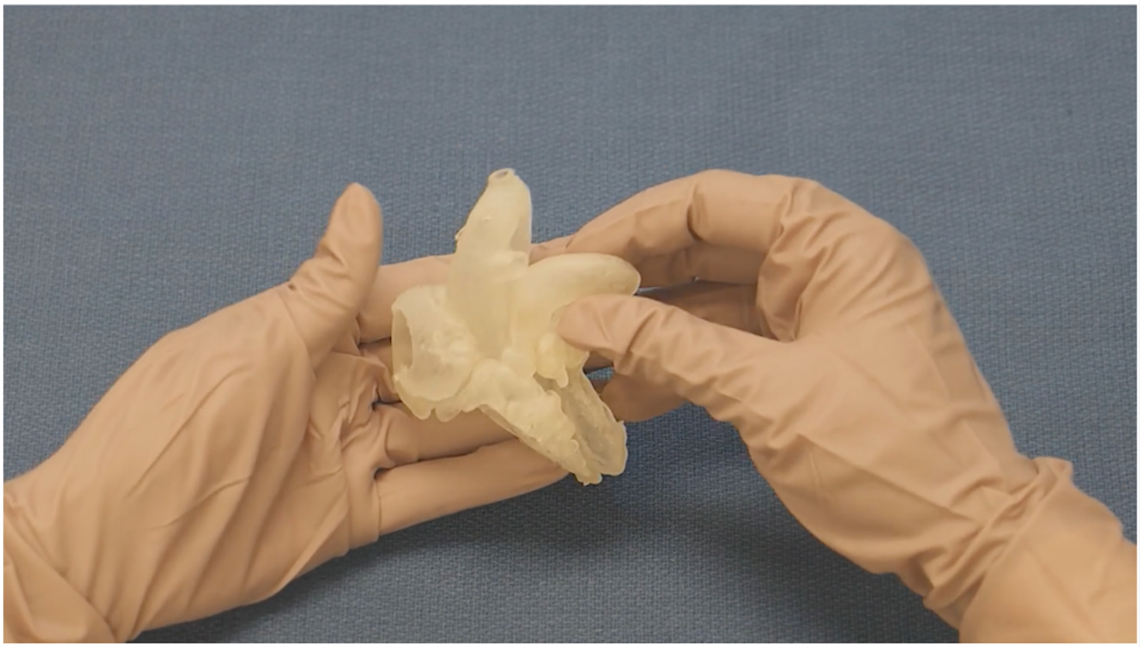


Figure 2. Video describing tetralogy of Fallot using a cadaveric specimen.

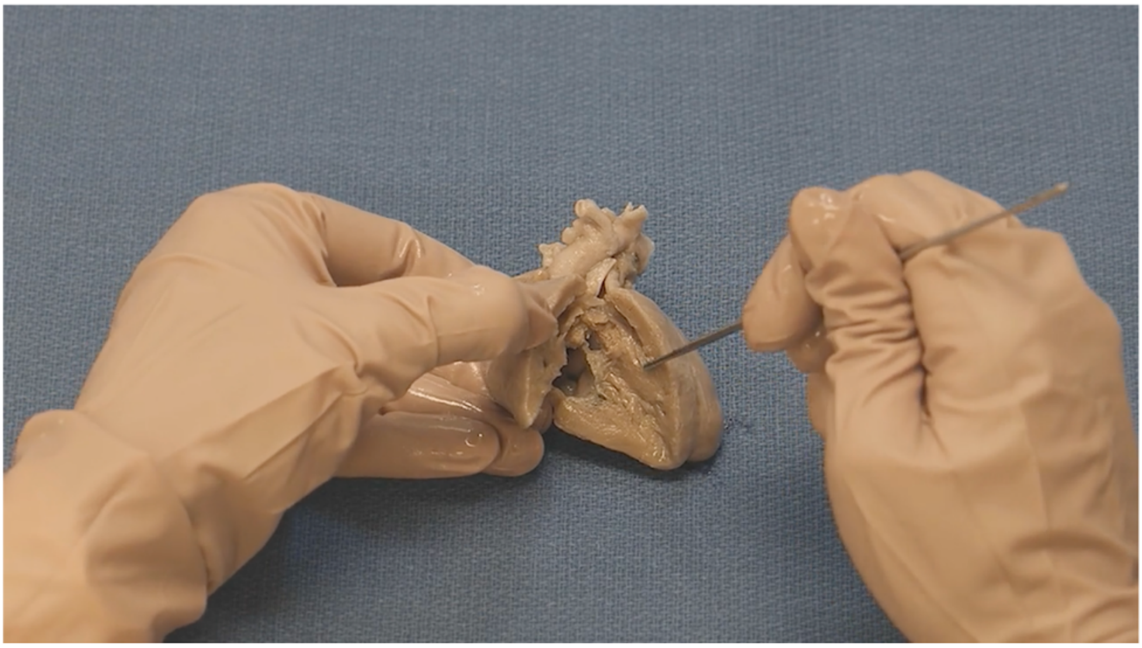


Figure 3. Interactive 3D virtual models of tetralogy of Fallot.

Representative cadaveric learning cases with corresponding computed tomography scans of congenital heart defects were featured in the media of the course. It presented 6 CHD pathologies across a spectrum of disease severity: atrial septal defects, tetralogy of Fallot, transposition of the great arteries, coarctation of the aorta, truncus arteriosus, and hypoplastic left-heart syndrome. A *normal* heart was also represented for comparison.

Storing and Managing the Content

The e-learning course was made accessible via a direct link that could be posted to various learning management system platforms used by the teaching institution or disseminated via email; this mode of delivery was pragmatically selected instead of directly embedding the course within a learning management system to reduce potential for access issues during implementation, and to improve future reach [19].

Pre- and posttests were administered using Qualtrics, a survey data capture system, and seamlessly embedded within the course content. Students were made aware that the completion and the results of these quizzes were electronically tracked.

Packaging the Content

In this study, the e-learning course was offered to undergraduate medical students as a component of their studies on CHDs. The e-learning course was released after virtual lectures were hosted; however, student participation in these elements was not standardized, as it would not have been reflective of the current environment. Flexibility is a tenet of remote learning. The e-learning course was conceptualized as 11 modules, each consisting of an introduction, module-specific multimodal content, and learning checks (Textbox 1) [19].

Textbox 1. Modules of the e-learning course

The 11 modules of the e-learning course

1. Course overview and learning objectives
2. Gross anatomical features of the normal heart
3. The sequential segmental approach
4. Atrial septal defects
5. Tetralogy of Fallot
6. Transposition of the great arteries
7. Coarctation of the aorta
8. Truncus arteriosus
9. Hypoplastic left-heart syndrome
10. Virtual reality models
11. Course summary

The content was presented in smaller manageable chunks (as individual modules) to allow for flexible learning and shareability. When new technologies (eg, virtual models) were introduced, a tutorial was available to provide orientation. The learning modules had to be completed sequentially, and each subsequent module was only accessible after passing a brief learning check on the prior module content. There were no explicit time constraints for the course, and completion was not mandatory, nor was it officially graded. Nonetheless, assessments (eg, pre- and postassessments) were presented as an optional part of the course, and students were made aware that the completion and the results of the quizzes were electronically tracked [19].

Student Support

During COVID-19, the status quo for anatomy sessions at our institution transitioned to virtual lectures over Zoom (Zoom Video Communications Inc) videoconferencing, in combination with web-based demonstrations and discussions. The e-learning course was added as an adjunct to these sessions to provide diverse teaching material for instructors [19].

Learning Check Assessments

Learning check assessments were created by an instructor and cardiac specialist and tested with students before being deployed within each module [19]. The goal was to reinforce the learning objectives through multiple-choice questions, true or false questions, matching questions, or short answer questions. To ensure the quality and validity of testing, the questions were developed by content experts and informed by the structure of current anatomy tests published in peer-reviewed literature [21,22]. Students had to receive at least 60% on each learning check to move onto the subsequent module. After completing the learning check, feedback was provided. Feedback included the student's test score and referenced to the section that should be reviewed for incorrect responses.

Principal Objective

The primary objective of this study is to determine whether undergraduate medical students gained new knowledge from the course. The secondary objective is to evaluate whether students reported positive attitudes and experiences from the course and whether any of the measures of attitude, knowledge, and experiences were related.

Participants and Protocol

Protocol

A cohort of 290 first-year undergraduate medical students at a large postsecondary institution were selected for analysis because the cohort included a sufficiently powered number of students. Within the course, each student was invited to complete 3 optional questionnaires throughout the implementation (pretest, posttest, and feedback surveys). Questionnaires were embedded within the Articulate Rise e-learning course and hosted on Qualtrics to be completed remotely and concurrently with the course. On completion of the evaluation components, students were entered to a draw for 1 of 3 CAD $50 (US $40) Amazon Gift Cards. Ethics approval was granted by the Children's and Women's Research Ethics Board of the University of British Columbia (#H20-03660).

Inclusion and Exclusion Criteria

The inclusion criteria were that data had to be entered by first-year undergraduate medical students during November 2020. There were no exclusion criteria.

Outcome Measurement

The primary outcome was learning outcomes. The secondary outcomes include attitudes and experiences with the e-learning modules, time to complete the modules, and browser metadata.

Learning Outcomes

Learning outcomes were measured as a factor of test scores (Multimedia Appendix 1). The mean of paired pretest and posttest scores was calculated and compared. Mean change in test scores was calculated and reported by subtracting pretest scores from posttest scores for each individual.

Attitudes

Attitudes were calculated as a factor of motivation to learn with the e-learning modules. Questions in the feedback pertained to motivation to learn and were included in the composite variable for attitudes. These questions were based on an adapted version of Zaharias and Poylymenakou's usability survey [23].

Experiences

Experiences with the e-learning course were measured by Zaharias and Poylymenakou's metrics on content and resources, media use, learning strategies design, self-assessment, and learning support [23]. Items that addressed experiences with the e-learning modules in the feedback were combined as a composite variable to integrate the multiple measurements into a single variable representing student experience with the learning module. Variables for experience included questions focusing on content and resources, media use, learning strategies design, self-assessment, and learning support.

Time to Complete

Time to complete the course was calculated using the time stamps in the metadata. Because the course was not administered on a learning management system, we used the time stamps from the pre- and posttests as a proxy measure of time. Total time to complete the course was calculated by subtracting the time stamp of the start of the posttest from the time stamp of the completion of the pretest.

Browser Metadata

Browser metadata were recorded by the e-learning module and included information about the browser, operating system, and screen resolution used by participants to access the e-learning materials. Metadata included information about the internet browser, operating system, and screen resolution. Browser metadata relationships were extracted from the course metadata and were compared with learning outcomes, attitudes, and experiences.

Internet browser information was acquired through the course metadata. As part of the technical requirements for the course, students were informed that the course did not function well in Internet Explorer and advised to use other web browsers to complete the course (eg, Chrome, Firefox, and Safari).

Operating system information was acquired through the course metadata. As part of the technical requirements for the course, students were advised that tablets, smartphones, and other mobile devices may not work in all areas of the course (eg, interactive 3D models), so they should use a PC or Mac-based computer to fully use the course materials.

Resolution is the number of pixels a screen can show, both horizontally and vertically, and it is generally agreed that higher-resolution devices provide a better experience when using immersive media. Students use a variation of hardware, and thus screen resolutions, to complete their school work. We included a measure of screen resolution to assess whether screen resolution impacted learning of the material and reported experiences. Screen resolution information was acquired through the course metadata.

Qualitative Feedback

The results of the open-ended user feedback were reviewed for relevant information related to attitudes and experiences.

Analysis and Reporting

Power Calculation

A priori power analysis was calculated using G*Power 3 [24]. Assuming a small to moderate effect size (Cohen *dz*=0.35) with 95% power and probability of a type 1 error of .05, a total sample size of 109 was needed.

Analysis

Statistical analysis was performed using the IBM SPSS Statistics for Mac, Version 27 (IBM Corp.). Data were analyzed according to the protocol set; that is, students had to complete the pre- and posttests measuring learning outcomes to be included in the analysis.

Descriptive statistics were reported. To assess whether students' learning outcomes improved with the e-learning course, test scores from the *pre and posttests* were analyzed using a Wilcoxon signed-rank test. Test scores were not normally distributed. We dichotomized scores such that no partial marks were provided for question responses (ie, all correct answers had to be selected for a *select all that apply* question). To investigate whether experience, attitudes, and test scores were related, a bootstrapped bias-corrected and accelerated Spearman rank-order correlation was performed. For missing values, a single value was filled for each missing value with the mean score for that question. The results of the feedback questionnaire were calculated using descriptive statistics and analyzed in SPSS statistical software.

The findings of open-ended feedback were coded using a rapid analysis framework [25]. This framework involves summarizing the comments in a table and then consolidating summaries on broad themes or categories with supportive quotes to indicate areas for improvement.

Results

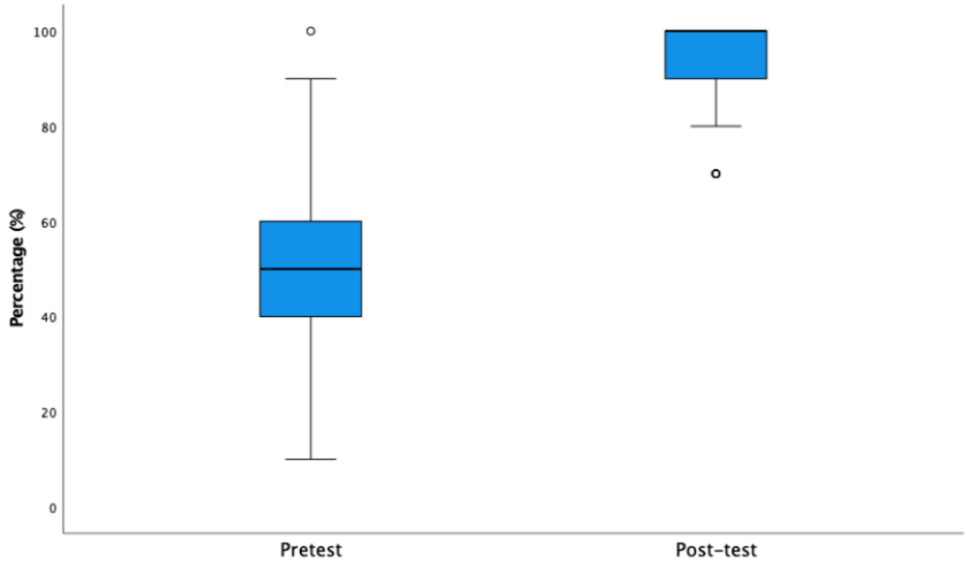
Study Group

A total of 290 first-year undergraduate medical students enrolled in the course and were invited to use the e-learning modules as part of an educational series on congenital heart defects. Students engaged with the initial pretest 228 times, with the posttest 198 times, and the usability questionnaire 155 times. After obtaining consent and removing duplicate and incomplete responses, 141 students were included in the analysis.

Learning Outcomes

On the basis of the test scores measured before and after using the e-learning course, students' knowledge significantly improved by an average of 44.6% between tests (SD 1.7%; Z=−10.287; *P*<.001; Figure 4). The median score for the pretest was 50.0% (IQR 20.0%, SD 15.7%), and the median score for the posttest was 100% (IQR 10.0%, SD 7.4%).

Figure 4. The median (middle quartile) test scores for the pre- and posttests taken by students using the e-learning course. Students' knowledge significantly improved by an average of 44.6% between tests (SD 1.7%; Z=−10.287; *P*<.001). The circles denote outliers.



Time to Complete

The time to complete the modules was calculated using the time stamps on the pretests captured before starting the course and from the posttests immediately following the completion of the course. The median time to complete the modules was 2.3 (IQR 4.7, SD 26.2) hours. Most students (83/144, 58.9%) completed the course in <3 hours. Some students completed the course within 1 day (47/144, 33.3%), and a few students completed the course within a few days (11/144, 7.8%). No relationships were found between the time and change in test scores (*P*=.75), attitudes (*P*=.20), or experiences (*P*=.17).

Interactive Courses May Take More Time to Complete

Completion times for interactive modules is dependent on the time spent interacting with the modules and knowledge while entering the course. A small number of students reported that the course took longer than described in the course outline to complete. Of them, 1 student mentioned "To really take this module seriously it took longer than the 1.5 hours stated in the intro."

Attitudes

Overview of Attitudes

Regarding attitudes, 88.5% (108/122) of the students were highly motivated to learn with the course (Table 1). In total, 59.8% (73/122) of the students indicated that the course stimulated further inquiry with mentors or other students, 96.7% (118/122) indicated that the course was enjoyable and interesting, 94.3% (115/122) indicated that the course provided instruction or training that matched their experience, 97.5% (119/122) indicated that the course met their needs, and 93.4% (114/122) of the students indicated that the learning requirements and criteria for learning success were clear within the course.

We also asked questions about students' motivation in the usability survey. Students mentioned that the course met their needs for learning congenital heart defects and that the course was of high quality.

Table 1. Students' motivation to learn with the multimodal e-learning course (N=122).

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The course stimulated further inquiry (eg, with mentors or other students), n (%)	2 (1.6)	4 (3.3)	43 (35.2)	36 (29.5)	37 (30.3)
The course was enjoyable and interesting, n (%)	2 (1.6)	0 (0)	2 (1.6)	36 (29.5)	82 (67.2)
The course provided instruction or training that matched my experience, n (%)	2 (1.6)	1 (0.8)	4 (3.3)	36 (29.5)	79 (64.8)
The course met my needs, n (%)	1 (0.8)	0 (0)	2 (1.6)	28 (23.0)	91 (75.0)
The learning requirements and criteria for learning success were clear within the course, n (%)	1 (0.8)	2 (1.6)	5 (4.1)	31 (25.4)	83 (68.0)

e-Learning Courses Can Meet Undergraduate Medical Student Needs for Learning Congenital Heart Defect Anatomy

Students reported that the course covered congenital heart defects in sufficient breadth and depth to meet the learning objectives. Students reported the following:

> *I was able to draw distinctions between different congenital heart diseases and differentiate between them.*

> *I found this course to provide sufficient detail and information, allowing me to fill my knowledge gaps with respect to CHD.*

However, when creating e-learning modules for undergraduate medical learning, students could benefit from a progress save function to allow for flexible learning experiences:

> *If [I] did not complete the module all in one go, I was bumped out and had to repeat all of the quizzes again before I could move forward. If there was a way to save your spot in the module, that would be very useful to be able to come back later!*

Furthermore, when providing the module asynchronously, it is important to acknowledge how the pieces fit together. Some students were motivated to seek additional information:

> *It would be nice to provide success rates of surgeries/management.*

> *Would love more information about the sequential analysis approach.*

In general, students reported that "the [course] was so helpful." However, administration may work better when offered in advance of live sessions, where students can ask questions to instructors and inquire about access to additional resources.

Innovative Multimodal Teaching Tools Can Help to Offer High-Quality e-Learning Experiences

Students were motivated by the multimodal web-based delivery afforded by the course. A student said:

> *I really enjoyed learning this way and I hope we can do this more often.*

Students also described the content as of high quality, which influenced motivation to learn. The course offered a high-quality alternative to other learning experiences. A student commented:

> *Wow, this was an amazing module, probably one of the best online modules we've done so far. Best module I have encountered since entering med[icine].*

Experiences

Overview of Experiences

Regarding experiences, 93.5% (114/122) of students reported positive experiences with the course (Table 2).

Table 2. Students' experiences with the multimodal e-learning course (N=122).

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Content and resources					
Concepts (ie, segmental approach, defects) were illustrated with concrete, specific examples, n (%)	0 (0)	4 (3.3)	1 (0.8)	30 (24.6)	87 (71.3)
The vocabulary and terminology were used appropriately, n (%)	1 (0.8)	1 (0.8)	3 (2.5)	36 (29.5)	81 (66.4)
The course covered congenital heart defects in sufficient depth to meet the learning objectives, n (%)	1 (0.8)	2 (1.6)	7 (5.7)	2 (1.6)	100 (82.0)
The course was free from technical problems, n (%)	4 (3.3)	11 (9.0)	1 (0.8)	39 (32.0)	67 (54.9)
Media use					
The text and images included had a strong connection to the learning objectives, n (%)	1 (0.8)	1 (0.8)	1 (0.8)	23 (18.9)	96 (78.7)
Graphics and multimedia were used appropriately to assist in highlighting and learning critical concepts rather than merely entertaining or distracting me, n (%)	1 (0.8)	3 (2.5)	8 (6.6)	34 (27.9)	76 (62.3)
Learning strategy design					
It was clear to me what was to be accomplished and what I would gain from using the course, n (%)	2 (1.6)	0 (0)	1 (0.8)	25 (20.5)	94 (77.0)
Self-assessment					
Learning checks and other assessments adequately measured my accomplishment of the learning objectives, n (%)	1 (0.8)	0 (0)	0 (0)	28 (23.0)	93 (76.2)
Learning and supports					
The course offered tools (resources, FAQs, glossary, and so on) that supported my learning, n (%)	1 (0.8)	4 (3.3)	18 (14.8)	45 (36.9)	53 (43.4)

Content and Resources

Experiences With Content and Resources

In terms of experiences with content and resources (Table 2), 95.9% (117/122) of the students reported that concepts were illustrated with concrete, specific examples; 95.9% (117/122) reported that the vocabulary and terminology were used appropriately, 91.8% (112/122) indicated that the course covered congenital heart defects in sufficient breadth and depth to meet the learning objectives, and 86.9% (106/122) completed the course with minimal technical problems.

e-Learning Courses Offer a Permanent Resource to Support Learning

We also asked questions about students' experiences with the content and resources in the usability survey. Students mentioned that the course offered a permanent resource that supported their learning.

The e-learning course offered students a positive learning environment by offering resources and tools that were easily accessible. Students commented that the e-learning package "really helped to solidify the material." However, providing students with a PDF export or key concept summaries to accompany modules may improve the note taking experience. Several students commented:

> *I would suggest creating some supplemental content by compiling images and notes from these modules into a PDF/PowerPoint slide so students have condensed take home messages to download and refer back to.*
>
> *A final summary page would be nice of all the CHD and their key clinical presentations.*

Technical Difficulties Can Create Inequities in Learning Experiences

Although most students did not describe having technical difficulties, we found the students who reported technical issues had difficulties interacting with the 3D virtual models, which prevented them from using them as instructed:

> *Myself and a few others in my class could not get the interactive models to load. Of the people who did get it to work, they reported it being slow and hard to use.*

Our assessment included measuring some requirements for viewing the models, but we were not able to assess all the system requirements. Hardware, internet connections, graphics cards, and web browsers that do not meet the minimum requirements can impact experience and often explain why models are reported to be *slow*. The sample size for students using OS systems that did not meet the minimum requirements was small

(1/141, 0.7%) and would not be large enough to detect differences in our analysis. This 1 student reported having significant technical difficulties.

Media Use

Experiences With Media Use

In terms of experiences with media use (Table 2), 97.5% (119/122) of students reported that the text and images included had a strong connection to the learning objectives, and 90.2% (110/122) reported that the graphics and multimedia were appropriately used to assist in highlighting and learning critical concepts rather than merely entertaining or distracting them.

Text and Images Improve Learning When There Is a Strong Connection to the Learning Objective

The course used images and text to highlight the key learning objectives of the course. The use of multiple types of media to convey concepts enhanced education quality. In addition, the use of patient-specific models increased value by offering real clinical examples. A student commented that they:

> *Very much liked how the blood flow was highlighted [in the blood flow animations], so that it was easy to understand what we would see clinically.*

However, we did not duplicate all material across different modes of delivery (eg, text and videos), and some students mentioned that they missed this content. Providing video transcripts may help to alleviate this issue. A student commented as follows:

> *I also felt like some of the questions asked things that weren't necessarily covered in the specimen videos. Overall, the specimen videos felt out of place at times compared to the text.*

Graphics, Videos, and Multimedia Can Be Used to Highlight Learning Critical Concepts

The incorporation of graphics, videos, and 3D models offered students an interactive experience that allowed them to develop an understanding of the learning objectives through different ways of learning. In addition, the different modes of showcasing CHDs allowed the students to understand the concepts in different situations. Students commented as follows:

> *The videos of the real neonatal hearts were extremely helpful and well done, with a great level of detail.*

> *The illustrations and videos were really helpful, especially for visualizing blood flow and the different procedures.*

> *The interactive-ness and organization of the module is more effective way of learning.*

In fact, students were seeking more diversity in all learning scenarios. A student commented as follows:

> *Would be nice to have static graphics showing blood flow in addition to animations.*

However, the 3D virtual models that offered the students a more interactive form of learning were perceived by some students as more difficult to use. The interactive models focus on higher-order thinking skills, such as the ability to break the cardiac components down into their constituent parts to determine the relationship of the parts. These types of learning situations may require more support for new (first-year undergraduate) anatomy learners. The comment below highlights the sentiments offered by many students:

> *In the embedded models, it was difficult to see the defect discussed.*

Interactive models for new learners could be improved by the addition of anatomical notations.

Learning Strategy Design

Experiences With the Learning Strategy Design

In terms of experiences with the learning strategy design (Table 2), 97.5% (119/122) of the students reported that it was clear to them what would be accomplished and what they would gain from using the course.

Learning Requirements Were Packaged for Learning Success

Students reported that the learning objectives within the course were clear:

> *I know what I'm supposed to be learning from this.*

> *This course was easy to follow.*

Furthermore, students found that the packaging of the content in small modules for flexible learning provided a suitable progression. Several students commented as follows:

> *I really enjoy going through things on my own when they are organized like this module.*

> *[The course] provided us with lots of info but at the same time it was not overwhelming.*

Another student said the following:

> *[I] learned a lot in a short amount of time, much more than having a 2-hour lecture on congenital heart disease.*

Self-assessment

Experiences With the e-Learning Self-assessment

In terms of experiences with the e-learning self-assessment (Table 2), 99.2% (121/122) of the students indicated that the learning checks and other assessments adequately measured their accomplishment of the learning objectives.

Learning Checks Help to Measure Accomplishment of e-Learning Objectives

Our qualitative results suggested that the learning checks and other assessments adequately measured student accomplishment of the learning objectives. Students expressed appreciation for the learning checks, which allowed them to measure their learnings from the course. A student mentioned the following:

> *The knowledge checks really helped cement the material and know when I had to go back to review a concept.*

However, students requested a larger question bank that offered greater diversification, so they could further test their understanding. Students wrote as follows:

> *I liked the integrated assessments, but it would be beneficial if there was a little more variety in questions.*

Learning and Supports

Experiences With Learning and Supports

In terms of experiences with the learning and supports (Table 2), 81.1% (98/121) of the students indicated that the course offered tools that supported their learning.

The Segmental Approach and Congenital Heart Defects Can Be Taught on the Web

The multimodal components of the e-learning course were positively perceived by students for learning the segmental approach and congenital heart defects. The variety of videos, animations, text, images, and 3D modeling provided students with examples to solidify the concepts. Students commented as follows:

> *The animations of blood flow in a normal heart vs abnormal heart for each condition were very helpful when understanding blood flow (especially when color-coded to indicate where blood was mixing).*

> *I really enjoyed the videos that helped me visualize the defects and the explanations that went along with it, walking me through the anatomy.*

Furthermore, students preferred the course over traditional laboratories and lectures. Students reported as follows:

> *I learned so much more here than in traditional lectures. I hope we will have more of these learning modules in the future.*

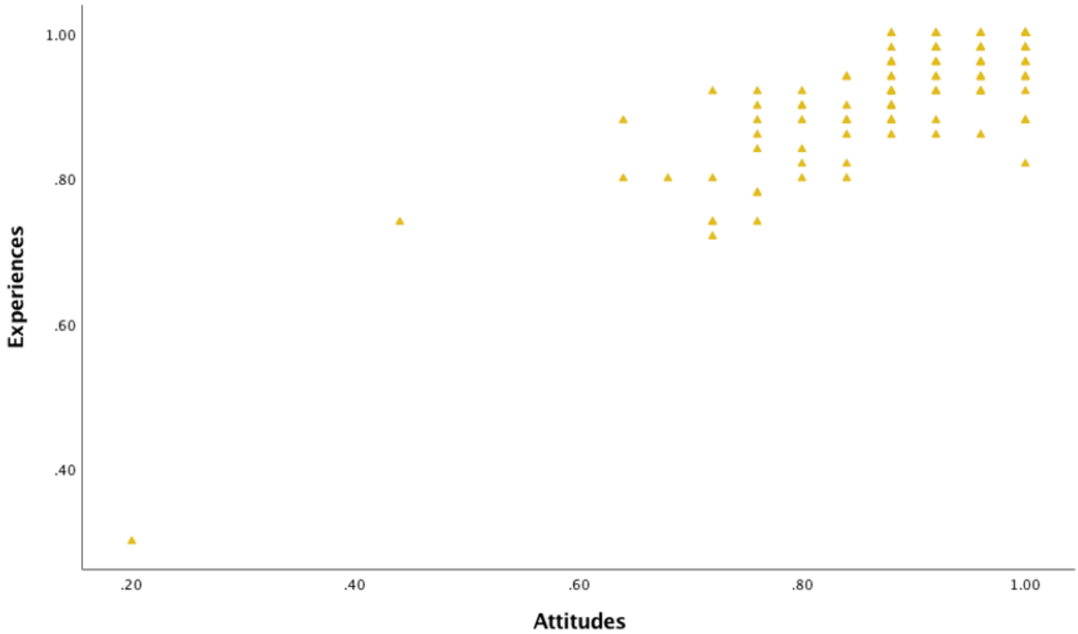
> *This module was more helpful than either of the lectures we have had so far on congenital heart defects.*

> *I much prefer this method of learning via modules with graphical depictions, videos, and quizzes for our laboratory courses.*

Relationship Between Attitudes, Experiences, and Test Scores

To test for relationships between the students' attitudes, experiences, and test scores, composite variables for attitudes and experiences were calculated and compared with the change in test scores. There was a strong correlation between attitudes and experiences, which was statistically significant (r_s=0.687; *P*<.001; n=122; Figure 5). No relationships were found between change in test scores and attitudes (*P*=.71) or experiences (*P*=.47).

Figure 5. The relationship between student attitudes and experiences. There was a strong correlation, which was statistically significant (r_s=0.687; *P*<.001; N=122).



Browser Metadata

Students used a variety of internet browsers, operating systems, and screen resolutions to access the course.

Internet Browser

Students most frequently completed the e-learning course with Chrome (Google: 109/141, 77.3%). Other browsers used to access the e-learning materials included Safari (Apple Inc: 17/141, 12.1%), Firefox (The Mozilla Foundation: 8/141, 5.7%), Edge (Microsoft: 5/141, 3.5%), and Chrome iPad (Apple Inc: 2/141, 1.4%).

Operating System

Students most frequently used Apple macOS (Apple Inc: 86/141, 61%) and Windows 10 (Microsoft: 52/141, 36.9%). Other operating systems used by students included iPads (Apple Inc: 2/141, 1.4%) and Windows 7 (Microsoft: 1/141, 0.7%).

Screen Resolution

Screen resolution of student devices ranged significantly. Ultrahigh-definition screens were considered above 1920×1080p, high-definition screens were considered between 1920×1080p and 1280×720p, and 720p was considered between 1280×720p to 852×576p. Most students had devices with high-definition screens (117/141, 83%), followed by ultrahigh definition (17/141, 12%), and 720*P* (7/141, 5%).

Discussion

Principal Findings

This study demonstrated that it may be possible to increase knowledge acquisition and positively impact student experiences and attitudes with multimodal e-learning courses when cadaveric specimens are rare, sparse, or otherwise impractical. This novel course followed successful implementation across 5 parameters: developing content with experts, storing and managing content in Rise Articulate, packaging multimodal content, offering student support through asynchronous e-learning, and confirming learning outcomes with assessments [18,26].

Our study responds to calls to support anatomy education using multimodal virtual approaches amid the COVID-19 pandemic [3,17,27,28]. The best methods for teaching anatomy are highly debated [2,15,29] because despite the availability of numerous teaching methods, students still report having insufficient anatomical knowledge [8]. Furthermore, the learning styles and associated learning needs of undergraduate medical students vary [30]. The variety of content and resources we presented were positively received by students, who reported that the concepts were illustrated with concrete, specific examples; that the vocabulary and terminology were used appropriately; and that the course covered congenital heart defects in sufficient breadth and depth to meet the learning objectives.

Multimodal e-Learning and Knowledge Acquisition

Content and resources available within the course surrounded the study of 6 CHD pathologies across a spectrum of disease severity: atrial septal defects, tetralogy of Fallot, transposition of the great arteries, coarctation of the aorta, truncus arteriosus, and hypoplastic left-heart syndrome. A *normal* heart was also represented for comparison. Despite the range in complexity for each cardiac defect, knowledge acquisition was uniformly high across defects. In addition, students reported positive attitudes toward the course. This finding supports other investigations that have found digital anatomy courses to be a useful adjunct to teaching at the undergraduate level across a spectrum of disease severity [9].

In this study, the low learning outcomes before the course (pretest scores) followed by the uniformly high learning outcomes after using the e-learning course (posttest scores) suggest that a multimodal approach to addressing different ways of learning was effective in teaching first-year undergraduate students about varying degrees of CHD. Furthermore, students thought that the learning checks adequately measured their accomplishment of the learning objectives. These findings are consistent with other investigators who have found 3D visualization tools to be an effective method, particularly as adjuncts for improving learning outcomes compared with other methods of teaching anatomy [10-13,31]. Future implementations may want to consider the sequence of asynchronous implementation, as completion of e-learning before live sessions could yield better discussions. The approach would also benefit from studying how multimodal e-learning tools perform as an adjunct compared with cadaveric laboratories, especially in supporting longer-term learning throughout medical school and residency.

Experiences and Attitudes With Multimodal e-Learning Materials

Our course translated high-resolution medical images into various novel learning tools (3D printed models and interactive virtual models) that were supplemented with simple materials (illustrations, animations, text, and teaching videos). Virtual learning environments that are low cost, offer self-assessments, are easy to use, align with the curriculum, have good graphics, and use simple material (such as plastic models and illustrations) are most sought by medical students [32,33]. Students in this study reported positive experiences with the multimedia; this suggests that some students may even prefer these modes of delivery. These findings support other investigators who have found that e-learning can improve access to learning materials, and that students are often highly satisfied with them [10-13,17,34,35].

Even though the course integrated many types of media that can have barriers during implementation [19], most students in this study reported that the end product had minimal technical problems and that the course offered tools that supported their learning. This is likely a factor of students using appropriate browsers, screen resolutions, and devices that supported the technical requirements of the course. We found that 1 student used hardware that did not meet the minimum requirements of the interactive virtual models and had resulting technical difficulties. For the other small percentage of students who reported technical difficulties, it was not clear from the results whether this was a factor related to access to the minimum hardware requirements or students not reading the technical requirements of the course. These issues should be closely monitored during implementation to ensure students have equitable learning experiences.

This study does highlight a concern associated with engaging students on the web, which is documented elsewhere [19]. Most students in this course indicated that they felt neutral about the course stimulating further inquiry with mentors or other students. An absence of social interaction between e-learners and instructors may emphasize a sense of disconnect in comparison with the traditional face-to-face learning environment [19]; it is hypothesized that this was also exacerbated by the COVID-19 pandemic. Recent editorials have expressed concerns about the transition to home-based learning and the struggle with establishing boundaries between work and home, which could affect faculty, students, and support staff [36].

Development of Multimodal e-Learning Materials

The development of this course involved an interprofessional team that included several professionals and students who learned from and about each other to improve collaboration and the quality of the product. Previous research shows that interprofessional teams can reduce the risk of duplication and fragmentation and reduce costs associated with delivery [37-39]. We echo other investigators who suggest that interprofessional teams involving students bring an important and unique experience to course development [39,40]. We included residents and medical students during this e-learning course development because as the end users, students have a deep understanding of what they need to feel prepared for the workplace. However, we did experience some challenges associated with the number and composition of stakeholders, their different goals, interests, mental models, and agreement on the outcomes and structure of the course. These challenges have been previously reported by other teams working in interprofessional teams [39]. We echo other investigators in their sentiments around expecting a lot of work, accepting resistance, and communicating and listening frequently when engaging in interprofessional product development [40].

Limitations

This study describes a group studied over a single point in time after the e-learning course was introduced during the COVID-19 pandemic. Changes in learning outcomes and attitudes and experiences are presumed to be the result of the e-learning course, but no control or treatment group was used. As such, it is not possible to dismiss other hypotheses or explanations for improved knowledge and positive attitudes and experiences. In addition, the longer-term retention of the acquired knowledge is unknown.

This study is also subject to several biases. The study is subject to information and selection bias, as we recruited participants through a first-year undergraduate medical course and offered a draw for a gift card. Motivation and reported outcomes related to using the course could have been impacted by these extrinsic motivations (eg, the draw). In addition, this study is subject to response bias because learners answered questions before the course, engaged in the e-learning modules, and then answered the same questions again after finishing the course.

Conclusions

Access to alternative and adjunct options to cadaveric learning is beneficial and offers potential solutions to accessibility, economic, and ethical limitations to the current standard. Students may improve their understanding of medical materials, have a greater overall learning experience, and have greater motivation to learn the course contents. Future studies should assess long-term knowledge retention, compare multimodal e-learning to cadaveric laboratories, and include ways for interacting with other learners and mentors to reduce isolation.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Pre- and posttest questions administered to first-year medical students to assess learning outcomes.

[DOCX File , 22 KB - mededu_v7i4e30533_app1.docx]

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Abbreviations

CHD: congenital heart disease

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Original Paper

Critical Evaluation of the Efficiency of Colorectal Fellowship Websites: Cross-sectional Study

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Abstract

Background: Websites are an important source of information for fellowship applicants, as they can influence ongoing interest and potential program selection.

Objective: This study aims to evaluate the current state of colorectal fellowship websites.

Methods: This cross-sectional study evaluates the quantity and quality of information available on websites of colorectal fellowship programs verified by the Accreditation Council for Graduate Medical Education in 2019.

Results: A total of 63 colorectal fellowships were included for evaluation. Websites were surveyed for content items that previous studies have found to be influential to program applicants. The 58 (91%) programs with a functional website were evaluated using an information index (calculated as a function of availability of content items concerning education, application, personnel, and benefits) and an interactive index (calculated as a function of accessibility and usability of the webpage). Programs had a median total score of 27.8 (IQR 21.5-34.5) of 79. The median score for the interactive index was 7.5 of 15 and for the information index was 20 of 64. The median scores for website application, education, personnel, and benefits or life considerations were 5, 5.5, 3.3, and 4 of 13, 24, 13, and 14, respectively. There was no difference in total score between programs in different geographical regions (*P*=.46).

Conclusions: Currently, colorectal surgery fellowship program websites do not provide enough content for applicants to make informed decisions. All training programs, regardless of specialty, should evaluate and improve their digital footprint to ensure their websites are accessible and provide the information desired by applicants.

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KEYWORDS

recruitment; GME; social media; websites; content; accessibility; online information; fellowship information; colorectal; graduate education; graduate medical education

Introduction

Residency and fellowship training program websites often serve as a first impression and vital source of information for applicants. It is a resource for training programs to attract highly competitive applicants and for applicants to identify best fit programs.

As early as 1998, program websites were found to influence nearly three-quarters of emergency medicine applicants [1,2]. In 2011, a study on anesthesia applicants found that 98% of applicants visited program websites during their residency application process. Program websites have been found to influence where applicants apply and decide to interview; how applicants prepare for interviews; and, ultimately, the formulation of rank lists [2-5]. Thus, a functional and informative website is a necessary promotional tool for graduate medical education (GME) programs to attract interested applicants. However, evaluation of selected specialties including vascular surgery, general surgery, orthopedic spine surgery, and radiology have found training websites to be lacking in quality, content, and design [6-11].

Colorectal surgery is a popular field. The number of applicants to colorectal surgery fellowship programs increases with each passing year. The application and recruitment process is time-consuming and costly for both programs and applicants. Well-maintained program websites can facilitate this process for both parties, enabling programs and applicants in finding their best match. Colorectal training websites, however, have not been previously evaluated.

The aim of this study is to evaluate the accessibility, content, and design of colorectal fellowship websites.

Methods

A cross-sectional review of Accreditation Council for Graduate Medical Education (ACGME)–approved colorectal fellowship program websites was conducted using a validated assessment tool with two single-blinded reviewers [7].

Setting and Participants

A list of colorectal fellowship training programs within the United States was obtained from the ACGME program list in September 2019 [12]. The ACGME website was used to access program websites via the link provided. If no link was provided on the ACGME page or the link was nonfunctional, the program website was reached via Google search with “program name + colorectal fellowship” as the search parameters. Websites were accessed from a US internet service provider between October 3 and November 27, 2019.

Outcome Measured

Each program website was evaluated by two independent reviewers who were blinded to the other’s scores. A validated website assessment tool was used, including an interactive index and an information index [7]. The interactive index encompassed accessibility, design, organization, and user-friendliness. Accessibility was graded out of 3 points: 1 point for having a link on the ACGME website, 1 point if the link provided was functional, and 1 point if the link led directly to the colorectal fellowship webpage. Design, organization, and user-friendliness were graded on a 4-point scale: 1, poor; 2, acceptable; 3, good; and 4, excellent. An information index was created to quantify 64 content items known to be valued by applicants. Content was evaluated in the categories of application (13 items), education (24 items), personnel (13 items), and benefits (14 items; see Multimedia Appendix 1 for definitions of each content item). Each content item was weighted equally. If a content item was found on the main webpage of the fellowship program or through a direct link on the main webpage, it was awarded 1 point. If the information was incomplete (eg, different types of conferences were listed but frequency—day of the week, every week or once a month, etc—was not included) or found through a separate website (eg, benefits and salaries listed on the GME site or faculty profiles listed on the departmental site), it was awarded 0.5 points. When reporting the percentage of websites containing a specific information, websites that scored 0.5 or 1 were both considered as having the information. If the information was unavailable, it was awarded 0 points. Overall, websites could receive 15 points for the interactive index and 64 points for the information index, for a maximum total score of 79 points.

Rater Training and Performance

Reviewers were given detailed definitions of each scoring criteria and trained using a sample of 10 general surgery residency websites of various quality. Interrater correlation coefficient for total score was 0.94 (95% CI 0.91-0.97). Rater agreement was 81% and weighted Kappa was 0.74. If there was disagreement between two reviewers regarding accessibility or content items in the information index, it was reviewed, and consensus was reached. For design, organization, and user-friendliness, the average score of two raters was used as the final score.

Analysis of the Outcomes

Continuous variables were reported as median (IQR) values. Categorical variables were reported as count (percentage) values. An analysis of programs based on four main geographic locations, as defined by the United States Census Bureau (Northeast, South, Midwest, and West), was performed using a Kruskal-Wallis test for continuous variables and chi-square for categorical variables. Association between two continuous variables was assessed by Kendall correlation coefficient. Statistical analysis was performed in RStudio version 1.2.5001 (RStudio, Inc).

Institutional Review Board and Ethics Statement

All data reviewed was open to the public, and there was no contact with fellowship staff; thus, no institutional review board review, ethics approval, or informed consent was necessary.

Results

Overall Performance

There was a total of 63 ACGME-accredited colorectal fellowship programs in the United States. Of 63 programs, 5 (9%) did not have a functional website (in spite of being established prior to 2012) and thus were excluded from analysis. Of the 58 programs with a functional website, the median total score was 27.8 (IQR 21.5-34.5) of 79. When stratified by geographic location, there were 21 programs in the Northeast, 18 in the Midwest, 17 in the South, and 7 in the West. There was no significant difference in the total score of programs in different geographic regions within the United States (P=.46). There was no correlation between age of the program and total score (P=.38). No program had a Facebook profile or Instagram account to promote their fellowship.

Interactive Index

Programs scored a median of 7.5 (IQR 6.0-10.0) of 15.0 for the interactive index, including design (median 2.0, IQR 1.5-2.5 of 4), organization (median 2.0, IQR 1.0-2.5 of 4), user-friendliness (median 2.0, IQR 1.0-2.5 of 4) and accessibility (median 2.0, IQR 2.0-2.0 of 3.0). For accessibility, the ACGME website provided a website link for 53 of 58 (91%) programs. Of those 53 programs with links, only 85% (n=45) of those links were functional, and only 31% (n=14) of the functional links led directly to the colorectal fellowship webpage; the remaining functional links led to a general departmental page.

Information Index

Programs scored a median of 20.0 (IQR 14.1-24.5) of 64 possible points for the information index content items. When further broken down, the median score (IQR) was 5.0 (4.0-6.5) of 13.0 for application information, 5.5 (3.1-9.0) of 24.0 for education information, 3.3 (2.5-5.0) of 13.0 for personnel information, and 4.0 (1.6-6.8) of 14.0 for benefits information. Over one-third (20/58) of programs received less than 16 points, while only 2 (3.4%) programs received 32 points or more for the presence of the information index content items.

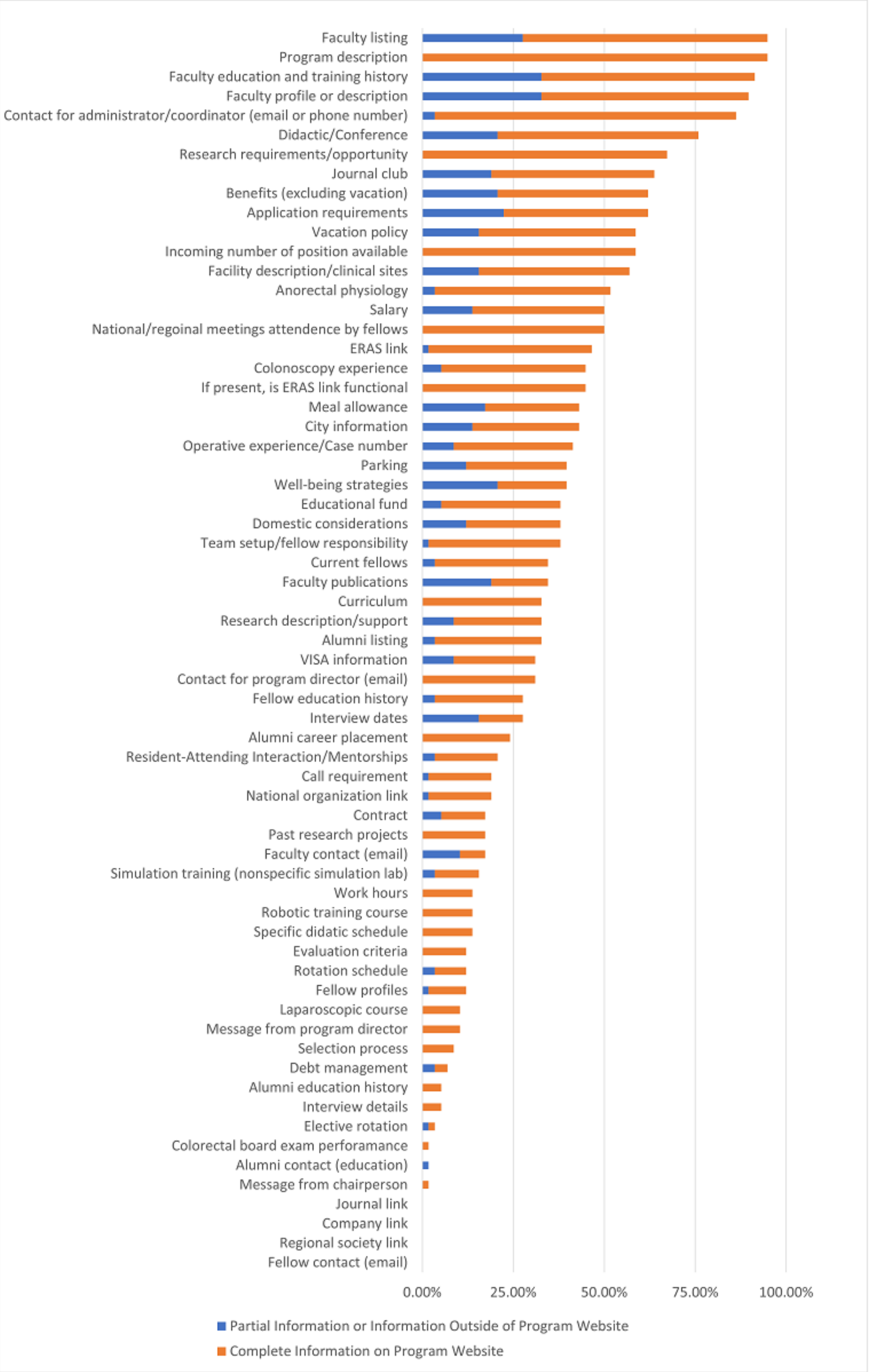
Only 59% (34/58) of the functional fellowship websites disclosed the number of fellowship positions available (Figure 1). Although 86% (50/58) of programs provided contact information for program administrative staff, only 31% (18/58) provided contact information for the program director. Most programs (50/58, 86%) identified their program director. A total 40% (23/58) of programs presented detailed fellowship application requirements and a list of documents required for a complete application, while 22% (13/58) offered only general eligibility criteria. Few programs provided detailed information on applicant selection criteria or interview information.

Most of the 58 colorectal fellowship websites provided faculty listings (n=55, 95%), information on the education of their faculty (n=53, 91%), and dedicated faculty profiles (n=52, 90%). However, 28% (n=16) of faculty listings and 33% (n=19) of faculty profiles were on the general departmental website without a direct link from the specific fellowship website. Only 34% (n=20) of websites listed the current fellows and 33% (n=19) listed information on their alumni. Contact information for faculty (n=10, 17%), fellows (n=0, 0%), and alumni (n=1, 2%) was rarely reported publicly on the websites.

Most (n=44, 76%) of the 58 programs provided a list of conferences and didactic education, with 55% (n=32) of programs reporting frequency of these conferences. Journal club was mentioned by 64% (n=37) of programs. Although research requirements or opportunities were listed for 67% (n=39) of the programs, a description of the research or potential research support resources were only available for 33% (n=19) of the programs; past research projects were listed on 17% (n=10) of the sites. Only 33% (n=19) of programs provided operative caseload of the fellows, while an additional 9% (n=5) listed examples of operations without case volume. Colonoscopy volume or time allocated to endoscopy was provided by 45% (n=26) of the program websites and anorectal physiology was mentioned by 52% (n=30) of the programs. Half of the programs had information regarding expectations on national or regional meeting attendance by fellows. Only 1 (2%) program provided any information regarding the colorectal board performance of prior fellows.

Most (n=48, 83%) of the 58 websites provided some information regarding employment benefits or practice location lifestyle. Benefits (n=36, 62%), vacation policy (n=34, 59%), and salary (n=29, 50%) were the three most common benefit or lifestyle content items provided by programs. Debt management (n=4, 7%), work hours (n=8, 14%), and a sample contract (n=10, 17%) were the three least common benefit or lifestyle content items reported by programs. About one-third of the websites that provided benefit or lifestyle information had to be found on the associated GME page via search.

Figure 1. Program website content items across 58 colorectal programs. ERAS: Electronic Residency Application Service.



Discussion

Principal Results

Colorectal fellowship programs have lagged in embracing program websites as a recruitment tool despite the ubiquitous use of program websites throughout the application process [3,4]. A total 9% (5/63) of programs did not have a functional program website. Programs that had a functional website frequently were difficult to access, not user-friendly, and lacked applicant valued content.

Limitations

This study has several limitations. This is a cross-sectional study. It is possible that program websites were altered after data collection. However, data was collected from September to November 2019. This period of time encompasses the fellowship application season and should reflect what applicants were able to access in the 2019 application cycle. Additionally, no survey of colorectal fellowship applicants was performed to identify what that particular pool of applicants finds important on program websites. This information was inferred from the literature where studies have been performed for other specialties. However, each applicant likely has their own perception on what information is considered valuable. Thus, it would benefit both the programs and applicants for these websites to be as comprehensive as possible. Information was evaluated as being either present or absent, but it could not be verified if the information was current and accurate. Lastly, we were not able to evaluate changes in program websites over a period of time, as this was a cross-sectional study performed in 2019.

Comparison With Prior Work

In this study, it was unexpectedly found that 5 of 63 (9%) colorectal fellowship programs did not have an accessible website. In the current era, all programs should have a functional website. Studies from other specialties have revealed an absence of program websites for less than 1% of radiology programs to as high as 30% of pediatric orthopedic surgery programs [3,8-11,13,14]. Fellowship programs, as compared to residency programs, tend to have a greater percentage of websites that are not regularly maintained. Silvestre et al [8] postulated that a subspecialty within a specialized field may be a smaller community where word of mouth and reputation play a bigger role than online presence. Studies as early as 1999, however, have shown that 1 out of 7 applicants would rank programs without a website lower than those with a website [1]. Programs without websites risk losing highly competent applicants. Additionally, Instagram and Facebook are great avenues for both education [15] and fellowship program promotion; however, this is not used by any colorectal fellowship program.

Program websites should not merely exist but should be easily accessible and user-friendly. One-fifth of the links provided on the ACGME webpage were not functional, and only a quarter led directly to the fellowship website. Programs should check and update links on the ACGME website and other major program listing sites on an annual basis. Additionally, applicants value ease of navigation more than the presence of individual content items [4]. In this study, many websites were disorganized and lacked links to allow easy navigation between content domains such as the GME webpage and colorectal department webpage. Program websites ought to provide direct links to the desired content and design an interface that is easy to interact with, allowing users to find information quickly [6].

Only a quarter of the content items we evaluated were presented by half or more programs. Information regarding application process; current faculty, residents, or alumni; and training information are highly valued by applicants [2,3,5]. Interview dates and details are incredibly important for fellowship applicants, as senior residents must balance time spent interviewing with a heavy clinical workload, but was only provided by 5% (29/58) of the programs. Surprisingly, 14% (8/58) of colorectal programs, double that reported by plastic surgery, did not list contact information for administrative staff, denying the possibility of reaching out when applicants have questions [9]. Personal profiles of current faculty and fellows can help applicants gauge their self-perceived fit with a program, influencing where they choose to apply and interview. However, this information is frequently missing on colorectal program websites. Even though information regarding education and training is the most important content for applicants, the program with the most information about education and training reported less than half of the content items evaluated in our study. Lastly, quality of life is an important driver in career choice and may be viewed as a *sensitive topic* not discussed during an interview [7,10,16]. Thus, it is important for program websites to provide such information.

Although this analysis is limited to colorectal fellowships, it serves as an alarm that current training program websites are not meeting the needs of applicants. Although the program websites of some specialties have been reviewed and showed similar deficiency in quality, there exists a gap in many specialties where program websites have not been reviewed. Thus, all training programs, regardless of specialties, should maintain a program website that is updated before each application cycle. Direct links to the program website should be updated on all major listings such as the ACGME program list, FRIEDA, or the Electronic Residency Application Service. Information available on the departmental webpage or GME webpage should be connected to the fellowship program website via a direct link. Programs should optimize the design, organization, and usability of their websites by grouping information (when appropriate), using hyperlinks to lead applicants to the departmental webpage or GME webpage, and separating content in a way that maintains easy navigation between pages. Future studies that survey applicants of different specialties or subspecialties on their specific needs will further clarify the important content to include that may be unique to each specialty. Guidelines from GME or professional societies would also provide guidance for individual programs in the development of a high-quality program website.

Conclusions

This study found the overall quality of colorectal fellowship program websites to be poor. Colorectal fellowship programs need to increase the amount of information available and improve the usability of their websites. Absent or poorly designed fellowship websites can negatively impact the application and recruitment process for both applicants and fellowship programs, as both seek to find the best fit for the program.

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Authors' Contributions

QY, KJ, HEDC, AL, WBP, and MGD were responsible for study planning. QY, KJ, AF, and CG were responsible for data collection. QY was responsible for statistical analysis. All authors were responsible for data interpretation. QY was responsible for drafting the manuscript, and all authors were responsible for critical revision of the manuscript and overall content.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Definition and scoring criteria for information index.
[PDF File (Adobe PDF File), 115 KB - mededu_v7i4e30736_app1.pdf]

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Abbreviations

ACGME: Accreditation Council for Graduate Medical Education

GME: graduate medical education

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Original Paper

Effect of Electronic Device Addiction on Sleep Quality and Academic Performance Among Health Care Students: Cross-sectional Study

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Abstract

Background: Sleep quality ensures better physical and psychological well-being. It is regulated through endogenous hemostatic, neurogenic, and circadian processes. Nonetheless, environmental and behavioral factors also play a role in sleep hygiene. Electronic device use is increasing rapidly and has been linked to many adverse effects, raising public health concerns.

Objective: This study aimed to investigate the impact of electronic device addiction on sleep quality and academic performance among health care students in Saudi Arabia.

Methods: A descriptive cross-sectional study was conducted from June to December 2019 at 3 universities in Jeddah. Of the 1000 students contacted, 608 students from 5 health sciences disciplines completed the questionnaires. The following outcome measures were used: Smartphone Addiction Scale for Adolescents–short version (SAS-SV), Pittsburgh Sleep Quality Index (PSQI), and grade point average (GPA).

Results: The median age of participants was 21 years, with 71.9% (437/608) being female. Almost all of the cohort used smartphones, and 75.0% (456/608) of them always use them at bedtime. Half of the students (53%) have poor sleep quality, while 32% are addicted to smartphone use. Using multivariable logistic regression, addiction to smartphones (SAS-SV score >31 males and >33 females) was significantly associated with poor sleep quality (PSQI >5) with an odds ratio of 1.8 (1.2-2.7). In addition, male gender and older students (age ≥21 years) were significantly associated with lower GPA (<4.5), with an odds ratio of 1.6 (1.1-2.3) and 2.3 (1.5-3.6), respectively; however, addiction to smartphones and poor sleep quality were not significantly associated with a lower GPA.

Conclusions: Electronic device addiction is associated with increased risk for poor sleep quality; however, electronic device addiction and poor sleep quality are not associated with increased risk for a lower GPA.

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KEYWORDS

electronic devices; addiction; sleep quality; grade point average; academic performance; health care students; medical education; sleep; student performance; screen time; well-being

Introduction

Electronic devices such as smartphones, laptops, tablets, personal computers, and televisions have become essential parts of people's lives due to their easy accessibility and the benefits they offer in facilitating activities of daily living. However, electronic devices can have a detrimental effect on an individual's health, work, or academic performance if not used in moderation. Serious effects on individual physical and psychological health have been reported with electronic device overuse, such as headache, visual disturbances, chronic neck and back pain, stress, anxiety, and sleep disruption [1-5].

Sleep is a naturally occurring essential process characterized by altered level of consciousness and decreased bodily movement and responsiveness to external stimuli. Sleep is necessary physiologically to restore and maintain physical health and cognitive performance [6-8]. Several factors have been shown to alter sleep and its regulatory processes, including endogenous hemostatic, neurogenic, and circadian processes together with exogenous environmental and behavioral factors [9]. Sleep hygiene and behavioral factors play an essential role in sleep control processes and alter other sleep regulatory mechanisms. Behavioral factors such as drinking coffee, walking around, or talking to someone result in a delay of the sleep process and affect sleep quantity and quality [10]. Poor sleep quality secondary to behavioral factors has been linked to poor or suboptimal academic performance among undergraduate students [11,12].

Electronic devices cause an alteration in sleep architecture, including delayed sleep onset latency and circadian process and decreased rapid eye movement sleep and sleep duration, which are affected by the brightness of screen display in computer and video games when used just before bedtime [13,14]. The bright light exposure from electronic devices at bedtime increases psychophysiological arousals and delays circadian rhythm with other possible neuropsychiatric effects such as depression, anxiety, and night alertness [1-3,15,16].

The negative impact of electronic device use on sleep has been primarily attributed to late-bedtime or longer hours of its use. In 2012, a cross-sectional study found that almost all participants in Norway use electronic devices within 1 hour before sleep [2]. The relationship between mobile phone overuse and disturbances in sleep habits was reported, and the study showed that 61% of adolescents were using mobile phones for 5 hours or more before bedtimes after midnight, and two-thirds of the participants slept less than 6 hours per day [3]. Furthermore, short sleep duration, delayed sleep onset latency, and insomnia were prevalent in adolescents, warranting a public health concern [9]. This link between nocturnal use of electronic devices and sleep insufficiency among adolescents and university students was present in different studies, and the overall use of mobile phones for 5 hours per day was associated with shorter sleep duration and insomnia [1,3,17,18].

Smartphones and other electronic device use have been increasing in recent years among young adults and have become an attribute altering sleep quality and mental health and may affect student academic performance. Therefore, we aimed to study the effect of electronic device addiction on sleep quality and academic performance among health care students at different public universities in Saudi Arabia.

Methods

Study Settings

After obtaining approval from the university institutional review boards, the research was conducted at 3 universities in Jeddah: King Saud bin Abdulaziz University for Health Sciences, King Abdulaziz University, and Jeddah University. The study was conducted from June to December 2019. Study participants were the undergraduate health care students at the universities. Students in their internship year were excluded.

Study Design

This is a cross-sectional study where undergraduate students of health care sciences were invited to participate in completing a self-administrated questionnaire about the effect of electronic devices on their sleep quality and academic performance.

Sample Size

Assuming that the prevalence of poor sleep is between 40% to 60% and the margin of error between 6% to 10%, the estimated sample size is approximately 600. Sample size calculation was done using PASS 2020 (NCSS LLC) software [19,20].

Data Collection Methods

The data were collected through an online self-administered questionnaire (Multimedia Appendix 1) comprising 5 major sections. The first section addressed sociodemographic data, including gender, age, and educational discipline. The second section pertained to the type and pattern of electronic device use before bedtime. The grade point average (GPA) used to reflect student academic achievement performance was in the third section. The outcome measures used have good validity and reliability. To measure addiction rate, the Smartphone Addiction Scale for Adolescents–short version (SAS-SV) was used [4]. The scale comprises 5 components: daily life disturbance, withdrawal, cyberspace-oriented relationship, overuse, and tolerance. The cutoff value for males was 31 and females was 33. The values were chosen based on the Haug et al [4] study, with an area under the curve of 0.963 (0.888 to 1.000), sensitivity of 0.875, and specificity of 0.886 for males. For females, the area under the curve was 0.947 (0.887 to 1.000), sensitivity was 0.875, and specificity was 0.886. The Pittsburgh Sleep Quality Index (PSQI) was used to evaluate sleep quality [21]. The PSQI uses 7 areas of measures to differentiate between poor- and good-quality sleepers: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction over the past month. The PSQI score ranges between 0 to 21, where the higher score represents poorer sleep quality. A total PSQI score of 5 or more indicates poor sleep quality. The invited participants were informed about the study purpose and their voluntary enrollment. Participant information confidentiality was assured.

Data Analysis

P<.05 was considered significant, with a confidence interval of 95%. The collected data were analyzed and managed in SPSS (version 24.0, IBM Corp).

Results

Response Rate

An electronic survey was distributed to 1000 students, and 61.80% (608/1000) of participants responded to the questionnaire. There are no missing data regarding the SAS-SV, 8.22% (50/608) of participating students did not enter their GPA, and 16.11% (98/608) of the students had missing data regarding the PSQI. The effects of missing data on the results were checked using multiple imputation, and there was no discrepancy between the results of the analysis of the original data and imputed data. In addition, pooled estimates of the original and imputed data are reported.

Study Group Characteristics and Electronic Device Use

The median age of the cohort was 21 years with a range from 18 to 40 years. The majority were females (437/608, 71.87%), and the median GPA was 4.5 out of 5. A majority of the students were from the medicine (227/608, 37.3%) and applied medicine (226/608, 37.2%) colleges. One-third (195/608, 32.07%) of the students who completed the SAS-SV were found to be addicted to smartphones, and 62.75% (320/510) of the students who completed the PSQI were considered poor sleepers (Table 1).

Table 1. Participant characteristics (n=608).

Variable	Value
Age (years)	
Range	18-40
Median	21
Gender, n (%)	
Male	171 (28.1)
Female	437 (71.9)
GPA[a] (median)	4.5
Specialty, n (%)	
Medicine	227 (37.3)
Nursing	74 (12.2)
Dentistry	35 (6.8)
Pharmacy	46 (7.6)
Applied medicine	226 (37.2)
Sleep quality based on PSQI[b] , n (%)	
Good sleep	190 (37.3)
Poor sleep	320 (62.7)
Addiction behavior based on SAS-SV[c] , n (%)	
Normal	413 (67.9)
Addicted	195 (32.1)

[a]GPA: grade point average.

[b]PSQI: Pittsburgh Sleep Quality Index.

[c]SAS-SV: Smartphone Addiction Scale for Adolescents–short version.

Habits of electronic device use are demonstrated in Table 2. Almost all (601/608, 98.84%) of the participants use smartphones and half of them use tablets or laptops. Around 19.24% (117/608) of the participants watch TV, and 15.78% (96/608) of the group play video games. Only one participant never used electronic devices before sleep and 67 students rarely did. Three-quarters (456/608, 75.0%) of the cohort always used electronic devices at bedtime, while 18.09% (110/608) reported that they usually did. When asked about putting their devices on silent mode, 44.57% (271/608) of them always did. More than half of the cohort never or rarely wake up due to calls or email at night, and only 5.92% (36/608) said they always wake up. Sleep quality was compared across educational disciplines using a chi-square test. There was no significant difference between disciplines regarding sleep quality (*P*=.50). Poor sleep was similarly prevalent across disciplines ranging between 66.66% (42/63) and 48.27% (14/29; Table 3).

Table 2. Electronic device use habits (n=608).

Variable	Value, n (%)
Type of electronic device	
Smartphone	601 (98.8)
Laptop	333 (54.8)
Television	117 (19.2)
Tablet	299 (49.2)
Video games console	96 (15.8)
Do you use your device before bed?	
Never	1 (0.2)
Rarely	4 (0.7)
Sometimes	37 (6.1)
Usually	110 (18.1)
Always	456 (75.0)
Do you put your device on silent before sleep?	
Never	99 (16.3)
Rarely	67 (11.0)
Sometimes	87 (14.3)
Usually	84 (13.8)
Always	271 (44.6)
Are you woken up by calls or emails at night?	
Never	219 (36.0)
Rarely	170 (28.0)
Sometimes	128 (21.1)
Usually	55 (9.0)
Always	36 (5.9)

Table 3. Sleep quality across disciplines (n=190).

Sleep quality	Medicine, n (%)	Applied medicine, n (%)	Pharmacy, n (%)	Nursing, n (%)	Dentistry, n (%)
Good sleep	70 (36.3)	69 (36.7)	15 (40.5)	21 (33.3)	15 (51.7)
Poor sleep	123 (63.7)	119 (63.3)	22 (59.5)	42 (66.7)	14 (48.3)

Effects on Academic Performance

There was no correlation found between PSQI and GPA (*r*=.018, *P*=.70) or addiction score and GPA (*r*=.02, *P*=.60). Even when GPA, PSQI, and SAS-SV were categorized and included in a logistic regression model along with age and gender to identify GPA predictors, poor sleep and addiction to smartphones were not associated with a lower GPA. However, male gender and age over 21 years were significantly associated (Table 4).

Table 4. Predictors of lower grade point average (GPA <4.5).

Predictor	Unadjusted			Adjusted		
	OR[a]	*P* value	95% CI	OR	*P* value	95% CI
Male gender	1.8	.002	1.2-2.5	1.6	.01	1.1-2.3
Age ≥21 years	2.4	.001	1.6-3.8	2.3	.001	1.5-3.7
Poor sleep[b]	1.0	.80	0.7-1.3	0.9	.50	0.6-1.3
Addiction[c]	1.4	.10	0.9-1.9	1.4	.10	0.9-2.0

[a]OR: odds ratio.

[b]Pittsburgh Sleep Quality Index >5.

[c]Smartphone Addiction Scale >33 females and >31 males.

Effects on Sleep Quality

There is a significant correlation between PSQI and SAS-SV (*r*=.2, *P*<.001). This significant relationship persisted even after GPA, PSQI, and SAS-SV were categorized and included in a logistic regression model along with age and gender to identify predictors of poor sleep. However, GPA, age, and gender were not significantly associated with poor sleep (Table 5).

Table 5. Predictors of poor sleep quality (PSQI[a] >5).

Predictor	Unadjusted			Adjusted		
	OR[b]	*P* value	95% CI	OR	*P* value	95% CI
Male gender	1.0	.80	0.7-1.5	1.0	.90	0.7-1.5
Age ≥21 years	1.2	.40	0.8-1.7	1.2	.40	0.8-1.7
GPA[c] <4.5	1.0	.80	0.7-1.4	0.9	.50	0.6-1.3
Addiction[d]	1.8	.005	1.2-2.7	1.8	.005	1.2-2.7

[a]PSQI: Pittsburgh Sleep Quality Index.

[b]OR: odds ratio.

[c]GPA: grade point average.

[d]Smartphone Addiction Scale >33 females and >31 males.

Discussion

Principal Findings

Our findings suggested that more than half of the study cohort experiences poor sleep quality. The percentage is similar in other studies [22-25]. A recent study by Aldhawyan and colleagues [26] found that 75.4% of the first-year medical students at Imam Abdulrahman bin Faisal University had poor quality of sleep.

Sleep importance cannot be overemphasized due to its critical role in immune, hormonal, and cardiovascular systems in addition to regulating appetite and metabolism [27,28]. The poor sleep quality observed in this study could cause significant health hazards. Sleep disruption mechanisms are believed to have adverse short- and long-term general well-being consequences [29-31]. The activations of the sympathoadrenal system, sympathetic nervous system, and hypothalamic-pituitary-adrenal axis are evident by virtue of multiple observations. Increased oxygen consumption and carbon dioxide production throughout brief and extended arousals during sleep indicate increased metabolism [29].

Moreover, oversecretion of the adrenocorticotropic hormone and altered levels of epinephrine, norepinephrine, and catecholamine are noticed in chronic insomnia [30,31]. Poor sleepers tend to have a higher risk of obesity and type 2 diabetes as suppression of slow-wave sleep leads to decreased insulin sensitivity and leptin levels and increased ghrelin [32,33]. Determining reversible etiologies leading to poor quality of sleep may aid in improving sleep hygiene.

Almost all of the enrolled population uses electronic devices before bedtime to some extent. A significantly positive correlation between the SAS-SV and PSQI was observed. These results support the findings of Van den Bulck et al [34,35] where individuals using electronic devices before bedtime go to bed later and tend to be more tired during the day. Choi et al [36] conducted a study on 2336 high school students on internet overuse and its correlation with excessive daytime sleepiness as a reflection of poor sleep quality. The study found that internet addiction is strongly associated with excessive daytime sleepiness in adolescents, and the prevalence rate of excessive daytime sleepiness for internet addicts was 37.7%, in addition to a higher prevalence of insomnia, witnessed snoring, apnea, teeth grinding, and nightmares. These observations were reported in another study correlating electronic device overuse or addiction with negative consequences on students' sleep quality and overall health [37].

There are a few suggested mechanisms through which screens affect sleep. Using electronic devices displaces time that could have been spent sleeping. Electronic devices alter bedtime behaviors as users seek more extended screen entertainment, postponing bedtime [38,39]. Furthermore, psychological stimulation from both violent and nonviolent video games increases arousal [40]. Another likely mechanism of negative impact on sleep from electronic device is exposure to the light emitted by screens at bedtime. Melatonin ideally increases in the hours before bedtime, but studies have demonstrated that screen light suppresses its levels in the blood, quelling sleep drive [41]. In addition to melatonin suppression, screen lights prolong the time to fall asleep and reduce the length of rapid eye movement sleep [42].

Minimizing electronic device use, particularly smartphones, around bedtime is expected to ensure better sleep quality. A small randomized pilot study found that sleep quality and working memory improved in participants who restricted mobile phone use for 30 minutes before bedtime [43]. Limiting the use of smartphones before bedtime could improve the quality of sleep. Restricting phone use for just a week increases lights off time by 17 minutes and sleeping time by 21 minutes [44].

Multiple studies have correlated poor academic performance with bad sleeping habits [45-47]. Interestingly, our study has shown that the PSQI score was not associated with a low GPA. However, our findings suggest that poor academic performance is mainly associated with male gender and age of over 21 years.

The gender-GPA association has been described before where females had significantly higher grades than males by 6.3% [48]. Similar outcomes were described in another study where females excelled at every academic assessment tool [49]. On the other hand, GPA and age association seems to have different patterns. Sheard [49] concluded that mature - age students scored higher GPAs compared to young undergraduates, while another study did not show an association between GPA and age [50]. Moreover, older females outperform both older males and younger females in medical school [51].

Limitations

Missing data related to the PSQI and GPA probably decreased the power of the study to detect a significant association between them. The study was not designed to assess the relationship between sleep quality and outcomes like physical health, psychological well-being, and quality of life. Also, the study lacks an objective way to measure the exact duration of electronic device use. Finally, social desirability bias may be considered with self-reporting of GPA.

Conclusion

Using electronic devices is common among health care science students and was significantly associated with poor sleep quality. This concern should alert public and academic organizations as more attention is required to motivate students to minimize electronic device use at bedtime to ensure sound sleep hygiene and quality.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Study questionnaire.
[DOCX File , 23 KB - mededu_v7i4e25662_app1.docx]

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Abbreviations

GPA: grade point average
PSQI: Pittsburgh Sleep Quality Index
SAS-SV: Smartphone Addiction Scale for Adolescents–short version

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Original Paper

Evaluating Applicant Perceptions of the Impact of Social Media on the 2020-2021 Residency Application Cycle Occurring During the COVID-19 Pandemic: Survey Study

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Abstract

Background: Due to challenges related to the COVID-19 pandemic, residency programs in the United States conducted virtual interviews during the 2020-2021 application season. As a result, programs and applicants may have relied more heavily on social media–based communication and dissemination of information.

Objective: We sought to determine social media's impact on residency applicants during an entirely virtual application cycle.

Methods: An anonymous electronic survey was distributed to 465 eligible 2021 Match applicants at 4 University of California Schools of Medicine in the United States.

Results: A total of 72 participants (15.5% of eligible respondents), applying to 16 specialties, responded. Of those who responded, 53% (n=38) reported following prospective residency accounts on social media, and 89% (n=34) of those respondents were positively or negatively influenced by these accounts. The top three digital methods by which applicants sought information about residency programs included the program website, digital conversations with residents and fellows of that program, and Instagram. Among respondents, 53% (n=38) attended virtual information sessions for prospective programs. A minority of applicants (n=19, 26%) adjusted the number of programs they applied to based on information found on social media, with most (n=14, 74%) increasing the number of programs to which they applied. Survey respondents ranked social media's effectiveness in allowing applicants to learn about programs at 6.7 (SD 2.1) on a visual analogue scale from 1-10. Most applicants (n=61, 86%) felt that programs should use social media in future application cycles even if they are nonvirtual.

Conclusions: Social media appears to be an important tool for resident recruitment. Future studies should seek more information on its effect on later parts of the application cycle and the Match.

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KEYWORDS

residency application; social media; medical education; resident; medical student; perspective; residency recruitment; virtual application; virtual residency

Introduction

In the United States, the residency selection process begins when fourth-year medical students (US seniors) submit their residency applications through the Electronic Residency Application Service. It ends on "Match Day," when the National Resident Matching Program informs applicants of the specialty and program to which they matched. Students who match into urology and ophthalmology follow a similar process, but match through the American Urological Association residency match and San Francisco Match, respectively. The process lasts approximately six months, during which US seniors apply to an average of 70 programs [1] and rank 13 programs [2]. In 2020, 93.7% of US seniors matched to a residency position [3]. Applicants spend October through January of the application cycle traveling to and interviewing with an average of 13 programs [2]. In selecting a residency program, applicants consider many factors, including program location, reputation, “fit,” curriculum quality, work/life balance, quality of faculty, and program size, among others [2]. Traditionally, residency programs have relied heavily on interview day to introduce and recruit applicants to their program. As social media and digital influence become more integrated into global culture, there has been a paradigm shift in residency recruitment methods. Many US residency programs across several specialties have expanded their websites and increased their social media presence [4-7].

Due to the COVID-19 pandemic, the Coalition for Physician Accountability recommended that all interviews during the 2020-2021 application season be conducted virtually [8]. As such, programs were limited in their ability to interact with and recruit candidates due to the virtual nature of the interview season and virtual methods of connection became even more important.

Few studies have surveyed how residency applicants are influenced by social media, with none doing so across all specialties. It has been previously shown that social media plays a moderate role in influencing anesthesia applicants' decisions of which programs to apply to and rank highly [9]. However, prior studies focused primarily on a single social media platform, such as Facebook [10]. With the COVID-19 pandemic and the transition to a virtual interview process, medical students were faced with the challenge of obtaining information through nontraditional means.

Our objective was to explore the extent of applicants’ use of social media during an entirely virtual residency match cycle. We also sought to determine whether decisions regarding where to apply were influenced by social media.

Methods

In October 2020, we surveyed 2021 US residency applicants via an anonymous REDCap-generated survey [11]. Identifying information, such as school attended, was not collected to maintain the privacy of respondents. The survey, detailed in full in Multimedia Appendix 1, was distributed via listserv email to medical students at the University of California (UC) Irvine, UC Davis, UC San Francisco, and UC Riverside. In total, 465 students were eligible to complete the survey across the 4 sites. Students were sent reminder emails via their respective listserv once every 2 weeks over a 6-week time frame to encourage survey participation. This study was exempt from Institutional Review Board approval by UC because participants were anonymous and the study posed minimal risk of ascertaining participant identities.

Results

Of the 465 students who were emailed the survey, 72 (15.5%) completed the survey and represented multiple specialties (Table 1). Applicants applying to more than one specialty selected all applicable specialties.

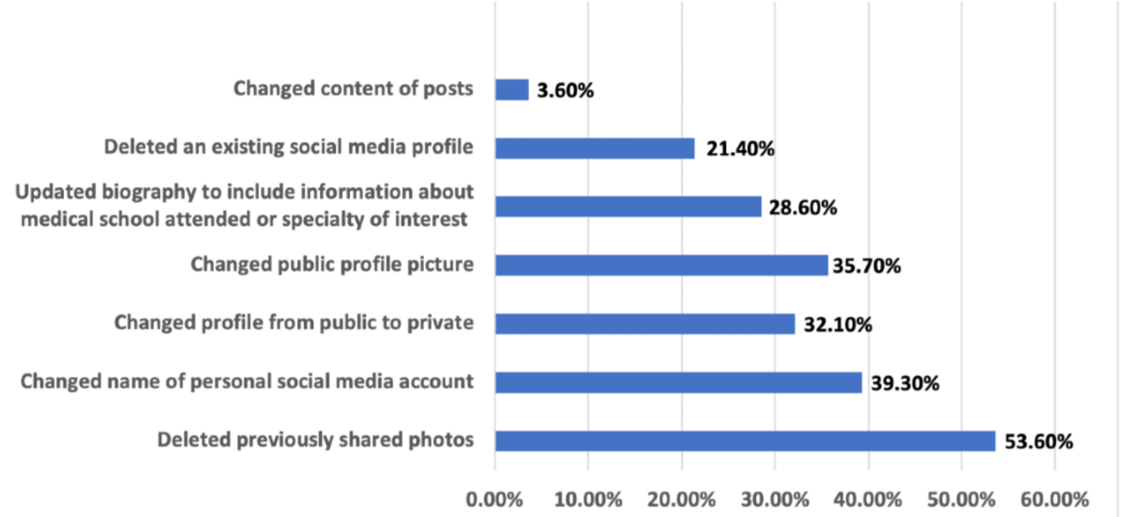
Table 1. Overview of survey respondents by specialty.

Specialty	Students, n (%)
Anesthesia	6 (8.3)
Dermatology	1 (1.4)
Emergency medicine	5 (6.9)
Family medicine	12 (16.7)
General surgery	9 (12.5)
Integrated surgery (cardiothoracic, vascular)	1 (1.4)
Internal medicine	11 (15.3)
Obstetrics and gynecology	4 (5.6)
Ophthalmology	4 (5.6)
Orthopedic surgery	3 (4.2)
Pediatrics	9 (12.5)
Plastic surgery	1 (1.4)
Physical medicine and rehabilitation	1 (1.4)
Psychiatry	4 (5.6)
Radiology	1 (1.4)
Urology	4 (5.6)

Of respondents, 85% (n=64) used social media prior to the 2021 residency cycle. Of those who were previously using social media, platforms used were as follows: 93% used Facebook (n=57), 85% used Instagram (n=52), 36% used YouTube (n=22), 34% used LinkedIn (n=21), 28% used Twitter (n=17), 7% used TikTok (n=4), and 2% answered Other (n=1).

Of applicants using social media prior to the residency cycle, 39% (n=28) adjusted their profiles prior to submitting applications. Actions taken by applicants are depicted in Figure 1. For those that made changes (n=28), the top reasons cited were “I wanted to avoid being portrayed in an ‘unprofessional’ light” (n=23, 82%), “I wanted to be less visible to residency programs” (n=16, 57%), “I wanted to decrease time on social media” (n=5, 18%), “I wanted to be more visible to residency programs” (n=3, 11%), and “I want to highlight present rather than past interests” (n=2, 7%).

Figure 1. Actions performed by the 28 survey participants who reported adjusting their social media accounts prior to the residency application cycle.



Some applicants (n=7, 10%) created new social media accounts for the residency cycle, specifically Twitter (n=6) and Instagram (n=1).

Many respondents reported “following” specific prospective programs (n=38, 54%) or faculty, resident, or staff members of those programs (n=21, 29%) on social media. Of these, most reported being influenced (positively or negatively) in their decision to apply to a specific program based on the account (n=14, 70% for specific accounts; n=34, 89% for residency accounts).

The most common digital methods used by applicants to learn about programs were the program website, digital conversations with trainees of that prospective program, and Instagram. Other notable resources were speaking to current program faculty and residents about other prospective programs, virtual (live or recorded) information sessions, and online resources such as FREIDA and Doximity. Most respondents (n=32, 53%) indicated they attended a virtual information session.

A portion of applicants (n=19, 26%) adjusted the number of programs to which they applied based on new information found on social media platforms. Of these, most (n=14, 74%) increased the number of programs to which they applied.

On average, survey respondents ranked social media’s effectiveness in allowing applicants to learn about programs at 6.7 (SD 2.1) on a visual analogue scale, with 1 being least effective and 10 being most effective. Most students (n=61, 86%) felt that residencies should continue to use social media as a method to spread information about their program in future cycles, even if interviews revert back to an in-person format.

Discussion

Principal Findings

Residency applicants in 2021 at select UC medical schools in the United States used social media to interact with and learn about residency programs across a broad range of specialties. This study demonstrates that social media is a valid and necessary use of residency programs’ time and efforts to aid with recruitment of prospective trainees.

Having access to digital information may help mitigate the barriers applicants face in receiving information about prospective programs during the COVID-19 pandemic. As no prior studies have assessed how applicants learn about residency programs, it is plausible that—due to this year’s virtual application process and travel restrictions—speaking to trainees from both the applicant’s home and prospective programs became more critical than in prior application cycles.

We noticed that virtual information sessions became more prevalent during the 2020-2021 application cycle; these were attended by a majority of our survey respondents. It would be of interest to directly study how virtual residency information sessions affect applicants’ views of a program. However, it can be inferred that because a majority of applicants adjusted the number of programs applied to favorably based on social media, that increased dissemination of information can contribute to applicants applying to programs they had not considered prior to the session.

Social media can have a critical impact on the application process because it not only enables applicants to receive information about programs, but also provides programs with information about applicants. Largely, survey respondents indicated the changes they made to their profiles were to avoid being portrayed in an unprofessional light and be less visible to residency programs. However, there were a few applicants who created profiles to become more visible to residency programs. It has previously been found that program directors use social media to gain additional information about applicants [12-14]. It is possible that the applicant-specific information publicly displayed on social media may have the potential to negatively affect an applicant's final ranking. It remains controversial whether or not it is ethical for programs to consider an applicant's publicly available social media profiles when scoring an applicant during committee meetings for many reasons including the potential to bias their view of the applicant [15].

Additional large-scale studies are needed to fully determine if applicants are using social media as a way to display their personal hobbies, interests, or academic achievements to residency programs. A small-scale study focused on obstetrics and gynecology applicants at Brown University found a low incidence of inappropriate content or posts on applicants' social media and postulated that this could either be a reflection of the professionalism of their applicants or their ability to hide inappropriate content [16]. Additionally, it would be valuable to assess if program directors are using social media profiles to learn about applicants and to what extent they feel this affects the preinterview, postinterview, and ranking process.

Limitations

Limitations of this study include small sample size, somewhat low response rate of survey audience, and regional focus of surveyed applicants. In particular, the response rate could introduce bias as those more likely to complete the survey may have used social media more heavily than those who chose not to respond. However, this is the first study of its kind to look at multiple specialties. Further studies should include a more widespread survey with a larger sample size to better generalize the utility of social media. If a larger number of applicants per specialty can be achieved in a nationwide survey, then it can be deciphered which specialties are using social media more than others to engage with applicants. It would also be beneficial to stratify applicants using social media by their respective specialties to identify whether there is an association between residency program engagement online and applicant social media use.

Our survey was distributed in October 2020, after the submission of all residency applications. Therefore, our study only offers the perspectives of applicants leading up to interview season. Although understanding how applicants create their initial first impression of programs is essential, it would also be beneficial to understand how social media can influence applicant perspectives throughout interview season and through the ranking process. Understanding how programs engage with applicants throughout the entire residency application process can inform the creation of national guidelines and consensus statements regarding best conduct by both programs and applicants to limit potential Match violations.

Conclusions

Applicants participating in the 2021 US residency application cycle believe that social media is a powerful tool for resident recruitment that should be used in future cycles. Notably, programs should focus recruitment efforts on the program website, Facebook, and Instagram, which are the top three platforms used by applicants for residency information.

Acknowledgments

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Survey distributed to 2021 residency applicants.

[PDF File (Adobe PDF File), 44 KB - mededu_v7i4e29486_app1.pdf]

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Abbreviations

UC: University of California

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Original Paper

Self-Reported Preferences for Help-Seeking and Barriers to Using Mental Health Supports Among Internal Medicine Residents: Exploratory Use of an Econometric Best-Worst Scaling Framework for Gathering Physician Wellness Preferences

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Abstract

Background: Burnout interventions are limited by low use. Understanding resident physician preferences for burnout interventions may increase utilization and improve the assessment of these interventions.

Objective: This study aims to use an econometric best-worst scaling (BWS) framework to survey internal medicine resident physicians to establish help-seeking preferences for burnout and barriers to using wellness supports by quantifying selections for 7 wellness support options and 7 barriers.

Methods: Internal medicine resident physicians at our institution completed an anonymous web-based BWS survey during the 2020-2021 academic year. This cross-sectional study was analyzed with multinomial logistic regression and latent class modeling to determine the relative rank ordering of factors for seeking support for burnout and barriers to using wellness supports. Analysis of variance with Tukey honest significant difference posthoc test was used to analyze differences in mean utility scores representing choice for barriers and support options.

Results: Of the 163 invited residents, 77 (47.2% response rate) completed the survey. Top-ranking factors for seeking wellness supports included seeking informal peer support (best: 71%; worst: 0.6%) and support from friends and family (best: 70%; worst: 1.6%). Top-ranking barriers to seeking counseling included time (best: 75%; worst: 5%) and money (best: 35%; worst: 21%).

Conclusions: Overall, our findings suggest that low utilization of formal mental health support is reflective of resident preferences to seek help informally and that increasing utilization will require addressing pragmatic barriers of time and cost. Assessing physician preferences for wellness-related initiatives may contribute to understanding the low utilization of formal mental health services among physicians, which can be determined using a BWS framework.

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KEYWORDS

residency program; choice; burnout; wellness

Introduction

Physician burnout affects physicians worldwide and has negative implications for physician well-being and patient care, with a reported worldwide prevalence of 67% [1,2]. Multiple interventions have been proposed to address physician burnout; however, existing evidence is insufficient to recommend firm practical recommendations [3]. Some of this difficulty arises from the significant variation in reported burnout prevalence, which ranges from 0% to 80.5% [2]. This variation is poorly understood; there has been evidence that this can be attributed to inconsistency in measuring burnout and that burnout is experienced in a heterogeneous fashion among practice settings and specialties [4]. Calls have been proposed to better understand subjective and workplace factors that shape a physician's experience outside the burnout construct [2,5,6].

Previous studies have attempted to identify factors associated with work-related stress and burnout. However, they have used traditional survey-based methodologies, such as Likert scales, focus groups, and ranking checklists [7,8]. Most surveys rely on these methods because of their ease of use and study design. However, these methods present multiple biases that affect statistical analysis and overall validity. Scale-use bias, the tendency for respondents to use rating scales in different ways, such as preferring to use higher or lower parts of the scale for all questions, can frequently be observed in studies using these scales [9]. There is also considerable debate as to whether Likert data are considered ordinal or interval, leading to the risk of flawed data interpretation [10]. Ranking checklists allow for improved discrimination among items but result in ordinal measures (which do not allow for mean calculations and relative differences between items) and become cognitively difficult when there are more than 7 items to rank [9].

It has been observed that physicians are low users of wellness resources to address burnout and other mental health issues such as depression and suicide [11]. Previous studies examining barriers to treatment have indicated that the most frequently cited issues are related to lack of time, lack of confidentiality, stigma, and preference to manage problems on their own [11,12]. Unfortunately, no published studies have examined whether physicians have differential attitudes toward mental health treatment options, such as individual therapy, group therapy, or peer support.

At our institution, we also encountered low use of wellness resources among physician residents in our internal medicine department with a desire to examine the barriers that contributed to this as well as their overall interest in these resources. We sought to use a novel technique to obtain this information.

Best-worst scaling (BWS) is a type of discrete choice experiment (DCE) based on economic choice modeling theory [13]. In this conceptual framework, individual and aggregate preferences to surveyed items can be developed by forcing respondents to choose from among two or more alternatives. BWS has been developed to resolve many of the biases associated with rating scales and ranking studies [9]. There is evidence that it allows for better item discrimination compared with rating scales in head-to-head comparisons, and BWS has recently been used to drive patient-centric health care decision-making by assessing patient preferences [13-16]. To date, no burnout-related studies have used this framework to investigate help-seeking preferences and barriers to using support services.

The primary goals of this study are to use the BWS framework to identify how residents prefer to seek help to prevent burnout and work-related stress and establish the relative importance of barriers to using commonly offered wellness interventions at our institution. We hoped to use this novel framework to better understand residents' preferences to help-seeking and barriers to seeking help. None of the prior studies examining barriers to physician mental health utilization have used an economic preference framework to establish the relative importance of these items, which would be helpful in determining the most important barriers to address and which mental health services should be preferentially deployed from a policy-making standpoint. This information would be helpful to increase the overall utilization of mental health services and better address physician burnout.

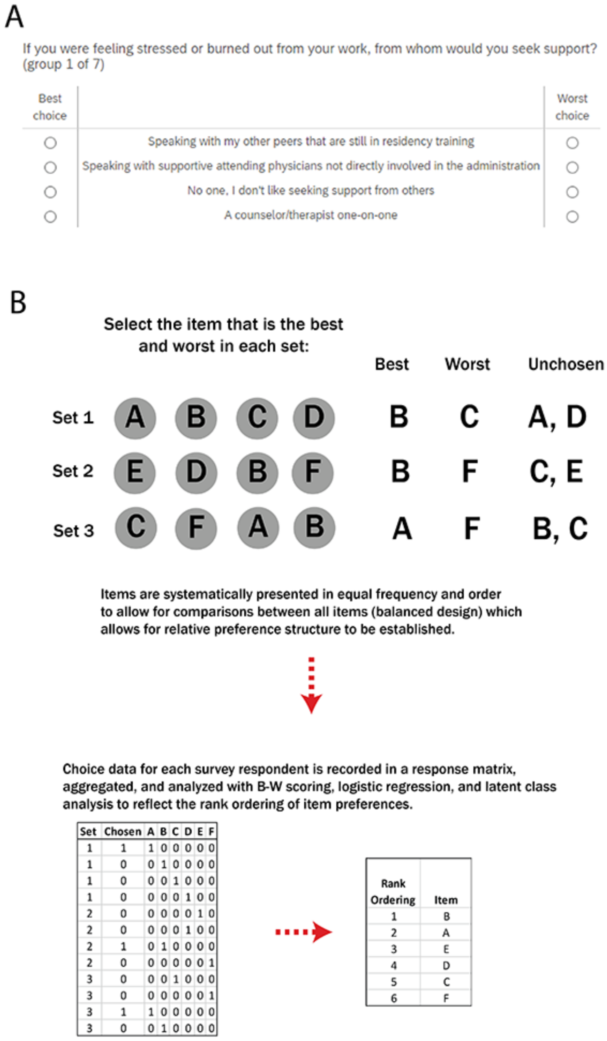
Methods

What Is BWS?

BWS is a type of DCE based in economic theory. DCEs elicit respondent preferences for goods or services based on their stated intentions in hypothetical situations [17]. The term utility refers to the mathematical representation of preference, which, under microeconomic theory, assumes that decision makers will make choices that maximize the value of their utility function, subject to constrained resources [18].

There are 3 types of BWS surveys that differ in survey design complexity. More complex BWS survey types, such as profile or multiprofile case, allow for the comparison of factors with multiple attributes (eg, a medication with different prices, side effects, and modes of administration). The simplest version, the object case (also known as MaxDiff), was used for this study, which determines the relative value of a list of mutually exclusive objects [16]. An example of a BWS object case question is shown in Figure 1, where respondents are asked to identify the most preferred and least preferred item from a set of scenarios.

Figure 1. An example best-worst scaling object case question. Respondents choose one factor as the best choice and one factor as the worst choice in each question, with each factor systematically shown with all other factors in subsequent questions to allow for relative comparison.



Study Design

The first step in designing this BWS experiment was to determine the relevant factors to be included in the study. We initially used a comprehensive literature search to identify commonly cited barriers to wellness support and various help-seeking interventions [11,19,20]. We then worked with contributing authors ET and TMS, who serve as assistant program directors in the internal medicine residency program and psychiatry residency program, respectively, to elicit their experiences while working with resident physicians with regard to help-seeking interventions and frequently cited barriers to seeking care. AW, VR, TMS, and ET then worked together to optimize this list of factors such that the items were clearly defined, relevant, and did not have a singular factor that would not be universally selected as best or worst (item dominance), which are required for BWS study generation [17]. Item optimization was further refined in the pretesting stage, as described in the following section.

Experimental Design

Inherent in BWS experimental design is the requirement to have systematic combinations of all surveyed items. This necessitates the need for a balanced design in frequency and orthogonality, where each surveyed factor needs to appear an equal number of times and equally with other factors, ensuring that each factor can be compared with all possible arrangements of other factors in the set. This was achieved using a balanced incomplete block design, a commonly used technique to design BWS sets and generated in JMP Pro 14 (SAS Institute Inc) [9,21]. Three BWS object case sets were created to assess preferences for each of the following factors: seeking support for work-related stress, barriers to using counseling, and barriers to using peer support groups. The three sets each tested seven factors, with every question in the set containing a subset of four factors, with a total of seven questions per set, which adhered to a balanced incomplete block design.

Pretesting

After the initial study design, AW pretested the survey with a subset of 9 volunteer psychiatry residents. Adhering to a previous framework on BWS instrument development, we focused pretesting on the comprehension of the surveyed factors, whether there were omitted factors, the clarity of the BWS format, and the study purpose [22].

Participants

Before study deployment, we worked with the Committee on Clinical Investigation for Beth Israel Deaconess Medical Center (BIDMC), the institutional review board for our institution, to receive an institutional review board exemption for this study. BIDMC is a teaching hospital in Boston, Massachusetts, with academic affiliations to Harvard Medical School. The internal medicine residency program is one of 13 Accreditation Council for Graduate Medical Education–accredited programs at the institution and comprises a total of 163 residents. It is a 3-year residency program that comprises resident physicians in their first postgraduate year of training (PGY-1) to their third postgraduate year of training (PGY-3). To be eligible for the survey, participants needed to be a resident physician between PGY-1 and PGY-3 years of training in the internal medicine program at BIDMC. Chief residents (who are in PGY-4 or PGY-5 of their training) were not invited, and the study did not include residents of other specialties.

In October 2020, residents in the BIDMC Internal Medicine residency were invited via email to participate in the study. This email contained a prospective agreement with consent and a link to the study, administered using Qualtrics Survey Software (SAP SE), emphasizing that participation in the study was voluntary and that data collected would not be individually identifiable. The demographic data collected included their age, postgraduate training year, and gender. These data were stored on Qualtrics Survey Software servers, which could only be accessed on an account that required two-factor encryption, for which only AW had access.

A total of 3 reminder emails were sent 1, 2, and 4 weeks after the study opened. After 6 weeks, the survey collection period ended. A US $5 Amazon gift card was given as compensation conditional to the completion of the survey.

Statistical Analysis

A typical survey response rate for a web-based survey is 40%, which, using a margin of error calculation with our sample size, would have resulted in a margin of error of 9%. Given the desire to explore the novel nature of this study method and the possibility that it could result in highly discriminative utility values, we aimed for a 50% response rate, which would result in a margin of error of 8%. A BWS-specific power analysis was also conducted, which indicated that a 50% response rate (n=82) would have an 80% chance of detecting utility differences >0.118 at 95% CI; with a 40% response rate (n=65), we would be able to determine utility differences of 0.132 at 95% CI [23].

Data Analysis

BWS data were analyzed using three techniques (Best-worst [B-W] scoring, multinomial logit [MNL], and latent class analysis [LCA]). For more details on multinomial logit and latent class analyses in this study, please refer to the Multimedia Appendices 1 and 2.

B-W scoring was conducted as described in previous BWS studies [13].

B-W scoring = ([number of times item selected best choice] – [number of times item selected worst]) / (*number of times surveyed factor displayed in the total survey*)

B-W scores have a range between −1.0 and +1.0, with scores closer to +1.0 having higher selected preference than lower-scoring options.

MNL and LCA modeling were performed using Lighthouse Studio 9.8 (Sawtooth Software). One-way analysis of variance with Tukey honest significant difference (HSD) posthoc test was performed using JMP Pro 14 to analyze the mean differences between factor preferences for survey respondents.

Rank ordering of factors was determined by sorting the raw utility values of the surveyed factors.

Results

Of the 163 residents, the survey resulted in 77 (47.2% response rate) completing the study. This corresponds to an error margin of 8%, using a 95% CI. The age of the respondents ranged between 25 and 35 years, with 63% (49/77) of the total respondents being female. PGY-1s comprised 45% (35/77) of the total respondents, PGY-2s comprised 29% (22/77) of respondents, and PGY-3s comprised 26% (20/77) of respondents. These demographic characteristics are presented in Table 1.

When examining rank-ordered preferences for seeking support, the first-ranked factor was informally speaking with other resident peers, and the lowest ranking factor (#7) was not seeking help at all. Other high-ranking factors included informally speaking with friends and family for support (#2) and speaking with a counselor or therapist (#3). A total of 4 statistically significant groupings were found for the seven surveyed factors when comparing MNL utility scores with Tukey HSD posthoc testing. LCA optimally identified four classes with distinct preferences: *open to formal help* (39.4%), *not open to therapy* (26.8%), *open to isolating* (25.9%), and *formal help-seeking* (7.9%). The results are presented in Table 2.

Rank-ordered preferences for stated barriers to seeking counseling are shown in Table 3. The first-ranked factor was time, with the second-ranked factor being unwillingness to pay for counseling. The lowest ranking factors included feeling weak for seeing a therapist (#7), shame and embarrassment (#6), and not finding therapy helpful (#5). A total of 4 statistically significant groupings were found for the seven surveyed factors when comparing MNL utility scores with Tukey HSD posthoc testing. LCA optimally identified five classes with distinct preferences: *time/money* (49%), *time/money/don't find it helpful* (20%), *confidentiality and future job concerns* (13%), *time/don't find it helpful* (11%), and *high self-/social-stigma* (8%).

Table 1. Baseline characteristics (N=77).

Characteristics	Participants
Age (years)	
Mean (SD)	28 (2)
Range	25-35
Gender, n (%)	
Female	49 (63)
Male	28 (37)
Training year, n (%)	
PGY[a]-1	35 (45)
PGY-2	22 (29)
PGY-3	20 (26)

[a]PGY: postgraduate year of training.

Table 2. Rank-ordered resident preferences for seeking support for work-related stress and/or burnout (if you were feeling stressed or burned out from your work, from whom would you seek support?): frequency counts, best-worst scoring, multinomial logistic analysis, and latent class segmentation rank ordering.

Surveyed factors	Aggregate data					Latent class segmentation (rank order)			
	Number of times selected (maximum possible: 308)		Best-worst score	MNL[a] utility score (SE)[b]	Rank order	Segment 1: "Open to formal help," (39.4%[c])	Segment 2: "Not open to therapy," (26.8%)	Segment 3: "Open to isolating" (25.9%)	Segment 4: "Formal help-seeking" (7.9%)
	Best choice	Worst choice							
Speaking with my other peers that are still in residency training	219	2	0.705	0.077 (0.15)[A]	1	2	1	2	1
Speaking with my family and friends outside of work	215	5	0.682	0.000 (N/A[d])[A]	2	1	2	1	3
A counselor or therapist one-on-one	36	53	−0.055	−3.01 (0.211)[B]	3	3	6	4	2
Residency-sponsored peer support group, (like Intern Forum, but not necessarily just for interns)	30	49	−0.062	−3.088 (0.212)[B]	4	4	5	5	6
Speaking with supportive attending physicians not directly involved in the administration	5	71	−0.215	−3.404 (0.213)[B,C]	5	5	4	6	5
Speaking with my administration (chief residents or program directors)	23	130	−0.347	−3.919 (0.215)[C]	6	6	3	7	4
No one, I don't like seeking support from others	11	229	−0.708	−5.043 (0.224)[D]	7	7	7	3	7

[a]MNL: multinomial logit.

[b]Four statistically significant groupings (A-D) were found for the 7 surveyed factors when comparing multinomial logit utility scores with Tukey honest significant difference posthoc testing. Mean utility scores followed by the same letter did not differ significantly (Tukey honest significant difference test, P>.05); exact P values for multiple comparisons are shown in Table S1 in Multimedia Appendix 1.

[c]The latent number of groups displayed was based on the lowest Bayesian information criterion. Owing to the probabilistic nature of the latent class method, respondents do not wholly belong to one group or another, although most respondents (74/77, 96%) had >90% probability of membership to a single group.

[d]N/A: not applicable.

Table 3. Rank-ordered resident preferences for stated barriers to seeking counseling (if the residency program offered one-on-one counseling for stress and burnout from work, what do you think could affect your participation?).

Surveyed factors	Aggregate data					Latent class segmentation (rank order)				
	Number of times selected (maximum possible: 308)		Best-worst score	MNL[a] utility score (SD)[b]	Rank order	Segment 1: "Time/ money," (49%)	Segment 2 "Time/ money/ don't find it helpful," (20%)	Segment 3: "confidentiality and future job concerns" (13%)	Segment 4: "Time/ don't find it helpful" (11%)	Segment 5: "High self-/ social-stigma" (8%)
	Most important	Least important								
I wouldn't have enough time	231	14	0.705	2.528 (0.150)[A]	1	1	1	4	1	1
I wouldn't want to pay for it	109	64	0.146	1.009 (0.133)[B]	2	2	2	3	7	7
I'm concerned that seeing a therapist will reflect poorly on my standing as a resident or impact my future job opportunities	58	75	−0.056	0.454 (0.131)[C]	3	4	7	1	4	4
I'm concerned about the confidentiality of talking about my issues to a therapist	53	78	−0.081	0.416 (0.133)[C]	4	3	6	2	3	5
I don't think it would help for addressing my wellness	56	81	−0.081	0.406 (0.132)[C]	5	5	3	6	2	6
I would be ashamed or embarrassed if my peers knew I was seeing a therapist	16	89	−0.237	0 (N/A[c])[C,D]	6	6	5	5	6	2
I would think I'm a weak person for seeing a therapist for stress or burnout	16	138	−0.396	−0.407 (0.129)[D]	7	7	4	7	5	3

[a]MNL: multinomial logit.

[b]Four statistically significant groupings (A-D) were found for the 7 surveyed factors when comparing multinomial logit utility scores with Tukey honest significant difference posthoc testing. Mean utility scores followed by the same letter did not differ significantly (Tukey honest significant difference test, *P*>.05); exact *P* values for multiple comparisons are shown in Table S1 in Multimedia Appendix 1.

[c]N/A: not applicable.

Stated barriers for participation in the resident peer-support group are shown in Table 4. The first ranking factor was not having enough time during the workday. Other top-ranking factors included being too fatigued (#2) and being off-site/on vacation (#3). The lowest ranking factors included not liking classmates (#7), embarrassing oneself in front of one's peers (#6), and fearing that what one shared would reflect poorly of oneself as a physician (#5). A total of 5 statistically significant groupings were found for the seven surveyed factors when comparing MNL utility scores with Tukey HSD posthoc testing. LCA optimally identified four classes with distinct preferences: *time/too tired* (32%), *time/too tired/don't find it helpful* (26%), time/too tired/don't want to share (22%), and *time/off-site* (20%).

Table 4. Rank-ordered resident preferences for stated barriers for participation in a resident peer support group. (Thinking back to intern year, select the most and least significant factors that affected your participation in the residency-provided peer support group [Intern Forum] that occurred during the day for work-related stress and/or burnout).

Surveyed factors	Aggregate data					Latent class segmentation (rank order)			
	Number of times selected (maximum possible: 308)		Best-worst score	MNL[a] utility score (SE)[b]	Rank order	Segment 1: "Time/too tired," (32%)	Segment 2: "Time/too tired/don't find it helpful," (26%)	Segment 3: "Time/too tired/Don't want to share," (22%)	Segment 4: "Time/off-site," (20%)
	Most important	Least important							
I don't have enough time during the workday	187	8	0.581	2.125 (0.150)[A]	1	1	2	1	2
I'm too tired	113	20	0.302	1.386 (0.147)[B]	2	2	3	2	3
I'm off-site, post-call, or on vacation	86	48	0.12	0.780 (0.139)[C]	3	3	4	6	1
I don't think it will help with addressing my wellness	79	42	0.12	0.858 (0.145)[BC]	4	4	1	5	6
I'm concerned that what I share will reflect poorly of me as a resident and physician	36	79	−0.139	0.000 (N/A[c])[D]	5	6	5	4	4
I don't want to embarrass myself in front of my peers	36	85	−0.159	−0.017 (0.142)[D]	6	5	6	3	5
I don't like my classmates	2	257	−0.828	−2.154 (0.170)[E]	7	7	7	7	7

[a]MNL: multinomial logit.

[b]Five statistically significant groupings (A-E) were found for the 7 surveyed factors when comparing multinomial logit utility scores with Tukey honest significant difference posthoc testing. Mean utility scores followed by the same letter did not differ significantly (Tukey honest significant difference test, *P*>.05); exact *P* values for multiple comparisons are shown in Table S1 in Multimedia Appendix 1.

[c]N/A: not applicable.

Each factor was shown a total of four times for each of the 77 respondents, resulting in a maximum possibility of 308 best or worst choice selections. For every question, respondents had the option of selecting two of the four factors as either the best or worst choice, leaving the remaining two factors unselected.

B-W scores have a range between −1.0 and +1.0, with scores closer to +1.0 having higher selected preference than lower-scoring options.

The utility score of one item is required to be set to zero because of linear dependency constraints (speaking with my family and friends outside of work). The mean utility scores followed by the same letter did not differ significantly (Tukey HSD test; *P*>.05); exact *P* values for multiple comparisons are shown in Table S1 in Multimedia Appendix 1.

The latent number of groups displayed was based on the lowest Bayesian information criterion. Owing to the probabilistic nature of the latent class method, respondents do not wholly belong to one group or another, although most respondents (74/77, 96%) had >90% probability of membership to a single group. Segment percentages refer to respondents that have been assigned to their respective segments using latent class segmentation over the total respondent population (n=77).

Each factor was shown a total of four times to each of the 77 respondents, resulting in a maximum possibility of 308 best or worst choice selections.

The mean utility scores followed by the same letter did not differ significantly (Tukey HSD test; *P*>.05); exact *P* values for multiple comparisons are shown in Table S2 in Multimedia Appendix 1.

Latent class MNL with 5 groups is shown. Owing to the probabilistic nature of the latent class method, respondents do not wholly belong to one group or another, although most respondents (73/77, 95%) had >90% probability of membership to a single group. Segment percentages refer to respondents that have been assigned to their respective segments using latent class segmentation over the total respondent population (n=77)

Each factor was shown a total of four times to each of the 77 respondents, resulting in a maximum possibility of 308 best or worst choice selections.

The mean utility scores followed by the same letter did not differ significantly (Tukey HSD test; *P*>.05); exact *P* values for multiple comparisons are shown in Table S3 in Multimedia Appendix 1.

Latent class MNL with 4 groups is shown. Owing to the probabilistic nature of the latent class method, respondents do not wholly belong to one group or another, although most respondents (68/77, 88%) had >90% probability of membership to a group. Segment percentages refer to respondents that have been assigned to their respective segments using latent class segmentation over the total respondent population (n=77).

Discussion

Principal Findings

To our knowledge, this is the first known survey on resident burnout and wellness support that uses a BWS methodology. This framework allows resident program leadership to gather specific information on what residents value when it comes to seeking help and relevant barriers. Overall, surveyed residents most preferred to seek emotional support informally from their resident peers and with friends and family when presented with other options of formal mental health support or administrative support. When examining self-stated barriers to using therapy, residents most frequently cited pragmatic barriers of time and money rather than those related to mental health stigma.

Our study findings also reflect prior studies where time was the most frequently cited barrier to using mental health services among resident physicians [11,24]. Future efforts designed to increase use should thus consider how to best mitigate this barrier, such as dedicating specific time in a resident's schedule to allow for medical appointments or to assess the viability of using telehealth services for these purposes, which would allow for more flexibility on a resident's schedule [20,25]. Although the preference for informal support over formal counseling among physicians would need to be reestablished in the future with a larger sample size, a recent BWS study examining help-seeking preferences for mental health concerns among college students also similarly reflected a preference toward informal sources of support through friends and family over formal counseling [26]. As such, when considering the low overall utilization rate of mental health services among physicians, it may also be worth considering that preferences for informal support over formal counseling exist among the general population and that this may not represent a particularly unique issue among physicians, although this is certainly worth investigating in the future.

The BWS framework also allows for the use of latent class modeling, identifying segments of residents that share similar preferences. Although these findings are difficult to generalize based on our small study size, the identification of segments of residents that mostly prefer formal counseling, prefer to deal with problems on their own, or prefer informal supports represent potential phenotypes of residents that warrant future investigation, such as whether the frequency of these groupings is stable across differing institutions, specialties, and countries. Although future studies showing similar frequencies and phenotypes would aid in the generalizability of our study findings regarding physician resident attitudes on barriers to using mental health and seeking help, it cannot be expected that preferences will be identical, given the aforementioned variations in clinical settings and the variety of personality traits and personal values that physicians possess [27]. What could also be more useful for policy makers would be using repeated assessments at singular institutions of BWS-based studies across time to assess resident physician preferences regarding wellness initiatives longitudinally, which would also aid in determining the impact of potential interventions designed to encourage wellness initiative utilization.

Limitations

The external validity of this study was limited by the singular specialty surveyed. Respondents only included 47% of the total internal medicine residency and may not reflect the aggregate preferences of all medical residents. There is a possibility that nonresponders could have had differing preferences from those that responded; given how a previous study examining physician response rates to web-based surveys cited lack of time as a primary reason for not responding to surveys, there is a possibility that the magnitude of time as a barrier to seeking help was understated [28]. As we did not survey other residents in other specialties, we cannot determine whether these preferences are generalizable to all residents or if they differ by specialty. However, we believe that the surveyed factors related to help-seeking barriers are universal to many residents; notably, most residents struggle with being able to take time to seek formal counseling, and issues of self-stigma and social stigma, when it comes to receiving mental health services, are not solely limited to our residency program. Furthermore, mental health interventions such as individual therapy and peer support are commonly offered wellness supports in many institutions. There is no reason to believe that these barriers are not encountered by other resident physicians; however, it would be interesting to repeat this survey in other specialties to observe the generalizability of our collected preferences. Although our study sample contained a higher proportion of female respondents, raising a concern that data would be skewed, we did not find meaningful differences in preference choices by gender, as shown in Table S5 in Multimedia Appendix 1.

Conclusions

To our knowledge, this is the first known study that uses a BWS approach to establish resident preferences for seeking support. [2]. In our study, understanding physician preferences for seeking help and stated barriers to seeking formal help was useful in generating potential reasons why these resources have been underutilized at our institution, in particular, a preference for informal help and strongly cited barriers related to time constraints.

By using a BWS framework for wellness initiative implementation, institutions can accurately assess the relevant barriers and demand for wellness services among their clinician population, for which these preferences will likely vary because of variations in practice settings, clinician specialties, and institutional culture. The design of BWS studies allows for repeated measurements of surveyed factors in a more efficient study design, allowing for more reliable measures of preferences of these factors on an individual respondent level in a survey that takes only a few minutes to complete. In contrast, traditional surveys using Likert scales cannot establish these preferences as they do not collect repeated measures of these data, do not force respondents to choose between surveyed factors, and are subject to scale-use bias, allowing policy makers to better understand how respondents value the surveyed factors.

This method may save money and time by reducing the likelihood of institutions implementing wellness initiatives that turn out to be underutilized because of unforeseen barriers and unique preferences for services. Physician residents are not a homogenous population where a singular intervention will be universally helpful to improve their wellness, as suggested by the lack of evidence of such a universal intervention and wide range of burnout prevalence among practice settings.

Although the design of BWS studies requires some understanding of the underlying discrete choice theory, several commonly used statistical platforms allow for the design and analysis of these studies (JMP, SAS, Qualtrics Survey Software, STATA, and R). Thus, the BWS framework provides an accessible opportunity to create personalized approaches to addressing clinician wellness.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Additional data and information provided on statistical interpretation of best-worst scaling data.

[DOCX File , 33 KB - mededu_v7i4e28623_app1.docx]

Multimedia Appendix 2

Full respondent survey.

[PDF File (Adobe PDF File), 487 KB - mededu_v7i4e28623_app2.pdf]

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Abbreviations

BIDMC: Beth Israel Deaconess Medical Center
B-W: best-worst
BWS: best-worst scaling
DCE: discrete choice experiment
HSD: honest significant difference
LCA: latent class analysis
MNL: multinomial logit

PGY: postgraduate year of training

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Original Paper

Use of Commercially Produced Medical Education Videos in a Cardiovascular Curriculum: Multiple Cohort Study

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Abstract

Background: Short instructional videos can make learning more efficient through the application of multimedia principles, and video animations can illustrate the complex concepts and dynamic processes that are common in health sciences education. Commercially produced videos are commonly used by medical students but are rarely integrated into curricula.

Objective: Our goal was to examine student engagement with medical education videos incorporated into a preclinical Cardiovascular Systems course.

Methods: Students who took the first-year 8-week Cardiovascular Systems course in 2019 and 2020 were included in the study. Videos from Osmosis were recommended to be watched before live sessions throughout the course. Video use was monitored through dashboards, and course credit was given for watching videos. All students were emailed electronic surveys after the final exam asking about the course's blended learning experience and use of videos. Osmosis usage data for number of video views, multiple choice questions, and flashcards were extracted from Osmosis dashboards.

Results: Overall, 232/359 (64.6%) students completed surveys, with rates by class of 81/154 (52.6%) for MD Class of 2022, 39/50 (78%) for MD/MPH Class of 2022, and 112/155 (72.3%) for MD Class of 2023. Osmosis dashboard data were available for all 359 students. All students received the full credit offered for Osmosis engagement, and learning analytics demonstrated regular usage of videos and other digital platform features. Survey responses indicated that most students found Osmosis videos to be helpful for learning (204/232, 87.9%; *P*=.001) and preferred Osmosis videos to the traditional lecture format (134/232, 57.8%; *P*<.001).

Conclusions: Commercial medical education videos may enhance curriculum with low faculty effort and improve students' learning experiences. Findings from our experience at one medical school can guide the effective use of supplemental digital resources for learning, and related evaluation and research.

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KEYWORDS

commercial videos; flipped classroom; organ-systems courses; medical education; medical students; teaching; education; health science education; e-Learning

Introduction

Short instructional videos can make learning more efficient through the application of multimedia principles [1], and video animations in particular can illustrate the complex concepts and dynamic processes that are common in health sciences education [2]. Medical students usually select and use videos in a self-directed manner; however, videos are increasingly being incorporated into the formal curriculum to enhance and reinforce knowledge, similar to the use of textbook or journal readings to supplement faculty-developed resources in traditional medical school curricula.

Published descriptions of instructional videos for medical students focus on faculty-created videos [3-6], and published advice for creating instructional videos [7,8] could imply that video development should be added to the list of skills that faculty should learn. However, optimizing the educational quality of instructional videos requires careful planning, familiarity with technology, and drawing ability [9]. Faculty may not have the time or interest to learn these skills, and institutions may not have adequate resources to support them. Working with companies that have clearly defined processes and the infrastructure for educational video production is one option for developing high-quality videos efficiently; however, such an option may be most appropriate for faculty who view video creation as a form of scholarship and when videos can be distributed broadly [10].

Purchasing videos produced by health education companies may be more practical than either asking faculty to create videos independently or to cocreate them with education companies. Although digital educational resources to supplement learning are universally purchased by students and invested in by a growing numbers of institutions, we are unaware of reports describing their implementation and evaluation as part of formal curricula. Therefore, our goal was to evaluate the incorporation of videos on a digital platform in a preclerkship curriculum.

Methods

This was a three-cohort study that examined student engagement with medical education videos in the Cardiovascular Systems course for first-year medical students at the University of Miami Miller School of Medicine (Miami, Florida). The videos selected were from Osmosis [11], a digital education platform that includes videos, flashcards, and case-based multiple-choice questions. The University of Miami is a private institution and the curriculum has been in place for over 20 years. The Cardiovascular Systems course lasts 8 weeks and runs twice each spring. The cohort of MD students completes the course first (usually in January-March) and MD/MPH students complete the course second (usually in April-May). The MD/MPH cohort has a model that is structured around problem-based learning (PBL) time. The students attend in-class lectures (as in the MD program), meet twice a week in small groups of 10 students to analyze cases, and then the full class meets once a week in a PBL wrap-up session. However, the content and number of lectures are equal between the MD and MD/MPH classes. We included MD and MD/MPH students from the class of 2022 who took the course in 2019 and MD students from the class of 2023 who took the course in 2020. For each of the 3 cohorts, the study applied to the 8-week duration of the course. We did not include the MD/MPH students who took the course in 2020 because their learning experiences were altered by the COVID-19 pandemic. For example, the students had all of their classes and assessments virtually.

Osmosis was selected because its video topics were organized similar to the course topics, and thus the faculty felt that the videos would provide a conceptual foundation that better prepared students for live activities in the course and that the videos could be useful for review after the content was covered in the course.

Prior to 2019, course faculty had created 17 videos on cardiovascular system physiology, lipids, and coronary blood flow lectures to be used in the course, called “Cane Academy” videos. These videos were intended to replace lectures, and were longer (average duration of 15 minutes) and more detailed than typical Osmosis videos (average duration of 7 minutes). Cane Academy videos were developed for multiple courses at the University of Miami Miller School of Medicine [12-14]. Students continued to have access to Cane Academy videos during the 2019 and 2020 Cardiovascular Systems courses. Most of the course topics did not have Cane Academy videos available and relied on traditional classroom lectures; Osmosis videos were assigned for these topics. The comparison in this study is not of Osmosis vs Cane Academy videos but rather the addition of Osmosis to our curriculum as a supplemental resource.

All students were given free access to Osmosis Prime and were advised by instructors to watch 1-2 specific videos among 58 Osmosis cardiovascular videos before each classroom session. In both years, engagement with Osmosis accounted for 4% of the students’ course grade. The course director monitored students’ engagement on a weekly basis using Osmosis dashboards that showed video-viewing data, and each week, the course director emailed histograms of the video-viewing data to each student that showed individual views compared to views of the whole class. Credit was provided based on the course director’s estimate of students having completed 60% of expected video views and associated questions.

All students were emailed electronic surveys after the final exam asking about the course’s blended learning experience and use of videos, including items with Likert-scale response options and open-ended prompts. The surveys were open for 10 days. Likert-scale items asked respondents to “Indicate the degree to which you agree/disagree with the following statements.” Items with open-ended prompts asked for students to comment on what they liked and would change about the “blended learning experience” and did not specifically ask about Osmosis. Osmosis usage data for number of video views, multiple choice questions, and flashcards were extracted from Osmosis dashboards.

We calculated descriptive statistics for Likert-scale items and Osmosis usage data. We compared differences in the proportions of students who agreed or strongly agreed to a survey items across cohorts using the χ^2 test. Based on visual inspection of histograms of cohort usage data, Osmosis usage did not fit a normal distribution. Accordingly, we report medians and IQRs as summary data, and used the Kruskal-Wallis test to examine differences across the 3 cohorts. We used Excel and Stata (StataCorp 2013) for statistical analyses. Responses to the open-ended survey questions were collated into a Microsoft Word document and analyzed independently by two individuals using an editing analysis method. Using thematic analysis [15], we report the themes that emerged from this analysis.

This study was carried out in accordance with the recommendations of the University of Miami Institutional Review Board (IRB protocol 2019-0323). All online survey results were deidentified, therefore negating the need for consent forms.

Results

Overall, 232/359 (64.6%) of the students completed surveys, with rates by class of 81/154 (52.6%) for MD class of 2022, 39/50 (78%) for MD/MPH class of 2022, and 112/155 (72.3%) for MD class of 2023. Osmosis dashboard data were available for all 359 students.

Student surveys indicated that most students (134/232, 57.8%) preferred Osmosis videos to traditional lectures, with greater proportions of students in 2020 preferring Osmosis compared to those in 2019 (P<.001). Preference for Cane Academy videos did not vary by class (Table 1).

Table 1. Respondents who agreed or strongly agreed with each item on the postcourse survey.[a]

Survey item	All (N=232), n (%)	MD 2022 (n=81), n (%)	MD/MPH 2022 (n=39), n (%)	MD 2023 (n=112), n (%)	*P* value[b]
Osmosis videos were easy to access	230 (99.1)	80 (98.8)	39 (100.0)	111 (99.1)	.40
Osmosis video quality (audio, visuals, and other technical aspects) was acceptable	226 (97.4)	76 (93.8)	38 (97.4)	112 (100.0)	.01
The Osmosis videos were helpful to my learning	204 (87.9)	64 (79.0)	34 (87.2)	106 (94.6)	.001
The blended classroom (ie, watching the online Osmosis videos before coming to class) allowed me to reflect on a deeper level…more so than a traditional lecture-based course	197 (84.9)	63 (77.8)	33 (84.6)	101 (90.2)	.01
The Osmosis self-assessment questions were helpful to my learning	177 (76.3)	48 (59.3)	32 (82.1)	97 (86.6)	<.001
I prefer the Osmosis videos to traditional lectures (live or via Panopto recordings)	134 (57.8)	32 (39.5)	20 (51.3)	82 (73.2)	<.001
I prefer the Cane Academy videos to traditional lectures (live or via Panopto recordings)	127 (54.7)	43 (53.1)	18 (46.2)	66 (58.9)	.16

[a]MD 2022 and MD/MPH 2022 took the class in the spring of 2019 and MD 2023 took the class in the spring of 2020.

[b]*P* values are based on the χ^2 test for proportions across the 3 classes.

Student comments to the open-ended prompts described appreciation for having multiple online resources suggested to supplement their learning (eg, “Access to numerous resources allowed me to understand the content from different perspectives…each resource that I used helped reinforce the other”) and greater control over their learning experience (eg, “I loved the autonomy of my schedule to really figure out what learning strategies work best for me”). Students mentioned Osmosis as particularly helpful in preparing for lecture or PBL sessions (eg, “The Osmosis videos did a great job introducing concepts before watching lectures. This method of ‘priming’ was helpful in formulating questions that I could then ask in small group sessions and overall more effectively retain class content”). Suggestions for improvement in Osmosis video implementation related to the course credit linked to Osmosis usage (eg, “The Osmosis videos shouldn’t be mandatory but rather leave recommended videos to supplement the material in class”).

All students received the full credit offered for Osmosis engagement. Across the 3 classes, on average per week, students watched a median of 9 videos, and completed a median of 74 multiple choice questions and a median of 80 flashcards. Video views were greater in 2020 than in 2019 (P<.001), but flashcard usage was lower (P<.001) (Table 2).

Table 2. Median (IQR) student usage of Osmosis during the 8-week Cardiovascular Systems course.

Usage metric	All (N=359)	MD 2022[a] (n=154)	MD/MPH 2022[a] (n=50)	MD 2023[a] (n=155)
Total for course				
Video views[b]	75 (56-103)	61 (50-73)	57 (42-69)	105 (89-136)
MCQs[c] completed	593 (349-779)	595 (349-737)	552 (349-820)	593 (356-815)
FCs[d] completed[b]	637 (10-900)	872 (787-1036)	854 (716-945)	2 (0-32)
Average per week				
Video views[b]	9 (7-13)	8 (6-9)	7 (5-9)	13 (11-17)
MCQs completed	74 (44-97)	74 (44-92)	69 (44-103)	74 (45-102)
FCs completed[b]	80 (1-113)	109 (98-130)	107 (90-118)	0 (0-4)

[a]MD 2022 and MD/MPH 2022 took the class in the spring of 2019 and MD 2023 took the class in the spring of 2020.

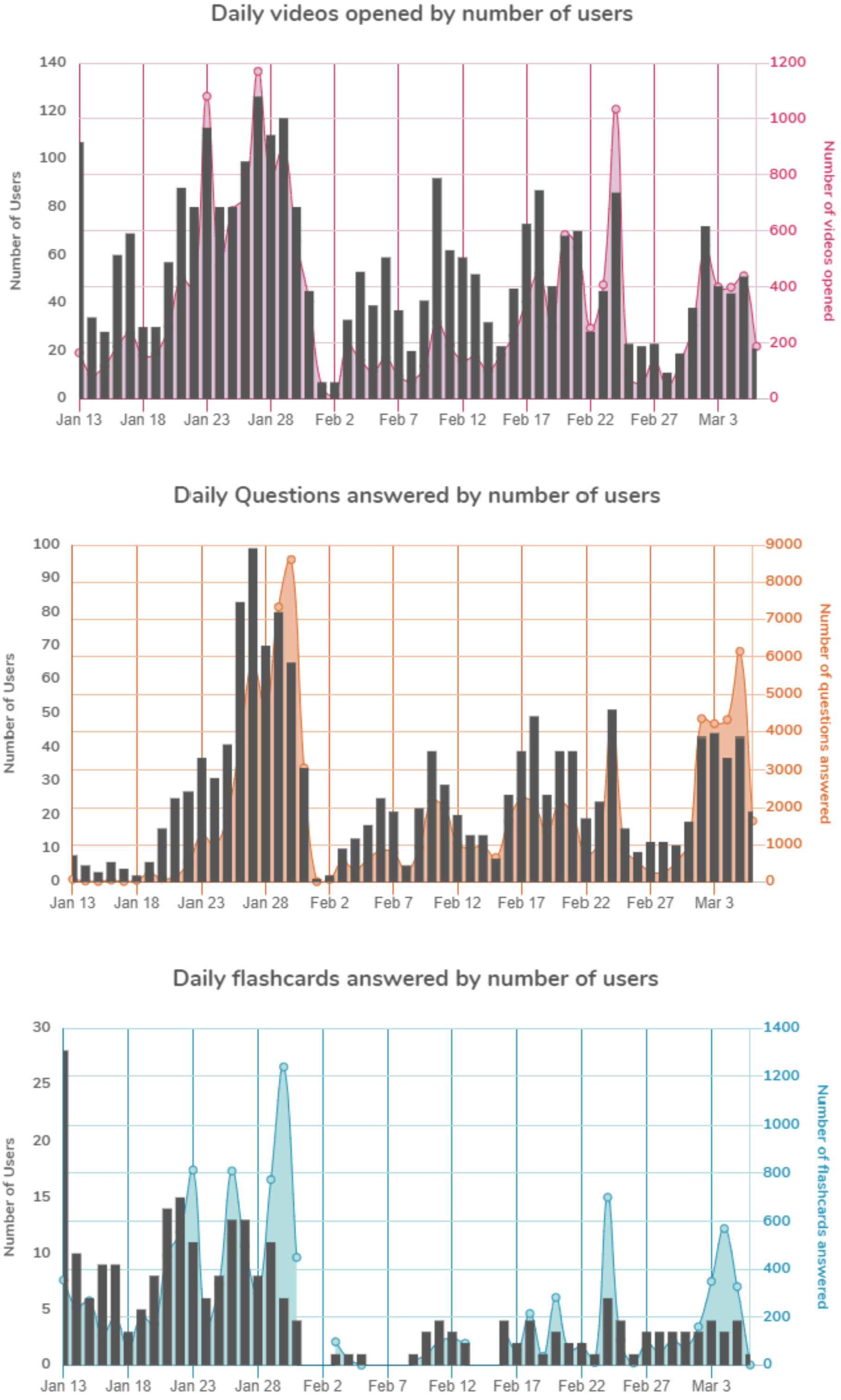
[b]*P*<.001 based on the Kruskal-Wallis test for differences across the 3 classes.

[c]MCQ: multiple choice question.

[d]FC: flashcard.

Overall usage varied over time throughout the course (Figure 1). Usage of videos, multiple choice questions, and flash cards tracked together, likely indicating that students were more prone to use multiple platform features once they began using one feature.

Figure 1. Osmosis dashboard data for MD class of 2023 showing video views, multiple choice questions, and flashcards for all users during the 8-week Cardiovascular Systems course.



Discussion

This evaluation of Osmosis videos in a preclinical cardiovascular systems course at one medical school suggests that videos were acceptable to students, and Osmosis usage expanded beyond video viewing to include answering multiple choice questions and flashcards.

Commercially published resources in the form of textbooks and journal articles are taken for granted in health sciences education; however, it remains a challenge for medical educators to determine the best approaches to incorporate commercially produced digital learning resources for similar purposes. Implementing digital learning resources in medical education has been described as requiring the consideration of 3 technological factors (ie, relative advantage, ease of initial adoption, and availability), 4 teacher factors (ie, attitude toward change, capabilities, pedagogical beliefs and practice, and control), and 4 contextual factors (ie, bureaucracy, politics and purpose, prioritization of research, and culture and discipline) [16]. Technological factors were addressed in our course by selecting a product that students perceived as accessible, easy to use, and preferred over traditional approaches, as illustrated by student survey responses. Most teacher factors were in place as our core group of faculty, including course directors, were enthusiastic about innovation. Some participating faculty expressed resistance, but felt more comfortable after they were invited to edit Osmosis video scripts or point out areas in videos (eg, oversimplification) that were inconsistent with what they typically taught. We previously described a careful choreography that is needed when aligning face-to-face elements with technology-enhanced solutions (such as educational videos) [17]. Part of this blend is to ensure that measurable learning objectives are aligned with educational interventions, formative feedback, and summative assessments. Obtaining faculty feedback and buy-in throughout this blended learning implementation process enriched opportunities for successful course redesign efforts [18]. Faculty generally saved time by using a resource that aligned with their content. Finally, contextual factors favored innovation. The Dean of University of Miami Miller School of Medicine was promoting culture change and curriculum transformation. In obtaining leadership support, we explicitly aligned changes in the Cardiovascular Systems course to leadership goals.

Empiric reports of commercial digital resources for medical student learning are limited and usually focus on licensing exam preparation [19-26]. One report found highly variable usage and a smaller proportion of students using Osmosis when it was provided to students for free without linkage to the curriculum. Lack of faculty champions and time to learn how to use Osmosis were described as barriers to adoption [27]. Although we observed variation in how students used Osmosis in the Cardiovascular Systems course, they all engaged with the platform. We primarily attribute this high usage to providing course credit for Osmosis use, which incentivized students to overcome the barrier of finding time to adopt Osmosis as a new learning resource. Weekly feedback (from the course director to students) on student engagement, which required minimal time and effort, may have also incentivized students to engage with the platform. It is also possible that we helped students avoid the paradox of choice [28], in which having too many options creates distress and decreases the chance that a choice will be made. By offering and supporting a single platform aligned with the course, we simplified their choices, which may have allowed more cognitive effort to be available for learning.

Osmosis learning analytics were useful for tracking student behaviors and providing feedback that compared students to their peers. Learning analytics have examined learning behaviors for other medical education videos [29,30]; however, to our knowledge, this is the first report for videos integrated into a medical student curriculum. Analytics prompted interesting observations. For example, the relatively low usage of Osmosis flashcards was most likely because the students were already accustomed to using Anki flashcards. The peak engagement with the Osmosis platform was before the midterm and final exams, providing insights into how students used Osmosis to study (eg, reviewed videos and practiced questions more intensely before exams). Future work would be required to understand how learning analytics impacted students, as some have expressed concern that learner dashboards may adversely influence learning [31].

Important limitations must be kept in mind when interpreting this work. Although we captured a majority of students from each class with our course evaluation survey and our overall response rate was on par with previously published survey studies [32], our survey relied on student self-report and Likert-scale response options, which are subject to potential measurement error [33]. Although we included 3 classes of students over 2 years, rendering a reasonably large sample, our study was conducted at a single institution; thus, whether our findings would hold in other contexts would require further empiric investigation. We did not design the study to make head-to-head comparisons for Osmosis and Cane Academy videos, and we did not systematically evaluate the perceptions or activities of faculty in the course. Osmosis videos appeared to be comparable in many respects to Cane Academy videos; however, future work is required to understand if Osmosis may have offered a return on investment by decreasing faculty effort. Histograms of cohort usage data were inspected visually without formal statistical testing. We did not design our study to examine relationships between usage and knowledge gains; future work that potentially uses controlled study designs or assesses student behaviors outside of the Osmosis platform may help us to better understand how Osmosis might influence student learning.

In conclusion, commercial medical education videos may enhance curriculum with low faculty effort, improve students' learning experiences, and offer a favorable return on investment to medical schools. This short communication can guide ideas for more robust evaluation and research to better understand how engagement with a digital educational platform and its analytics can influence learning.

Conflicts of Interest

ST receives salary support from Osmosis for research and scholarship. All other authors have no conflicts of interest to declare.

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Abbreviations

PBL: problem-based learning

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Original Paper

Digital Health and Digital Learning Experiences Across Speech-Language Pathology, Phoniatrics, and Otolaryngology: Interdisciplinary Survey Study

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Abstract

Background: Advances in digital health and digital learning are transforming the lives of patients, health care providers, and health professional students. In the interdisciplinary field of communication sciences and disorders (CSD), digital uptake and incorporation of digital topics and technologies into clinical training programs has lagged behind other medical fields. There is a need to understand professional and student experiences, opinions, and needs regarding digital health and learning topics so that effective strategies for implementation can be optimized.

Objective: This cross-sectional survey study aims to interdisciplinarily investigate professional and student knowledge, use, attitudes, and preferences toward digital health and learning in the German-speaking population.

Methods: An open-ended, web-based survey was developed and conducted with professionals and students in CSD including phoniatricians and otolaryngologists, speech-language pathologists (*German: Logopäd*innen*), medical students, and speech-language pathology students. Differences in knowledge, use, attitudes, and preferences across profession, generation, and years of experience were analyzed.

Results: A total of 170 participants completed the survey. Respondents demonstrated greater familiarity with digital learning as opposed to eHealth concepts. Significant differences were noted across profession ($P<.001$), generation ($P=.001$), and years of experience ($P<.001$), which demonstrated that students and younger participants were less familiar with digital health terminology. Professional ($P<.001$) and generational differences were also found ($P=.04$) in knowledge of digital therapy tools, though no significant differences were found for digital learning tools. Participants primarily used computers, tablets, and mobile phones; non–eHealth-specific tools (eg, word processing and videoconferencing applications); and digital formats such as videos, web courses, and apps. Many indicated a desire for more interactive platforms, such as virtual reality. Significant differences were found across generations for positive views toward digitalization ($P<.001$) and across profession for feelings of preparedness ($P=.04$). Interestingly, across profession ($P=.03$), generation ($P=.006$), and years of experience ($P=.01$), students and younger participants demonstrated greater support for medical certification. Commonly reported areas of concern included technical difficulties, quality and validity of digital materials, data privacy, and social presence. Respondents tended to prefer blended learning, a limited to moderate level of interactivity, and time and space–flexible learning environments (63/170, 37.1%), with a notable proportion still preferring traditional time and space–dependent learning (49/170, 28.8%).

Conclusions: This comprehensive investigation into the current state of CSD student and professional opinions and experiences has shown that incorporation of digital topics and skills into academic and professional development curricula will be crucial for ensuring that the field is prepared for the ever-digitalizing health care environment. Deeper empirical investigation into efficacy and acceptance of digital learning and practice strategies and systematic training and practical organizational supports must be planned to ensure adaptive education and practice.

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KEYWORDS

digital learning; e-learning; speech-language pathology; phoniatrics; otolaryngology; communication disorders; mobile phone

Introduction

Background

Rapid technological progress is transforming health care and clinical teaching and learning. Telepractice wearable medical devices, medically certified apps through mobile health (mHealth), health portals, and personalized medicine are among just a few of the many technologies that are increasingly affecting the health care sector. In this context, the multifaceted terms *eHealth* or *digital health*, which encompass many of these technologies, have emerged to describe the evolving means through which technology can be used for information processing and sharing, communication, clinical diagnosis, and treatment to improve human health and well-being [1-4]. Along with these advances in digital health comes the increase in learning through digital means (eg, web courses, simulations, and apps) that allow for learner contact across time and space to promote knowledge creation, expansion, collaboration, and lifelong learning, a phenomenon otherwise known as *e-learning* or *digital learning* [5-8]. The influx of new technological means for health care delivery, teaching, and learning underscores an urgent need to incorporate digital subjects and skills into academic training and professional development milieus [9,10].

However, research has demonstrated that digital skills and the use of digital tools are still not an integral component of professional health care education [11-14]. Suggested explanations for this lack of integration include the demands and competing prioritization of already intensive curricula and the lack of requirements among accrediting bodies [9,15]. Given the current landscape of almost universal ownership of mobile devices among health professionals and students, there is evidence, however, that most health care students prefer web-based resources as their primary source of clinical information [16,17]. Moreover, students often use these devices to access resources for subjects including but not limited to anatomy, drug information, clinical scoring systems, with evidence of increased use of devices during clinical placements [18-20]. However, everyday use of electronic devices does not necessarily translate to effective application in clinical learning contexts. Several studies have shown that students and health professionals are not confident in their eHealth knowledge and skills. In a recent study that surveyed students in 39 European countries, more than half reported poor or very poor eHealth knowledge and skills, and only 40% felt prepared to work in health care contexts increasingly infused with new technologies [21]. Many students cited lack of explicit education on digital skills and tools as a primary reason for feeling unprepared. In the 2016 European Health Parliament survey, more than 80% of the surveyed health care professionals stated that they were insufficiently trained in information and communication technologies and did not feel prepared for developments in eHealth [22]. Considering these findings and rapid technological progress, it is crucial that we begin to examine current student and clinician knowledge, familiarity, and opinions regarding digital health and learning experiences to better incorporate digital skills into clinical education.

In the field of communication sciences and disorders (CSD), investigation into such topics appears to fall behind other medical fields [23,24]. Professionals in CSD treat disorders that affect speech, language, voice, hearing, and the ability to functionally communicate. Although digital technologies such as augmentative and alternative communication (AAC) devices, mathematical-linguistic language modeling, and cochlear implant or hearing aid technologies are well-established [25-27], evidence for digital therapy applications, game-based interventions, and digital screening tools is still emerging [28-33]. Telemedicine and teletherapy are building an evidence base and offer a useful means to deliver services in a patient's natural environment [34-39]. Despite the influx of new digital solutions, knowledge and implementation of such methods and their quality or efficacy as well as the extent to which these are explicitly incorporated into academic training programs remain unclear [40,41]. For example, while several studies have explored telepractice training for students, formal instruction on such service delivery models appears limited [42-44]; in one study, only 26% of the 97 surveyed universities across the United States indicated formally teaching aspects of telepractice in their programs [44]. As professionals and students in CSD have indicated interest in digital health topics and increased digital learning opportunities, it is essential that digital learning competencies and new therapeutic technologies are deliberately incorporated into clinical education and professional development [40,45,46].

Objectives

Importantly, CSD is an interdisciplinary field that includes speech-language pathologists (SLPs; *German: Logopäd*innen*), phoniatricians, and otolaryngologists among other professionals who work closely together to comprehensively treat communication disorders. Given that interdisciplinary education has been identified as a key component to *future proofing* the ever-digitalizing health care environment, it will be useful to investigate interprofessional perspectives and experiences [47-51]. To date, an analysis examining digital health and learning across the interdisciplinary professions involved in CSD has not been conducted, and much existing research primarily comes from the English-speaking population. Examining across profession could be critical to identifying gaps in strategy or implementation and could help to encourage exchange to find collaborative solutions. Thus, this study aims to investigate knowledge, use, attitudes, and preferences toward digital health and learning of current students and professionals across the interdisciplinary fields of speech-language pathology, phoniatrics, and otolaryngology, specifically in the context of German-speaking countries (Germany, Austria, and Switzerland). The potential impacts of profession, generation, and years of experience were also explored.

Methods

Overview

The following cross-sectional survey study was conducted in accordance with the guidelines of the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [52]. In a second part of the survey, the feasibility, attitudes, and preferences for a hypothetical digital learning library app were explored; the results for this second section are presented in a separate article to allow for greater depth of analysis.

Participants and Recruitment

The study was approved by the Ethics Committee of the Medical Faculty, RWTH Aachen University, and participation was voluntary, anonymous, and could be ended at any time. A convenience sample was collected through sharing an invitational letter and flyer containing a link to the open survey with professional regulating bodies and university clinical programs in speech-language pathology, phoniatrics, and otolaryngology, as well as open student and professional groups on Facebook. To partake in the survey, participants had to be one of the following: (1) physician in phoniatrics or otolaryngology, (2) SLP, (3) medical student, (4) speech-language pathology student (SLP student). Before beginning the survey, participants were prompted to read through the detailed study background, aims, procedures, anonymous data to be collected, and data protection policies; were given the information of relevant contact persons for the study such as the study organizer and data privacy office; and were required to give informed consent before proceeding. No personal information was collected other than demographic information including profession, years of experience, generation, and gender. No incentives were offered.

Platform

The web-based survey was hosted on university licensed LimeSurvey version 4.3.14+200826, a web-based statistical survey web application that conforms with the required data security legislation as dictated by the German Federal Data Protection Act, the European Data Protection Directive 95/46/EC, and the European General Data Protection Regulation (GDPR) [53]. Unique survey visitors were tracked by cookies as allowed per participant browser settings to prevent repeated access to the survey, though no IP addresses or personal data were saved. Cookies were set at the start of the survey and were valid for the LimeSurvey default of 365 days.

Survey Design and Content

A semistructured anonymous questionnaire was designed, pretested, and cross-checked by an interdisciplinary team consisting of an SLP, a phoniatrician, and an instructional designer to ensure that questions were clearly formulated and targeted desired data. The survey contained 24 questions pertaining to knowledge, use, attitudes, and preferences regarding digital learning and health as well as sociodemographic information. In total, 1 to 4 questions were displayed per page depending on the question type. There were 12 screens, including the initial page with participant information on which the participant had to give consent before proceeding. The following question types were included in the survey: multiple choice with single fixed choice, multiple answers (with a free-text response option), arrays with Likert scale ratings, yes or no questions, and free-text entries. Directions were provided for each question to avoid confusion (eg, *please choose one of the following answers*, *multiple answers may be chosen*, and *please rate the following statements*), and technical terms were defined as appropriate to ensure common understanding of the topic or intention of the question. Array questions contained 2 to 5 interrelated statements, which participants rated on a 4-point Likert scale (*translated from German:* disagree, somewhat disagree, somewhat agree, agree). An even-numbered scale was used to avoid central tendency bias, and positive versus negative statements were counterbalanced. Free-text entries were conditionally displayed and followed branching logic based on the preceding yes or no question; they allowed for expansion upon the chosen answer and additional comments. All questions except for free-text entries were mandatory for survey completion and submission. As previous literature has demonstrated no differences in missing data, internal consistency reliability, and mean scale scores across survey participant groups given and not given the option of forward and backward navigation [54], these buttons were included as a safeguard to allow for revision in cases of incorrect responses and to allow for reference to previously defined terms. Responses were collected from August to December 2020. Screenshots of the survey are included in Multimedia Appendix 1.

Statistical Analysis

Data from the anonymous surveys were analyzed using the IBM SPSS version 27 [55] to generate descriptive summaries of quantitative data. To investigate the potential effects of (1) profession, (2) generation, and (3) years of experience, Kruskal-Wallis H-tests were performed using an α level of $P<.05$ for survey responses involving ranks, such as increasing levels of agreement, familiarity, and frequency (questions 5, 6, 12, 15, 17, 18, 20, and 22). A Bonferroni adjustment was applied for post hoc pairwise comparisons for all reported significant findings. Chi-square tests were implemented using an alpha level of $P<.05$ to determine whether there were associations among (1) profession, (2) generation, and (3) years of experience and knowledge of digital tools, associated concerns, and perceived benefits in terms of time and space (questions 11, 13, 16, 19, and 21). Cramer *V* coefficients provided insight into the strength of associations. Post hoc *Z* tests for significant chi-square tests were also performed.

Results

Overview

This study analyzed student and clinician knowledge, use, attitudes, and preferences regarding digital health and learning in CSD in German-speaking countries. Of the 213 unique survey visitors, 13 visited the start page (page containing study information and informed consent) but never began the survey and 29 began the survey though did not complete it. Thus, the participation rate was 93.9% (200/213) and the completion rate was 80.3% (171/213). Only completed questionnaires (optional responses not required) were analyzed. One survey from a student in dentistry could not be used, and thus 170 total surveys were analyzed for the study. Participant characteristics are summarized in Table 1. Generations were defined according to divisions specified by the Pew Research Center [56].

Table 1. Participant characteristics.

Characteristics	Values, n (%)
Gender	
Female	150 (88.2)
Male	20 (11.8)
Profession	
Physician (phoniatrician, ENT[a])	34 (20)
Speech-language pathologist	72 (42.4)
Medical student (German: *Humanmedizin*)	21 (12.4)
Speech-language pathology student	43 (25.3)
Generation	
Generation Z (1996+)	57 (33.5)
Generation Y, millennial (1980-1995)	64 (37.6)
Generation X (1965-1979)	35 (20.6)
Baby boomer (1946-1964)	14 (8.2)
Years of experience	
0[b]	61 (35.9)
1-5	40 (23.5)
6-10	15 (8.8)
11-15	11 (6.5)
16-20	19 (11.2)
>20	24 (14.1)

[a]ENT: ear, nose, and throat.

[b]Still studying.

Knowledge

Regarding knowledge of the terms *digital health* and *eHealth*, of the total 170, 20 (11.8%) respondents had heard of the terms and felt confident in their knowledge, 88 (51.8%) respondents indicated having heard of the terms but having limited knowledge, 38 (22.3%) indicated having heard of the terms but being unsure of their meaning, and 24 (14.1%) indicated having never heard of the terms. Kruskal-Wallis tests further revealed significant effects of profession (H_3=30.918; P<.001), generation (H_3=15.914; P=.001), and years of professional experience (H_3=27.054; P<.001) on the level of familiarity with these terms. Pairwise comparisons using the Bonferroni correction revealed that differences were particularly prominent between SLPs and SLP students (P=.013), physicians and SLP students (P<.001), physicians and medical students (P<.001), and physicians and SLPs (P=.03), with the former reporting greater familiarity with the terms than the latter. Pairwise comparisons also revealed that Generation X reported greater familiarity with the terms than generations Z (P=.002) and Y (P=.04). Respondents who were still studying (no experience) tended to be significantly less familiar with the terms *digital health* and *eHealth* than those who had 16 to 20 years of experience (P=.001) and those who had more than 20 years of experience (P=.005).

In contrast, when respondents were asked about their familiarity with the terms *digital learning* or *e-learning*, 40.6% (69/170) respondents reporting being familiar with and feeling confident with the terms, 54.7% (93/170) indicated being familiar with the terms but having limited knowledge, and 4.7% (8/170) reported having heard of the terms but being unsure of their meaning. No significant differences were found across profession, generation, or years of experience. These terms were explicitly defined following these questions to ensure common understanding for the remainder of the survey. The terms *digital health*, and *eHealth*, were defined as *the use of technology or digital media to promote, maintain, or manage a person's health*. The terms *digital learning* and *e-learning* were defined as "all forms of learning in which electronic or digital media are used to support learning processes, in this case especially in the context of medical or clinical education."

To similarly establish common understanding, the term *digital therapy tool* was broadly defined as "any electronic or digital media to be used for clinical or clinical research purposes (eg, health tracking, diagnostic tool, therapy exercises)." Regarding familiarity with such tools, 61.8% (105/170) respondents indicated being familiar with such tools, whereas 38.2% (65/170) were not. Significant differences in knowledge of digital therapy tools were found across profession (χ^2_3=20.3; *P*<.001), with a moderate effect size (Cramer *V*=0.346; *P*<.001). Post hoc Z tests demonstrated significant differences at the *P*=.05 level for physicians and medical students who were less familiar with digital therapy tools and for SLPs who were more familiar with digital therapy tools. Significant differences were also found across generations (χ^2_3=8.5; *P*=.04) with a moderate effect size (Cramer *V*=0.224; *P*=.04). Generation Y (millennials) had more respondents who were familiar with digital therapy tools (*P*=.05). No significant differences were demonstrated across years of experience.

A total of 50% (85/170) participants responded to the optional follow-up question "What digital therapy tools are you already familiar with? What did you think of these tools?" Free-text responses consisted of references to general digital therapy tools (19/85, 22.4%; eg, *apps*, *computer programs*, *teletherapy platforms,* and *AAC devices*), specific tools (63/85, 74.1%; eg, *Neolexon, Lexico,* and *Metatalk*), and responses that included both general and specific tools (3/85, 3.5%). Notably, there were several digital health tools mentioned that were unrelated to communication disorders or used for personal use (eg, fitness apps or health insurance apps; n=16). The relevant digital therapy tools that were mentioned included therapy apps (n=77), AAC devices/software (n=13), computer learning software for children (n=19), teletherapy videoconferencing platforms (n=8), computer-based web programs (n=8), diagnostic apps or computer software (n=3), and other (n=4). The most frequently reported digital tools were the therapy apps Neolexon (n=26), Speech Care (n=11), Phonolo (n=6), and Lexico (n=5). Opinions regarding digital therapy tools were mixed. Positive reports included ease of access, increased practice opportunities for patients, user-friendliness of some applications, usefulness of complexity and stimuli settings, and the potential for increasing patient motivation through interactive activities. Reported negative opinions included associated costs, issues with navigation and user-friendliness (especially for older patients), concerns of screen time and distractibility for children, and an emphasis on digital tools only as a supplement to traditional therapy. In relation to associated costs, one respondent added that paid apps often provided greater user support and features.

To ensure common understanding, the term *digital learning tool* was predefined *as* "electronic or digital media that can be used for learning purposes at the undergraduate, graduate, or professional development levels." In terms of knowledge of digital learning tools, of the total 170, 131 (77.1%) respondents indicated that they were already familiar, whereas 39 (22.9%) were not. No significant differences were found across profession, generation, or years of experience. A total of 62.4% (106/170) participants responded to the optional follow-up question "What digital learning tools are you already familiar with for academic studies, teaching, or continuing education? What did you think of these tools?" Responses consisted of references to general digital learning tools (41/106, 38.7%; eg, *podcasts, webinars,* or *platforms*), specific tools (52/106, 49.1%; eg, *Moodle, KenHub,* or *Zoom*), and responses that included both general and specific tools (13/106, 12.3%). Digital learning tools fell into the general categories of learning management systems (n=50), videoconferencing systems (n=34), web courses or webinars (n=28), videos (n=26), web journals (n=18), apps (n=17), websites and search engines (n=17), learning platforms (n=15), podcasts (n=8), digital notecards (n=7), collaboration platforms (n=7), web polling (n=6), repositories of shared materials (n=5), forums (n=2), e-books (n=2), presentation software (n=3), clinical learning tools (n=2), and other (n=5). In terms of specific resources, the learning management system Moodle (n=33), the videoconferencing platforms Zoom (n=19) and Microsoft Teams (n=9), the video platform YouTube (n=9), and the web journal platform PubMed (n=5) were the most frequently mentioned. Notably, many of the mentioned digital learning tools were not specific to the field of CSD, but rather general to educational milieus. Opinions regarding digital learning tools were mixed. Reported benefits included flexibility and accessibility, usefulness for learning theoretical material, the variety of tools available, and multifunctionalities. In addition, 3 participants mentioned that experiences were often dependent on specific implementation by instructors. Frequently reported concerns included limited direct interaction and opportunity to ask follow-up questions, lack of user-friendliness, the learning curve to use digital tools, and concerns regarding the effectiveness for complex topics or practical skills.

Use

Digital tool use was primarily descriptively analyzed across devices, software or digital system, formats, and frequency of use. Whereas *devices* referred to specific electronic equipment (eg, computer, smartphone), *software or digital system* referred to commonly used clinical and non– clinical-specific tools or programs serving a specific purpose (eg, word processing software or e-billing), and formats referred to the text-, visual-, or multimedia-based presentation of the information (eg, video or podcast). Students and professionals in CSD appear to use computers (n=168), smartphones (n=137), and tablets (n=90) as their primary devices for digital therapy, teaching, and learning purposes. They also use e-Readers (n=7) and MP3 players (n=6). Other devices mentioned in the optional free response *other* category included *electronic communication supports* (n=1), *laptops* (n=2), and *audio recorders* (n=2). Only one respondent used game consoles or virtual reality (VR) equipment for therapy, teaching, or learning purposes. A summary of device use across profession, generation, and years of experience is shown in Table 2.

Word processing software (n=169), presentation software (n=141), videoconferencing software (n=141), research databases (n=115), and spreadsheet software (n=114) were the most frequently reported software or digital systems used among respondents. Respondents also reported using online appointment systems (n=70), electronic health records (n=60), statistics software (n=52), hospital information systems (n=38), e-billing ((n=28), hospital communication systems (n=18), e-prescriptions (n=15), and telemedicine (n=13). In the optional free response *other* category, respondents also reported using *WhatsApp* (n=1), *cloud learning platform* (n=1), *test evaluation software* (n=1), *therapy apps* (n=1), *therapy material database* (n=1), and *handwritten digital notes via Notability* (n=1). A summary of software or digital system used across profession, generation, and years of experience is shown in Table 3.

Table 2. Device use across profession, generation, and years of experience.

	Computer	Smartphone	Tablet	e-Reader	MP3	Virtual reality equipment	Game console	Other
Profession (number of participants), n (%)								
Physicians	34 (100)	20 (59)	16 (47)	2 (6)	2 (6)	0 (0)	0 (0)	0 (0)
SLPs[a]	71 (99)	58 (81)	40 (56)	3 (42)	4 (5)	1 (1)	0 (0)	2 (3)
SLP students	43 (100)	38 (88)	17 (40)	1 (2)	0 (0)	0 (0)	0 (0)	3 (7)
Medical students	20 (95)	21 (100)	17 (81)	1 (5)	0 (0)	0 (0)	0 (0)	0 (0)
Generation (number of participants), n (%)								
Generation Z	56 (98)	53 (93)	31 (54)	3 (5)	0 (0)	0 (0)	0 (0)	0 (0)
Generation Y	64 (100)	55 (86)	30 (47)	0 (0)	3 (5)	0 (0)	0 (0)	4 (6)
Generation X	34 (97)	23 (66)	23 (66)	3 (9)	3 (9)	0 (0)	0 (0)	1 (3)
Baby boomer	14 (100)	6 (43)	6 (43)	1 (7)	0 (0)	1 (7)	0 (0)	0 (0)
Experience (years), n (%)								
0[b]	60 (98)	55 (90)	32 (52)	2 (3)	0 (0)	0 (0)	0 (0)	2 (3)
1-5	40 (100)	37 (93)	19 (48)	2 (5)	2 (5)	0 (0)	0 (0)	1 (3)
6-10	15 (100)	12 (80)	9 (60)	0 (0)	2 (13)	0 (0)	0 (0)	1 (7)
11-15	11 (100)	10 (91)	6 (55)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16-20	18 (95)	10 (53)	13 (68)	1 (5)	2 (11)	0 (0)	0 (0)	1 (5)
>20	24 (100)	13 (54)	11 (46)	2 (8)	0 (0)	1 (4)	0 (0)	0 (0)

[a]SLPs: speech-language pathologists.

[b]Still studying.

Table 3. Software or digital system use across profession, generation, and years of experience.

	Word processing	Videoconferencing	Presentation software	Research databases	Spreadsheet software	Web Appt. system[a]	Electronic health record	Statistics software	Hospital information system	e-Billing	Hospital communication system	e-Prescriptions	Telepractice	Other
Profession (number of participants), n (%)														
Physicians	33 (97)	27 (79)	27 (79)	27 (79)	28 (82)	19 (56)	24 (71)	15 (44)	19 (56)	14 (41)	13 (38)	8 (24)	7 (21)	2 (6)
SLPs[b]	72 (100)	55 (76)	59 (82)	49 (68)	56 (78)	34 (47)	30 (42)	26 (36)	15 (21)	13 (18)	4 (6)	4 (6)	6 (8)	3 (4)
SLP students	43 (100)	42 (98)	42 (98)	30 (70)	22 (51)	10 (23)	3 (7)	8 (19)	0 (0)	1 (2)	1 (2)	3 (7)	0 (0)	0 (0)
Medical students	21 (100)	17 (81)	13 (62)	9 (43)	8 (38)	7 (33)	3 (14)	3 (14)	4 (19)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)
Generation (number of participants), n (%)														
Generation Z	57 (100)	53 (93)	49 (86)	38 (67)	30 (53)	14 (26)	10 (18)	12 (21)	4 (7)	4 (7)	0 (0)	1 (2)	4 (7)	1 (2)
Generation Y	64 (100)	48 (75)	52 (81)	44 (69)	45 (70)	29 (45)	25 (39)	25 (39)	16 (25)	6 (9)	8 (13)	7 (11)	2 (3)	3 (5)
Generation X	35 (100)	28 (80)	29 (83)	22 (63)	29 (83)	22 (63)	18 (51)	9 (26)	12 (34)	16 (46)	6 (17)	6 (17)	7 (20)	1 (3)
Baby boomer	13 (93)	12 (86)	11 (79)	11 (79)	10 (71)	5 (36)	7 (50)	6 (43)	6 (43)	2 (14)	4 (29)	1 (7)	0 (0)	1 (7)
Experience (years), n (%)														
0[c]	61 (100)	56 (92)	53 (87)	38 (62)	29 (48)	17 (28)	7 (11)	10 (16)	4 (7)	2 (3)	0 (0)	3 (5)	0 (0)	1 (2)
1-5	40 (100)	29 (73)	31 (78)	29 (73)	28 (70)	13 (33)	13 (33)	17 (43)	5 (13)	7 (18)	3 (8)	3 (8)	5 (13)	3 (8)
6-10	15 (100)	12 (80)	12 (80)	9 (60)	12 (80)	9 (60)	10 (67)	6 (40)	8 (53)	2 (13)	3 (20)	2 (13)	1 (7)	0 (0)
11-15	11 (100)	9 (82)	10 (91)	9 (82)	11 (100)	8 (73)	8 (73)	6 (55)	5 (45)	1 (9)	3 (27)	0 (0)	3 (27)	1 (9)
16-20	18 (95)	15 (79)	13 (68)	12 (63)	15 (79)	8 (42)	9 (47)	6 (32)	5 (26)	8 (42)	4 (21)	3 (16)	4 (21)	1 (5)
>20	24 (100)	20 (83)	22 (92)	18 (75)	19 (79)	15 (63)	13 (54)	7 (29)	11 (46)	8 (33)	5 (21)	4 (17)	0 (0)	0 (0)

[a]Web Appt. system: Web Appointment system.

[b]SLPs: speech-language pathologists.

[c]Still studying.

In terms of digital formats, respondents most frequently used videos (n=155), websites (n=150), web-based seminars or courses (n=130), and apps (n=100). When compared with digital formats that respondents could imagine themselves using in the future, many respondents reported also being open to other currently less frequently available digital formats including podcasts (n=112), 3D models (n=108), simulations (n=106), e-books (n=105), VR (n=72), serious games (n=66), and social networking (n=59). In the *other* category, respondents mentioned *learning platforms such as Moodle and Ilias* (n=1) and the Promethean ActivTable for Education. These results are shown in Figure 1. A summary of current and future digital format use across profession, generation, and years of experience is shown in Table 4.

Figure 1. Current and future use of digital format among study participants.

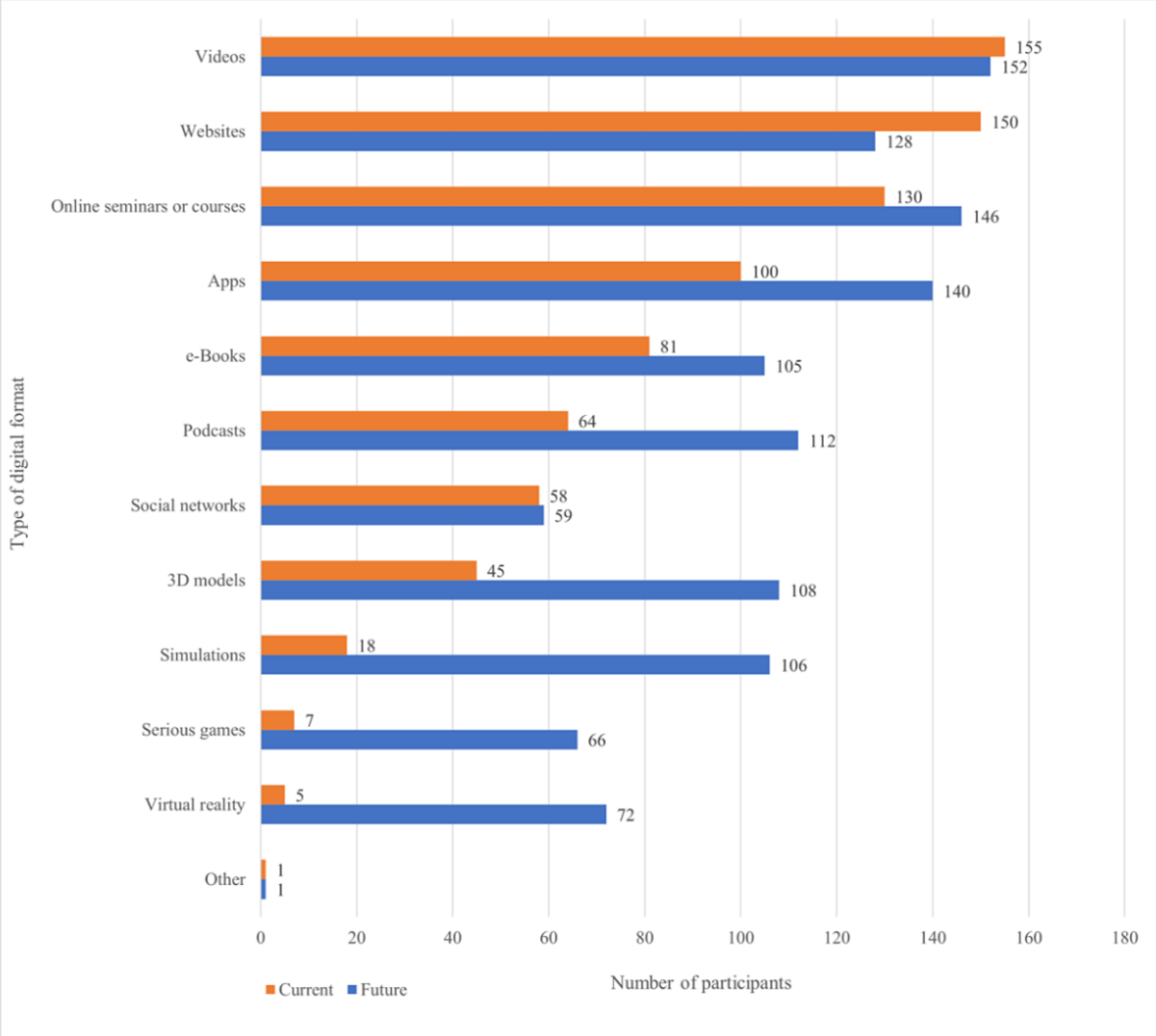

Table 4. Current (C) and future (F) digital format use across profession, generation, and years of experience.

	Videos	Websites	Web seminars or courses	Apps	e-Books	Podcasts	Social networks	3D models	Simula-tions	Serious games	Virtual reality	Other
Profession (number of participants), n (%)												
Physicians (C)	31 (91)	29 (85)	28 (82)	11 (32)	13 (38)	13 (38)	5 (15)	8 (24)	6 (18)	1 (3)	3 (9)	0 (0)
Physicians (F)	30 (88)	27 (79)	28 (82)	24 (71)	18 (53)	22 (65)	6 (18)	21 (62)	19 (56)	4 (12)	14 (41)	0 (0)
SLPs[a] (C)	64 (89)	65 (90)	57 (79)	44 (61)	33 (46)	28 (39)	33 (46)	16 (22)	3 (4)	2 (3)	1 (1)	1 (1)
SLPs (F)	66 (92)	56 (78)	65 (90)	63 (88)	46 (64)	46 (64)	30 (42)	48 (67)	47 (65)	35 (49)	34 (47)	1 (1)
SLP Students (C)	41 (95)	37 (86)	33 (77)	27 (63)	22 (51)	10 (23)	9 (21)	14 (33)	5 (11)	1 (2)	0 (0)	0 (0)
SLP students (F)	37 (86)	29 (67)	37 (86)	33 (77)	26 (60)	28 (65)	13 (30)	24 (56)	23 (53)	19 (44)	12 (28)	0 (0)
Medical students (C)	19 (90)	19 (90)	12 (57)	18 (86)	13 (62)	13 (62)	11 (52)	7 (33)	4 (19)	3 (14)	1 (5)	0 (0)
Medical students (F)	19 (90)	16 (76)	16 (76)	20 (95)	15 (71)	16 (76)	10 (48)	15 (71)	17 (81)	8 (38)	12 (57)	0 (0)
Generation (number of participants), n (%)												
Generation Z (C)	53 (93)	50 (88)	39 (68)	40 (70)	32 (56)	22 (39)	23 (40)	18 (32)	7 (12)	4 (7)	1 (2)	0 (0)
Generation Z (F)	52 (91)	44 (77)	48 (84)	50 (88)	37 (65)	42 (74)	24 (42)	36 (63)	40 (70)	29 (51)	21 (37)	0 (0)
Generation Y (C)	58 (90)	55 (86)	50 (78)	41 (64)	26 (41)	18 (28)	26 (41)	15 (23)	4 (6)	2 (3)	0 (0)	1 (2)
Generation Y (F)	56 (88)	45 (70)	53 (83)	53 (83)	39 (61)	39 (61)	23 (36)	42 (66)	37 (58)	23 (36)	26 (41)	1 (2)
Generation X (C)	31 (89)	32 (91)	29 (83)	13 (37)	18 (51)	19 (54)	8 (23)	9 (26)	5 (14)	1 (3)	3 (9)	0 (0)
Generation X (F)	31 (89)	27 (77)	32 (91)	27 (77)	22 (63)	23 (66)	9 (26)	20 (57)	21 (60)	11 (31)	17 (49)	0 (0)
Baby boomer (C)	13 (93)	13 (93)	12 (86)	6 (43)	5 (36)	5 (36)	1 (7)	3 (21)	2 (14)	0 (0)	1 (7)	0 (0)
Baby boomer (F)	13 (93)	12 (86)	13 (93)	10 (71)	7 (50)	8 (57)	3 (21)	10 (71)	8 (57)	3 (21)	8 (57)	0 (0)
Experience (years), n (%)												
0[b] (C)	58 (95)	53 (87)	42 (69)	44 (72)	34 (56)	22 (36)	19 (31)	19 (31)	9 (15)	4 (7)	1 (2)	1 (2)
0 (F)	54 (89)	43 (70)	51 (84)	51 (84)	39 (64)	42 (69)	22 (36)	38 (62)	39 (64)	28 (46)	23 (38)	0 (0)
1-5 (C)	35 (88)	35 (88)	31 (78)	25 (63)	21 (53)	11 (28)	22 (55)	10 (25)	1 (3)	1 (3)	0 (0)	0 (0)
1-5 (F)	35 (88)	30 (75)	33 (83)	33 (83)	26 (65)	23 (58)	15 (38)	27 (68)	26 (65)	16 (40)	15 (38)	0 (0)
6-10 (C)	13 (87)	14 (93)	12 (80)	9 (60)	4 (27)	6 (40)	6 (40)	4 (27)	0 (0)	0 (0)	0 (0)	0 (0)
6-10 (F)	15 (100)	12 (80)	14 (93)	14 (93)	8 (53)	10 (67)	7 (47)	9 (60)	6 (40)	6 (40)	4 (27)	0 (0)

	Videos	Websites	Web seminars or courses	Apps	e-Books	Podcasts	Social networks	3D models	Simula-tions	Serious games	Virtual reality	Other
11-15 (C)	11 (100)	8 (73)	10 (91)	5 (45)	3 (27)	6 (55)	4 (36)	2 (18)	1 (9)	1 (9)	1 (9)	0 (0)
11-15 (F)	10 (91)	9 (82)	8 (73)	9 (82)	6 (55)	9 (82)	6 (55)	8 (73)	9 (82)	5 (45)	8 (73)	1 (9)
16-20 (C)	16 (84)	17 (89)	16 (84)	7 (37)	7 (37)	9 (47)	2 (11)	5 (26)	2 (11)	1 (5)	0 (0)	0 (0)
16-20 (F)	15 (79)	14 (74)	16 (84)	17 (89)	10 (53)	14 (74)	2 (11)	12 (63)	11 (58)	6 (32)	8 (42)	0 (0)
>20 (C)	22 (92)	23 (96)	19 (79)	10 (42)	12 (50)	10 (42)	5 (21)	5 (21)	5 (21)	0 (0)	3 (13)	0 (0)
>20 (F)	23 (96)	20 (83)	24 (100)	16 (67)	16 (67)	14 (58)	7 (29)	14 (58)	15 (63)	5 (21)	14 (58)	0 (0)

[a]SLPs: speech-language pathologists.

[b]Still studying.

When asked about frequency of digital therapy tool use, of the total 170, 47 (27.6%) respondents indicated that they were still studying, 60 (35.3%) respondents indicated never using digital therapy tools, 27 (15.9%) indicated monthly, 26 (15.3%) indicated weekly, and 10 (5.9%) indicated daily. Significant effects for profession (H_3=15.200; P=.002), generation (H_3=12.184; P=.007), and years of experience (H_3=20.807, P=.001) were found. Post hoc comparisons revealed that SLPs used digital therapy tools significantly more frequently than SLP students (P=.01) and medical students (P=.03). Across generations, Generation Z reportedly used digital therapy tools significantly less frequently than Generation Y (P=.01) and X (P=.03), which can likely be attributed to the fact that these individuals are typically still studying and thus have yet to implement these tools in practice. Finally, respondents with 1 to 5 years of experience were noted to use digital therapy tools at a significantly greater frequency than respondents who were still studying (P=.001).

Regarding digital learning tools, 18.8% (32/170) respondents never used such tools, 31.2% (53/170) used these monthly, 32.9% (56/170) used these weekly, and 17.1% (29/170) used digital learning tools daily. Significant differences were found across generation (H_3=11.447; P=.01) and years of experience (H_3=12.476; P=.03). Post hoc comparisons revealed that Generation Z used digital learning tools significantly more frequently than Generation Y. No significant differences were found across years of experience in post hoc analyses.

Attitudes

Most of the respondents held positive views regarding digitalization in medicine. When asked whether they viewed digitalization positively, of the total 170, 68 (40%) respondents agreed, 90 (52.9%) somewhat agreed, 11 (6.5%) somewhat disagreed, and 1 (0.6%) disagreed. Significant generational differences were found (H_3=18.604; P<.001) with Generation Z viewing digitalization significantly more positively than Generation Y (P=.003), X (P=.02), and baby boomers (P=.008). When asked whether they felt prepared for the digital revolution, of the 170, only 29 (17.1%) respondents fully agreed, 78 (45.9%) somewhat agreed, 58 (34.1%) somewhat disagreed, and 5 (2.9%) fully disagreed. Significant differences were found across profession (H_3=8.522; P=.04) specifically with SLPs reporting greater preparedness than SLP students (P=.04). In total, of the 170, 105 (61.8%) respondents fully agreed and 60 (35.3%) somewhat agreed that eHealth, digital tools, and competences needed to be integrated into future curricula, whereas 5 (2.9%) individuals somewhat disagreed.

Regarding digital therapy tool attitudes, of the 170, 91 (53.5%) respondents agreed, 74 (43.5%) somewhat agreed, and 5 (2.9%) somewhat disagreed to being open to the use of digital therapy tools. In total, 28.2% (48/170) respondents agreed and 41.2% (70/120) somewhat agreed that digital therapy tools offered more advantages than disadvantages with the potential to individualize therapy, whereas 28.8% (49/170) somewhat disagreed and 1.8% (3/170) disagreed. A total of 2.9% (5/170) respondents agreed and 32.4% (55/170) somewhat agreed that they doubted the quality or validity of digital therapy tools, whereas 53.5% (91/170) somewhat disagreed and 11.2% (19/170) fully disagreed. When asked whether they would be more likely to use a digital therapy tool if it were medically certified, of the 170 respondents, 87 (51.2%) respondents agreed, 63 (37.1%) somewhat agreed, 16 (9.4%) somewhat disagreed, and 4 (2.4%) disagreed. Significant differences were demonstrated across profession (H_3=8.806; P=.03), generation (H_3=12.499; P=.006), and years of experience (H_3=14.270; P=.01). Pairwise comparisons revealed no significant differences across professions, though Generation Z tended to agree with using medically certified products more strongly than Generation X (P=.008). Across years of experience, respondents who were still studying agreed more with the use of medically certified products than their counterparts with ≥20 years of experience (P=.02). When asked whether they would pay a fair price for a digital therapy tool given good ratings, of the 170, 38 (22.4%) respondents agreed, 103 (60.6%) somewhat agreed, 26 (15.3%) somewhat disagreed, and 3 (1.8%) disagreed.

When asked about concerns regarding digital therapy tools, 8.8% (15/170) respondents indicated no concerns, 55.9% (95/170) indicated technical difficulties, 49.4% (84/170) indicated limited validity of digital therapy tools, and 72.9% (124/170) indicated insufficient diagnostic and therapeutic quality of tools. A total of 12.9% (22/170) participants indicated *other* concerns in the free response field. Of these, concerns regarding patient use in terms of patient resistance to such technologies, limited reliability and consistency of use, limits in terms of the individualization of care, potential associated costs, and the potential of cognitive overload especially for older patients were mentioned (n=10). In total, 2.9% (5/170) respondents emphasized problems with data privacy and security as an additional concern; 2.4% (4/170) respondents also emphasized the value of direct face-to-face therapy and human interactions, with 0.6% (1/170) respondent specifically citing the negative effects of screen time on child language and social development. Other notable concerns included legal repercussions in cases of medical malpractice and the current lack of sufficient knowledge and exchange regarding digital therapy tools.

Regarding digital learning tool attitudes, of the 170, 125 (73.5%) respondents agreed, 42 (24.7%) somewhat agreed, and 3 (1.8%) somewhat disagreed to being open to the use of digital learning tools. In total, 41.8% (71/170) respondents agreed, 44.7% (76/170) somewhat agreed, 12.4% (21/170) somewhat disagreed, and 1.2% (2/170) disagreed that digital learning offered more advantages than disadvantages. Furthermore, 0.6% (1/170) respondent agreed, 7.1% (12/170) somewhat agreed, 62.9% (107/170) somewhat disagreed, and 29.4% (50/170) disagreed that they doubted the quality and validity of digital learning tools. Many respondents agreed (97/170, 57.1%) and somewhat agreed (57/170, 33.5%) that they would be more likely to use a digital learning tool if it were to be developed by an academic institution or professional regulating body, whereas 5.9% (10/170) somewhat disagreed and 3.5% (6/170) fully disagreed. In total, 21.8% (37/170) respondents agreed, 44.7% (76/170) somewhat agreed, 26.5% (45/170) somewhat disagreed, and 7.1% (12/170) disagreed that they felt confident in their knowledge of digital learning tools.

When asked about their concerns regarding digital learning tools, 11.8% (20/170) respondents reported no concerns, 52.4% (89/170) reported technical difficulties, 45.3% (77/170) reported questionable quality of learning material, 40% (68/170) reported difficulties with self-discipline and sufficient learning competence, and 52.4% (89/170) had concerns regarding reduced social interaction. A total of 10.6% (18/170) participants indicated *other* concerns in the free response field. Of these 18 responses, 2 respondents' answers expanded upon closed answer choices (eg, *lack of discussion partners* in relation to the answer choice *concerns regarding potentially reduced social interaction*). Five respondents expanded upon concerns regarding the quality of learning, citing the difficulty to verify the quality of digital learning tools, compromised retention of knowledge, the questionable practical relevance of digital learning for the development of interpersonal skills, and fears regarding the potential depreciation of therapeutic competence. Other concerns mentioned included limited scope and specificity of learning materials, difficulty with tracking attendance and engagement, extensive preparation time for digital material, associated costs, and compromised data privacy.

Preferences

Respondents were asked to indicate their preferred level of virtuality, interactivity, and flexibility in terms of time and space. Out of the 170 total respondents, 4 (2.4%) indicated that they preferred in-person learning, 39 (22.9%) preferred in-person learning with additional e-material, 105 (61.8%) respondents preferred blended learning, and 22 (12.9%) preferred the inverted classroom approach. In terms of interactivity, 21 (12.4%) respondents preferred a passive level, 69 (40.6%) preferred a limited level, 63 (37.1%) preferred a moderate or complex level, and 17 (10.0%) preferred an advanced or active level. No significant differences across profession, generation, or years of experience were found regarding the preferred level of virtuality and interactivity. In terms of time and space flexibility, 28.8% (49/170) respondents preferred traditional time and space–dependent learning environments, 3.5% (6/170) preferred time flexibility only, 30.6% (52/170) preferred space flexibility only, and 37.1% (63/170) respondents preferred time and space–flexible learning environments. As data did not meet chi-square test assumptions for the minimal number of observations per cell, significant findings across profession and years of experience are not reported.

Discussion

Principal Findings

This cross-sectional survey study is, to the best of our knowledge, one of the first to investigate knowledge, use, attitudes, and preferences regarding digital health and learning topics interdisciplinarily across the fields of speech-language pathology, phoniatrics, and otolaryngology, which work collaboratively together to treat communication disorders. Although some previous studies have investigated some of these aspects within each respective field, it is useful to analyze across disciplines to identify knowledge gaps, areas for improvement, and collaborative problem-solving opportunities.

Knowledge

Participants overall reported greater surface level knowledge regarding terminology and specific therapeutic and learning tools. When presented with the terms *digital health* and *eHealth*, only 11.8% (20/170) of respondents indicated feeling confident in their knowledge of the terms. This was especially evident between students and working professionals, the latter of which indicated greater familiarity with terminology as they are more likely to encounter such concepts in their clinical practice. Moreover, the significant finding that older generations and professionals with more experience had greater familiarity of such terminology than their younger and less experienced counterparts highlights the urgency to make eHealth and digital skills an integral part of clinical curricula. In previous studies, health science students similarly reported uncertainty with information technology in health care settings, even if they were confident using technologies in everyday situations. An automatic transfer of digital skills to professional contexts cannot be assumed simply because students are *digital natives* [12,15,57,58]. In fact, the literature has shown that students develop their understandings of eHealth through exposure with concepts and thus require direct instruction and scaffolding. These can in turn help to build confidence with eHealth technologies and contextualized clinical skills [15,40]. Although a 2021 study found that 16 universities across Germany had integrated digital competence–related coursework in their curricula, the extent of integration varied significantly, and many only included elective coursework [59]. Exploring successes and areas for improvement in these examples could serve as a useful starting point from which to explore effective and expanded implementation. Notably, SLPs also demonstrated significantly less familiarity with these terms than their physician counterparts. This finding could potentially be explained by the fact that digital health developments and legislation, such as the Digital Healthcare Act (*Digitale-Versorgung-Gesetz*) in Germany has primarily been medicine-focused and has not equally engaged all clinical fields [60]. Given that quality patient care requires the coordinated efforts of interdisciplinary professionals, it will be crucial that allied medical fields are more deliberately included into digital health developments and legislative action moving forward.

In contrast, respondents reported being more knowledgeable regarding the terms *digital learning* and *e-learning*. This is not surprising given that the term *e-learning* emerged in the 1990s and has since even spread to outside academic contexts, whereas the definition of the term *eHealth* has been debated since the early 2000s, and the debate continues today [61-64]. Although the terms *digital health* and *eHealth* have often been used interchangeably, the World Health Organization has suggested that *digital health* refers to the general use of technologies for health and can encompass eHealth, which refers to the application of health care information technologies (eg, e-billing or e-prescriptions) [65]. However, the fact that over half of respondents still indicated limited knowledge regarding these terms demonstrates the continued need to deliberately familiarize and integrate digital learning tools into learning milieus. This is especially important amidst the ongoing COVID-19 pandemic when much academic learning and professional tasks have shifted onto digital platforms, calling for increased inquiry into effective methods for facilitating an effective and continued digital shift [66]. Learners must be invited to co-design and evaluate digital learning curricula and eHealth technologies so that they feel more prepared to adopt such strategies and adjust as innovations continue to emerge [67].

Most of the respondents indicated knowing digital therapy tools, especially SLPs when compared with physicians and medical students. Although this finding could be explained by different professional scopes of practice, it could also reveal a gap that interdisciplinary collaboration could help to close. Although there is existing literature regarding digital applications in otorhinolaryngology and phoniatrics in the German-speaking population [68,69], these were not well-known among the surveyed physicians and medical students, indicating a need for greater engagement of students and professionals in the evaluation of such tools. Given the surge of eHealth apps during Generation Y's entrance into the workforce, it is also not surprising that they reported significantly greater knowledge of digital therapy tools, having also been labeled as the most *health-conscious generation* [70-73]. Respondents reported general and specific tools, including digital health tools unrelated to CSD but rather for personal health use (eg, fitness apps). Consistent with previous reports, these findings suggest that student and professional understandings of digital health and therapy tools seem to be informed by personal experiences as health consumers and reflect both evidence- and non–evidence-based tools they may have encountered in academic settings [15,72,74]. Furthermore, positive comments such as increased accessibility, options to adjust complexity, and the potential for increasing patient motivation, as opposed to concerns surrounding costs, user-friendliness, distractibility, and screen time were consistent with previous studies [33,45,75,76].

Most respondents (131/170, 77.1%) reported that they were familiar with digital learning tools. General and specific tools were reported with learning management systems (eg, Moodle), videoconferencing systems (eg, Zoom), and web-based courses or webinars predominating, which may reflect the surge of these platforms during the ongoing COVID-19 pandemic [77]. Few digital learning tools specific to CSD were reported despite their growing number; given that such tools direly require evaluation by current and future professionals, it could be useful in future studies to investigate engagement and familiarization with field-specific learning tools [40,78-82]. Additional comments made by respondents praising the flexibility and accessibility of digital learning tools as well as its drawbacks such as limited interaction and exchange and technical challenges were in line with previous research [83-85]. The mention of instructor-specific implementation affecting the digital learning experience also emphasizes a need for improved systematic training of clinical instructors in effective digital learning implementation [15,21,40].

Use

In line with commonly reported device use, professionals and students mostly used computers, smartphones, and tablets for learning, teaching, and professional purposes [18,19,83,86]. Game consoles and VR devices were only used by one respondent, despite their growing presence in the literature across the surveyed professions [87-89]. Although an evidence base for such devices is still emerging and ethical considerations must be further evaluated, VR could provide an engaging means through which to deliver both clinical training and therapeutic activities that could be generalized to real-world tasks [89]. In terms of software or digital systems, technologies more closely related to eHealth such as electronic health records, telepractice, and hospital or clinic information or communication systems were mostly used by working professionals, though were still used to a lesser extent than word processing, presentation, spreadsheet, and videoconferencing software. This could reflect the reported lag in eHealth uptake in Germany despite significant progress in legislation for digital health care in recent years [90]. In the Bertelsmann Foundation 2018 international comparison of digital health index scores, Germany still ranked second to last among 17 surveyed Organization for Economic Cooperation and Development countries [86]. Socioculturally, Germany's lag in digital uptake and focus on data security and privacy have been associated with the country's problematic and traumatic history of heavy surveillance. This has inevitably affected the country's now cautious approach to digitalization [91,92]. However, considering reports of increasing acceptance of and demand for eHealth technologies, this trend will likely change in the coming years [91,93]. This can be seen in respondents' feedback regarding digital formats they could imagine using in the future. Many expressed a desire for learning with and implementing newer, often more interactive formats in the future, such as 3D models, simulations, and serious games. Notably, in the optional free response *other* category across questions pertaining to use of digital technology, respondents often did not differentiate among devices, software or digital systems, and formats, indicating a pressing need for foundational digital literacies education [2,21,22]. Here it is useful to mention that use of devices, software or digital systems, and digital formats were not separately analyzed between digital therapy tools versus digital learning tools as these are common to both types of tools. Nevertheless, a separate analysis in future studies could help with insights into the appropriateness of certain device, software, or format types for specific use cases.

In terms of frequency of use, the largest proportion of respondents (60/170, 35.3%) surprisingly responded that they never used digital therapy tools, further pointing to the lag in digitalization implementation. Given that students are usually not working clinically, the significant differences observed between them and SLPs is unsurprising. However, the finding that professionals with 1-5 years of experience used digital therapy tools more indicates a growing acceptance of digital eHealth solutions [94]; it could be interesting to investigate in future work what factors specifically contribute to this uptake in younger professionals. Regarding frequency of digital learning tool use, Generation Z (most of whom are students) demonstrated significantly greater digital learning use than Generation Y, which is expected given the shift toward web-based learning during the ongoing COVID-19 pandemic [95].

Attitudes

Attitudes toward digitalization were primarily positive, with Generation Z demonstrating significantly more positive views than their generational counterparts, as expected per previous research trends [96]. Consistent with previous studies, many respondents indicated uncertainty regarding their preparedness for the digital revolution [15,21,22]. This was especially the case between SLPs and SLP students, which questions whether digital skills are currently learned on the job or through professional development courses; this feeling of unpreparedness among SLP students once again emphasizes the urgent need to incorporate digital skills into clinical curricula, a sentiment also supported by most survey respondents.

Most respondents indicated being open to using digital therapy tools. Interestingly, Generation Z and respondents who were still studying reported being more likely to use digital tools with medical certification than their Generation X counterparts and those with ≥20 years of professional experience. To the best of our knowledge, this specific finding has not been previously reported in the literature. A study with French university students found that students were more comfortable with digital health interventions provided these would be promoted by institutional or official entities, though these opinions were not compared against those of seasoned professionals or older generations [74]. As Generation Z students have been reported to generally demonstrate greater levels of anxiety and need for guidance than previous generations of students, it could be that medical certification through an official entity provides a sense of security and guidance [97]. These findings nevertheless warrant follow-up investigation into the reasons for such perceptions regarding medical certification for digital tools, which may even extend beyond these observed differences in generation and years of experience. Although most respondents agreed that they would pay a reasonable price for a digital therapy app with good ratings, it would be useful to further investigate what respondents define as reasonable, as this loaded question requires deeper investigation.

Intriguingly, a little under one-third of respondents demonstrated skepticism regarding whether such tools provided more advantages than disadvantages and indicated doubts regarding their quality and validity, and a little over half of respondents reported concerns with technical difficulties. These concerns urge for focused research on efficacy and barriers to digital technology use. Current and future physicians and clinicians should be increasingly engaged in systematically evaluating eHealth technologies through tools such as the Mobile App Rating Scale (MARS) [98]. In the German-speaking context, tools such as HealthOn, APPKRI, and APPQ1.0 have emerged for the evaluation of health apps, and within the field of speech-language pathology, the Bewertungskatalog für Apps in Sprachtherapie und Sprachförderung instrument for evaluation of speech-language pathology apps is being optimized and could serve as a future useful evaluative tool [99]. In the optional *other* free response category, doubts regarding patient acceptance, secure data transfer and storage, and ethical consequences were mentioned concerns, which require co-operation with policy and governmental regulation for effective implementation [2,74,75,100,101]. Given reports that 2 in 3 Germans welcome eHealth technologies such as electronic health records and given the increasing number of patient satisfaction studies with digital applications, there appears to be growing patient demand and acceptance of digitalization [90].

In terms of digital learning, most respondents were open to its use, agreed that it offered more advantages than disadvantages, and felt mostly confident with their knowledge of digital learning tools. Interestingly, when reporting concerns, however, 45.3% (77/170) of respondents still questioned the quality of digital learning material, despite previous indications of not being doubtful of quality. This disconnect reveals hesitations in digital uptake and aligns with the reported need to find effective means of verifying the quality and validity of digital learning tools. Although technical standards exist through organizations such as the International Organization for Standardization (ISO) or the Institute of Electrical and Electronics Engineers, these are not immediately comprehensible for clinical instructors, and efforts are still being made to devise frameworks that fit within clinical professional responsibilities and standards [102-104].

Preferences

In the following study, no significant differences in preferred levels of virtuality, interactivity, and flexibility in terms of time and space were observed across profession, generation, or years of experience. The absence of generational differences aligns with several previous reports [105-107]. Most respondents preferred a blended learning model (half in-class and half virtual) and a limited or moderate to complex level of interactivity. There were almost similar proportions of respondents preferring flexibility in terms of space only (eg, synchronous lectures delivered on the web) or traditional in-person lectures. In a study by Küsel et al [108], German students similarly preferred synchronous web-based learning for directly asking questions; in contrast US students also valued asynchronous options. The German preference toward more traditional means of learning may reflect their general lower reported confidence and perceived readiness for engaging web-based in comparison to their US counterparts [108]. Such differences can be traced to cultural differences in teaching and learning; for example, the US system is known to incorporate more interactive means of learning and virtual learning much earlier on in education [109]. Such findings warrant a deeper investigation into cultural, educational, and societal differences that inevitably affect digitalization uptake, integration, and development in a country. However, it could also be interesting to consider whether the ongoing COVID-19 pandemic contributed to these preferences for more in-person learning because of the potential effects of social isolation and screen fatigue [110]. As Wiederhold [111] identified, factors such as asynchrony of communication even by milliseconds on video calls, lack of nonverbal cues, and additional components (eg, chat function) can introduce additional cognitive load, which can be mentally taxing and result in fatigue. As Bennett et al [112] suggest, having the option to turn off the microphone and fostering environments of inclusiveness and belonging helped to reduce this fatigue and are crucial elements to include moving forward in an uncertain digital future.

Limitations

Critically, this study must be interpreted in light of its limitations. First, this cross-sectional investigation was conducted in the German-speaking population and thus may have limited external validity to other cultural and geographical contexts. However, as digitalization is a global phenomenon, we hope that our findings shed some light on factors that could be playing into common trends, areas of opportunity, and barriers to the uptake of digital technologies. It is also important to note that the stark contrast in the number of female versus male participants can likely be attributed to the fact that the field of SLP is predominantly female (93%) and the number of female otorhinolaryngologists has been steadily rising (35.7% as of 2020) in Germany [113,114]. In addition, this was an open-ended survey that consisted of a convenience sample, which could have attracted individuals who were already more inclined toward taking interest in digitalization. Given this convenience sample, it was difficult to control for equal group sizes, though statistical adjustments were made, and the sample size of the study is relatively small. Our aim was primarily to obtain a comprehensive overview of the current state of knowledge, use, attitudes, and preferences regarding digital therapy and learning in CSD as such data were not previously available; thus, the survey data have only begun to scratch the surface of current trends, and furthermore deep investigation into underlying factors contributing to digital experiences, uptake, and progress is crucial. Given the rapid rate of digital progress, this survey study also offers just a snapshot of the state of digitalization and stakeholder opinions at the time of study.

Future Directions

As a survey study, the following investigation analyzed perceptions regarding digital therapy and learning, though it would be important in future studies to also measure actual knowledge, implementation, and use. In moving forward toward an uncertain digital future in which the evidence base for new technologies has yet to be developed or may even be rendered obsolete before one can even be formed, it will be essential to engage in *adaptive* education and practice. An incorporation of digital skills into clinical curricula will be necessary as the clinical landscape continues to evolve. It has been previously recommended, for example, that students begin to also receive formal coursework in data analytics, governance, and privacy as well as emerging models of care such as remote monitoring, self-management, and increasing telepractice [67]. Data visualizations could be used for problem-based learning, digital applications could be incorporated into treatment planning as part of collaborative clinical research, and current and future professionals must inevitably take part in patient empowerment and education through digital means [12,21,67]. To begin this process, however, clinical instructors must also receive systematic training in these areas, and more data must be collected regarding current gaps in access and professional and student needs. Further research into effective implementation could be informed through increasing interdisciplinary strategizing within and outside of CSD [115]. As collegial and organizational support has been previously shown to be essential for creating positive experiences with technology, it will be critical that practical supports for innovation are carefully planned and empirically substantiated to the best extent possible [2].

Our study has demonstrated that students and professionals in CSD continue to feel uncertain regarding their knowledge of digital health and digital learning, are still using more traditional devices, software or systems, and formats, though are interested in exploring more interactive, digital means for teaching, learning, and practice. They have understandable concerns surrounding quality and validity of digital resources, data privacy, technical complexity, social engagement, and effective implementation. These concerns amidst the rapidly changing digital landscape urges for the expedited exploration of empirically substantiated, though flexible, solutions.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Survey screens (in German).
[PDF File (Adobe PDF File), 1583 KB - mededu_v7i4e30873_app1.pdf]

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Abbreviations

AAC: augmentative and alternative communication
CSD: communication sciences and disorders
SLP: speech-language pathologist
VR: virtual reality

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Original Paper

Best Practices for the Implementation and Sustainment of Virtual Health Information System Training: Qualitative Study

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Abstract

Background: The COVID-19 pandemic has necessitated the adoption and implementation of digital technologies to help transform the educational ecosystem and the delivery of care.

Objective: We sought to understand instructors' and learners' perceptions of the challenges and opportunities faced in implementing health information system virtual training amid the COVID-19 pandemic.

Methods: Semistructured interviews were conducted with education specialists and health care staff who provided or had taken part in a virtual instructor-led training at a large Canadian academic health sciences center. Guided by the Technology Acceptance Model and the Community of Inquiry framework, we analyzed interview transcript themes deductively and inductively.

Results: Of the 18 individuals participating in the study, 9 were education specialists, 5 were learners, 3 were program coordinators, and 1 was a senior manager at the Centre for Learning, Innovation, and Simulation. We found 3 predominant themes: adopting a learner-centered approach for a meaningful learning experience, embracing the advances in educational technologies to maximize the transfer of learning, and enhancing the virtual user experience.

Conclusions: This study adds to the literature on designing and implementing virtual training in health care organizations by highlighting the importance of recognizing learners' needs and maximizing the transfer of learning. Findings from this study can be used to help inform the design and development of training strategies to support learners across an organization during the current climate and to ensure changes are sustainable.

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KEYWORDS

training; health care providers; educational technology; patient care; COVID-19; development; practice; best practice; pedagogy; teaching; implementation; medical education; online education; care delivery; perception; effectiveness

Introduction

COVID-19 has created social disruptions and contributed to unprecedented changes that have required that many organizations rapidly transition instructor-led classes to a virtual format [1]. The emergence and innovation of digital technology have played important roles in education and training. Virtual education and training for health information systems are critical in supporting timely care and patient safety and in preventing information technology–related patient harm [2]. Virtual instructor-led training has been defined as web-based education delivered via digital platforms, connecting instructors and learners across different geographic boundaries [3]. Education refers to the acquisition of knowledge and skills, enabling learners to develop reasoning and judgement surrounding broad topics [4,5]. Conversely, training is the process of teaching the skills that one needs to perform a particular job or activity [4], which is the emphasis of this study. Virtual training environments are designed to simulate classroom instruction and can be conducted synchronously or asynchronously [3]. Virtual instructor-led training is poised to transform health care across the country as organizations shift toward rapidly providing training to health care providers and staff, leading to a paradigm shift that could reshape the provision of training long-term (ie, in postpandemic conditions) [6].

Although virtual training has been an emergent part of health professional education for over a decade, this abrupt pivot to teaching virtually has become a significant challenge [7]. Challenges exist with the implementation of the change process in the education system due to the novel perspectives of virtual training and its technological complexities. Stakeholders may not be prepared to adjust to this shift to virtual training, as they are not technologically ready to adapt to this postpandemic educational landscape [8]. Moreover, Ali [9] asserted that adopting a virtual training environment is not only a technical issue but also a pedagogical and instructional challenge. With the focus on digital and technology-enabled learning, it is imperative to understand the required elements of virtual training and how the existing resources of institutions can be leveraged to effectively transform face-to-face instruction into virtual instruction [8].

A recent paper [2] discussed the accelerated development and implementation of a blended electronic medical record learning strategy for nursing staff across a large urban health care district in Sydney, Australia; the study demonstrated that virtual training's accessibility and flexibility provided a practical approach for delivering electronic medical record training to nursing staff, particularly in the context of an urgent need [2]. Collaboration with stakeholders was identified as a key feature in facilitating the rapid conversion of face-to-face training into a virtual approach. The feedback gathered from participants were self-reported measures, and thus, may not be reflective of practice observed in clinical settings [2].

Virtual delivery provides a promising avenue for offering an optimal learning experience while accommodating the various needs of learners due to geographic, physical, or other limitations [10]. Even though studies have reported that virtual training can be as effective as traditional instructor-based sessions, it is imperative to consider factors such as having clearly defined guidelines about the instructor's roles and responsibilities, learner competencies, technology accessibility, and funding [7]. Mishra et al [8] stated that theatrical skills are needed to successfully integrate technology into the teaching-learning process. Theatrical skills include empathy, mindfulness of learner needs, strong presentation skills, and the appropriate use of digital technologies to transmit some level of embodied experience and knowledge [8]. Virtual training is not only an advantageous step toward the future of education, but it is also an option that may contribute to an equitable and inclusive learning environment.

Paudel [11] stated that instructors and learners interacting with one another in a meaningful way indicates a successful virtual training experience. Interactive learning highlights the shift from instructor-controlled to self-directed (on the learners' part) learning [11]. With the range and features of technology at the instructors' disposal, virtual training can result in a more interactive experience [11]. The synergetic relationship between training and technology is ubiquitous and organizations must be afforded ongoing support and be able to appreciate and advance the opportunities provided by virtual training [12].

Given the current rapid transition toward wide-scale adoption of virtual training, it is crucial to provide high-quality training to enable health care providers to properly perform their clinical tasks. As a response to the COVID-19 pandemic, the Digital Education department at the University Health Network (UHN) has moved all training sessions to a virtual environment. Prior to the pandemic, Digital Education offered face-to-face sessions, e-learning, and blended learning. The instructor-led sessions are currently being taught through videoconferencing platforms that allow learners to attend sessions remotely. Although organizations have embraced technology-enabled learning during the pandemic, it is critical to ensure that the changes are sustainable after the pandemic. There is a dearth of in-depth and qualitative virtual training research in health care; therefore, this study was conducted to bridge this gap. The objective of this study was to examine instructors' and learners' perceptions regarding the effectiveness of virtual training amid the COVID-19 pandemic by determining the challenges and opportunities faced in the implementation of virtual training in the context of health care settings and health information systems.

Methods

Study Design

This qualitative study was guided by the Technology Acceptance Model, which was developed by Davis [13-15] to understand factors influencing the adoption and implementation of information technologies. The most proximal antecedent to the actual use of a technology is behavioral intention, which is affected by one's attitude [16]. Attitude toward behavior is thus influenced by two determining factors: perceived ease of use and perceived usefulness. *Perceived ease of use* is described as the effort an end user must apply to successfully use the technology, whereas *perceived usefulness* is the extent to which the end user believes that the technology will help improve their performance at work [16]. This study was approved as a quality improvement project and was granted an exemption by the UHN Research Ethics Board (QI ID: 20-0100).

The Community of Inquiry framework is based on a collaborative-constructivist approach [17], where reflection, critical discourse, and sustained dialogue enable learners to make both personal meaning and collective knowledge [18]. The symbiotic relationship between social, cognitive, and teaching presence provides an environment that stimulates deeper thinking for learners, which further enhances their understanding of the content. Cognitive presence is a vital element in critical thinking that allows learners to gain knowledge through discussions [17]. However, the dearth of connection and collaboration in technology-mediated communication makes it challenging for learners to engage in a virtual learning community [17]. Social presence fosters a collaborative virtual learning environment by facilitating the process of building trust, developing respect, and critical thinking within the community of learners [18]. Teaching presence allows for higher levels of cognitive presence to be developed, by designing meaningful learning activities, encouraging individuals to be active learners, and modeling behavior [18]. Collaboration and critical thinking do not necessarily occur spontaneously, hence leadership is necessary to advance collaborative inquiry [18].

Educational Intervention

UHN Digital Education offers virtual instructor-led training and e-learning to all incoming staff who will be using a health information system in their practice setting. The training was provided virtually using videoconferencing tools and led by an instructor with advanced health information system skills and adult education expertise. The training session was 4 hours in length, during which mini didactic lectures and demonstrations of the system were integrated with practice opportunities. The sessions were structured based on a few key objectives, which included a summary of the modules, navigation of the system, and an overview of frequently used features and functionalities. Learners then had the opportunity to practice and explore the various functional abilities of the system with respect to their roles.

Study Participants

Given that the purpose was to identify major themes from a diverse range of perspectives, a maximum variation purposive sampling strategy was employed. Purposive sampling is a technique widely used in qualitative research to identify and recruit participants who are particularly knowledgeable or experienced with a phenomenon of interest [19]. It is also used to ensure that participants in interviews reflect the demographics of the larger study population [19]. This sampling approach requires that the research analyst identify criteria based on relevant diversity characteristics, in advance, then select participants who meet these criteria to obtain maximum variation in data [20]. Participants were recruited with email invitations sent by the research analyst. Recruitment continued until theoretical saturation was reached. Saturation was defined as the point after which the interviews would not yield any new themes. Individuals were eligible to participate if they were instructors or learners who had taken part in a virtual instructor-led session at UHN and were able to provide informed consent.

Data Collection

One-on-one interviews were conducted virtually through Microsoft Teams platform (due to COVID-19 social distancing recommendations) and were on average 20 minutes in duration. The interviews were conducted by a research analyst (TJ) with experience in conducting qualitative interviews. The interviews were conducted until no significant new issues or ideas emerged and theoretical saturation was achieved. A semistructured interview guide was utilized to review participant experiences and suggestions for improving virtual instructor-led training within the organization. This format enabled the interviewer (TJ) to diverge and encourage participants to elaborate on their answers when necessary. The interview guide consisted of 6 open-ended questions for instructors and 4 open-ended questions for learners that explored the challenges and opportunities with the implementation of virtual training. The interview questions were modified based on an iterative process during data collection to challenge, refine, and elaborate on emerging themes. All participants provided informed consent for the interviews to be recorded; interview recordings were professionally transcribed verbatim.

Data Analysis

An iterative, inductive, constant comparative process was used to thematically analyze the interview transcripts. The data were analyzed after the first 2 interviews, and the themes identified from that analysis were used to shape further data collection. Throughout the data collection and analysis process, a research analyst (TJ) and an education specialist (CH) with digital education backgrounds independently coded the data from an exploratory lens and generated a codebook. The data were first deductively analyzed using Technology Acceptance Model constructs as predefined codes. The data were then analyzed inductively, by following the systematic process outlined by Braun and Clarke [21]. Open coding was used when data did not adequately capture the predefined codes, and themes were inductively generated. Iterative biweekly discussions with content experts within our team (a manager of Digital Education and an education researcher) enabled us to further contextualize the themes. Qualitative data analysis software (NVivo, version 12; QSR International) was used to code and organize the data. Methodological rigor was achieved by assessing the quality of the thematic analysis using a 20-question evaluation tool [22]. An audit trail of each team member's dependent coding, team meeting notes, and different versions of the coding structure were also maintained. Furthermore, sampling continued until theoretical saturation was achieved.

Results

A total of 18 participants (female: 14/18, 78%; male: 4/18, 22%) agreed to participate in semistructured interviews. Of the 18 individuals who participated in the study, 9 were education specialists, 5 were learners, 3 were program coordinators, and 1 was a senior manager at the Centre for Learning, Innovation, and Simulation.

Three predominant themes were identified through a thematic analysis of the data, each with several subthemes: (1) adopting a learner-centered approach for a meaningful learning experience, (2) embracing the advances in educational technologies to maximize the transfer of learner, and (3) enhancing the virtual user experience.

Theme 1: Adopting a Learner-Centered Approach for a Meaningful Learning Experience

Access to the Training Environment

Participants expressed that having access to a training environment would enable them to follow along during the training and provide an opportunity to practice afterwards.

Participants commented on the importance of following along with the instructor as the instructor was demonstrating to enhance their learning experience (by following the complete functionality from beginning to end, rather than just parts of it).

> *…they have a lot of resources and have this amazing playground. It's all web-based and people can just access it even offline without being monitored by the instructor. Just go in and play and click around learning the system. If we are able to provide that to UHN learners, that would be a huge advantage. And multiple people can go in at the same time, whereas at UHN our training environment, we kind of have to monitor it because we only have 10 logins. Well right now speaking of the current setup, like we only have 10 to 15 logins so only 15 people can log in at a time. Even then we kind of have to monitor, what if they change things around in the environment. We have to reset every evening.* [ID 16]

This is similar to a face-to-face instructor-led session, in which the instructor would be at the front demonstrating the functionalities as it is projected on the screen, and the learners would follow along at their own computer stations. Although currently, instructors work around this by granting screen control, learners feel that their learning experience may be affected slightly because only one person is able to use the training environment at a time.

Integration of Hands-on Experience and Interactivity

Nearly all participants desired hands-on practice as it allowed them to become familiarized with the system. They indicated that hands-on practice is very important for learning, since some individuals learn by experience.

> *Not everyone learns in the same way, where they watch and immediately understand how to do it. We need the hands-on, the muscle memory from experience. So that would be a huge advantage if we were able to provide that.* [ID 16]

A few participants described not being familiar with the new system; however, they were able to understand better when the instructor shared their screen and provided them with instructions on how to navigate and complete the tasks. The training provided them with the specific steps to critically reflect and attempt to understand not only the tasks themselves, but also the concepts underlying the tasks. Participants also reported that the interactive component of the session fostered collaboration between learners. For instance, the learners would help each other by saying what to click next when somebody was stuck as opposed to the instructors providing the answers.

> *It felt more intimate to then. It sounds weird, but I guess because everybody got a chance to do some stuff one on one, meaning everybody got a chance and everybody else got a chance to watch. I feel like people learned a lot more that way. I feel like people were more focused on learning as opposed to in class, they could pull out their phone, they could I mean, I guess they could still do that at home, too. But, you know, knowing that they had to prove their understanding by having to do examples in front of everyone else online. That then I feel like they paid more attention and they had good questions to ask.* [ID 13]

One participant stated that the physical action of practicing with the system enabled them to go through the process and effectively use it in their clinical environment. Other participants commented that it was more engaging than the classroom session since they knew they needed to take turns using the app and thus needed to understand what the person ahead of them did. With rapid advances in videoconferencing platforms, instructors felt that it was easier to use many classroom engagement techniques that would have been cumbersome to conduct in a live setting.

Theme 2: Embracing the Advances in Educational Technologies to Maximize the Transfer of Learning

Awareness of Nonverbal Communication

Interestingly, awareness of nonverbal communication was identified by all instructors as a barrier to teaching virtually. Due to the lack of feedback and nonverbal cues, instructors felt it was challenging to assess engagement and knowledge comprehension in virtual learning. For example, in an in-person setting, if someone was not understanding a concept, the instructors could usually recognize this based on their facial expressions or how they were interacting with the keyboard.

> *You have to adapt it in a way that you can still convey your point sometimes without having to necessarily see, like actually see a person in front of you. So if I have some nonverbal cues and stuff when I'm speaking, you don't necessarily see that. With virtual classrooms, I did notice one of the challenging things was the lack of being able to see the participants of the class. It makes it kind of difficult to gauge if people are understanding or if I didn't repeat something like someone actually has to literally tell me or else I wouldn't be able to catch those nuances. Whereas if I was doing it in person, I can actually look at their face, their body language and see the cues and pick up the cues that way.* [ID 7]

Oftentimes, in virtual learning, they had to make assumptions about whether learners had absorbed the content presented and could successfully use the system in their clinical environment. They expressed that, sometimes, there are learners in the class who are quiet; however, this does not always necessarily mean they do not understand. This can be attributed to the fact that they may not know what to ask.

> *And being in the instructor's seat, you know, the silence is a lot harder, I find, to bear. Like, if you throw out a question to the group, right. And you do that live, you can sort of look around and catch eyes with somebody and say, like, OK, like lets somebody respond to this question because I'm not just going to drone on for an hour. I'm going to try to have you guys tell me something. But online, that's it seems like you're just kind of throwing it out into the void*

> *sometimes. And, yeah, it feels like it's just like the silences seem so much longer.* [ID 10]

Technical Limitations

Participants generally felt that a more stable platform for virtual delivery would have enhanced their teaching and learning experience. Most of the issues were technologically based (eg, some learners in the same session would be able to control the instructor's screen while some could not). However, to mitigate this issue, instructors identified workarounds such as navigating the screen on behalf of the learners, with the learners providing instructions on how to approach the task. Technology was a barrier for many participants due to poor internet connection or not having access to a webcam or headset. Additionally, instructors stated that a major challenge was finding a balance while teaching virtually so that they were not only catering to one type of learner, but to all types of learners, while also managing the technology. Most of the participants contended that it would take time to become familiar with the platform and how it could be leveraged to run a virtual session in a fulsome way. Thus, it is vital to provide some scaffolding for those who are learning how to use the technology.

> *So that that I found a bit of a challenge to the ones that, you know, when I talked about clicking your mouse here, something as simple as that, when, where if for someone who was like medium savvy on the computer. Yeah versus someone who has no idea how to work a computer. So something as simple as clicking on your mouse required an explanation.* [ID 11]

Theme 3: Enhancing the Virtual User Experience

Need for a Positive User Experience for both the Instructor and the Learner

Analysis revealed that some of the tools used to teach virtually were not sufficient to properly host or facilitate a virtual session. Participants suggested that providing the hardware and infrastructure would facilitate their teaching process, since they encountered technical issues with some of the platforms.

> *I will say, though, that we need the proper tools to do it, because also with my experience, the tools that we used, we've used so far have not been the greatest. So, I mean, I would say [Platform A] is very simple to use. I use [Platform A] a lot without any issue, really, to be honest. And then but [Platform B], which is kind of what is being pushed or was being pushed for us to use to teach was not very stable. It crashed a lot. And so I didn't use it, to be honest. I know we were…encouraged to use it. But I refused.* [ID 13]

One participant referred to digital tools as merely a vehicle for content and pedagogy. They reported that translating the same 2-hour in-person session to a virtual format would neither make learning more efficient nor lead to the best knowledge transfer. Participants suggested that some of the videoconferencing tools promoted by the organization may not be sufficient to captivate the attention of learners and increase engagement. For instance, a few participants stated that certain virtual platforms were better for collaboration, but they were not tools for teaching. Such tools are critical as a part of the training is based on synchronous learning with a broader longitudinal conversation and engagement. Certain platforms were preferred as they provided the tools for teaching, such as live synchronous communication features, polls, annotations, and 2 types of chats. Although some platforms have the features available for teaching, the organization did not support these platforms and encouraged the use of the supported platform.

Fostering a Social Nature of Learning

A virtual community of learners was identified as a critical element in enabling learning and facilitating the sharing of best practices. One of the participants opined that based on the education theory, learning is essentially a social activity, and a majority of learning occurs outside of the synchronous lecture or teaching session. Additionally, participants stated that there should be a place for learners to be able to come together and have their own private sessions to do group work, share resources, or even have an informal chat. Existing virtual platforms enable the facilitation of this interprofessional virtual community of learners.

> *But I think the pandemic has allowed everybody to jump into the same pool and to be kind of because the challenge I've always had with virtual communities of practice is that, you know, they were a bit of a niche thing before. And if people weren't really fluid with interacting online, they wouldn't bother. So you would have this fragmented community where you would have some people who were virtually connected and other people who weren't. And it would be kind of a mess. So now, you know, zoom is a verb. So like, everybody is pretty savvy, like regardless of platform, like everybody is pretty savvy on getting connected. So I'm actually pretty excited for what this means for virtual communities of practice.* [ID 10]

The COVID-19 pandemic has accelerated the need to enable a virtual community of learners and recognize that learning is a social construct. Furthermore, since these platforms are hosted within the core infrastructure, the information shared will require some oversight to ensure shared learning information is accurate.

Implications of the Technology Acceptance Model Framework

The COVID-19 pandemic has compelled instructors and learners to embrace the virtual training experience and overcome any hurdles that arise during the virtual teaching-learning process. It is imperative to understand the factors that influence the adoption and implementation of virtual training to ensure virtual training is fully optimized (Table 1). The Technology Acceptance Model has allowed us to understand the instructors' and learners' perspectives about virtual training, specifically, current challenges and future opportunities for implementing virtual instructor-led training in health care organizations' postpandemic conditions. Many participants perceived the training was useful as it improved their learning performance and provided information they needed to successfully use the health information system in their clinical environment. When users perceive that the virtual platform is useful in learning, they tend to be more motivated to learn and use it. Others suggested that providing access to the training environment enables learners to deliberately practice with the health information system and increase their confidence. Thus, when the technology is easy to use, the desire to continue using the digital tool increases. Nevertheless, participants encountered technical challenges, which impacted ease of use of the virtual platform.

Table 1. Technology Acceptance Model constructs associated with the 3 major themes identified in the thematic analysis

Construct	Findings	Quotations
Perceived Usefulness	• Improved learning performance and the session was efficient • Learners were able to successfully use the technology in their practice setting	• One participant mentioned "I learn by doing it myself and the way they did it. I was still able to learn by myself. It just wasn't on my computer. I was just moving the mouse on somebody else's computer but it was still hands-on because they directed me through everything I needed to go through. And they kind of troubleshooted at the same time in the sense that they'll give you heads up. People normally have trouble with this and this. And this is how you avoid it. And that's what they did. I found that very helpful when I was on the job." [ID 18]
Perceived ease of use	• Access to the training environment provides an opportunity for participants to practice independently as opposed to using the instructor's computer to have access to a training database • Lack of feedback and awareness of nonverbal cues made it challenging for instructors to understand if learners were following along	• One of the learners stated, "I just liked it because it was so easy and I don't know, like I had never done anything like this before." [ID 14] • "To me, I found the workshop pretty straightforward, especially with the use of software I was using as well. It was pretty easy to grasp. I just needed to know how to workaround it. How to navigate it is what we needed to know. It was pretty straightforward and easy to learn." [ID 18] • An instructor reported "So it's very different than doing it virtually been in person. I find that a bit challenging. Sometimes it feels like you're just talking to a wall because no one's answering any questions or they're not saying if you're asking if sometimes you would pause, like, I would pause and ask you, are there any questions. And then there's complete silence and you can't see anything." [ID 7]
Attitude	• Videoconferencing tools with a more user-friendly interface and accessible outlets were perceived as superior tools among several participants	—[a]
Behavioral Intention	• Instructors refused to use certain platforms as they experienced technical issues and used platforms that were more resilient and easier to use	—

[a]A quotation is not provided.

Discussion

Principal Findings

Although there are many papers [23-30] about virtual education, little is known about the efficacy of virtual synchronous training to prepare health care professionals to use health information systems as a part of their professional practice. Many papers [1,8,11,12,31-34] focused on web-based teaching-learning in higher education. Given the relative paucity of literature focusing specifically on virtual training in health care organizations, this study sought to understand instructors' and learners' perceptions regarding the effectiveness of virtual training. Our study advances the findings from a recent study by Shala and colleagues [2] and provides insights on the challenges and opportunities associated with transforming face-to-face instruction to a virtual format. Three themes were conceptualized and related to adopting a learner-centered approach for a meaningful learning experience, embracing advances in educational technologies to maximizing the transfer of learning, and enhancing the virtual user experience. The findings are situated based on the community of inquiry framework, and opportunities for future research are summarized.

This study highlighted the importance of adopting a learner-centered approach by integrating hands-on practice as a part of the training and providing access to the training environment. Instructors supported cognitive presence by providing an opportunity for the learners to practice with the system as it enabled learners to follow the instruction step by step and receive appropriate feedback. Additionally, instructors delineated that this would provide a significant advantage to learners—by observing their peers demonstrate functions, they would become more motivated and invested in their learning. Cognitive presence is heightened by taking into consideration different learning preferences, one of which includes hands-on experience. Merrill [35] stated that learning is promoted when reflecting on prior experiences, demonstrating and applying skills, and integrating them into real-world problems. Edwards and colleagues [36] have outlined that, by providing an opportunity to practice with the system, active learning is fortified, thus increasing learners' confidence. Merrill [35] asserted that learning is enhanced when coaching and continuous feedback are used to guide their learning process. Scaffolding enables learners to have considerable support; however, as learning progresses, it is important to gradually attenuate the amount of guidance and provide the learner with greater control [35]. Similar to our study, previous research identified that access to a training environment provides an opportunity for continuous interaction with the system, and consequently, learners reduce the cognitive effort associated with performing a task [37]. Additionally, the instructors incorporated interactive components as a part of the training session to foster collaboration with the learners, thereby enhancing the social presence element, which is in alignment with the best practices for teaching. Social presence provides a propitious environment where learning can be successfully created and sustained [18]. Raza [38] and Chen [31] reported that platforms with rich interactive functionalities are critical for fortifying learners' sense of connectedness and creating an inclusive virtual learning space.

Despite the opportunities for virtual training to penetrate new areas and offer sustainable and effective learning solutions, there are challenges that may encumber the organizations' efforts to shift skills-based training to a virtual platform. Our study identified several challenges, including technical limitations, different levels of digital literacy among learners, and a need for a positive user experience for both the instructor and the learner. Another major challenge in the study was the instructor's decreased ability to recognize struggling learners so that they may be assisted promptly. Mishra and colleagues [8] corroborated this finding in a study that reinforced the importance of nonverbal communication. The authors [8] reported that instructors were unable to read the facial expressions and body language of learners; hence, it was difficult to adapt teaching patterns. Moreover, the virtual format made it challenging for instructors to determine whether participants were actively present during the session [8,32]. Our results suggest that awareness of nonverbal communication is essential in establishing teaching presence in a virtual environment. Consequently, instructors will be able to ensure that the learners are continuously engaged and facilitate the discussion in a meaningful way [39]. Teaching presence was enhanced when the instructor provided constructive feedback and actively facilitated tasks, thus allowing learners to critically explore and evaluate the information learned. Swan et al [39] reported that the capacity that various technologies have for transmitting nonverbal and vocal cues is critical in enhancing social presence. The literature highlights that the rapid shift to virtual training has further exacerbated the digital gap and cultural leap [1].

The findings in this study underlined the importance of developing a virtual community of learners to distill knowledge and facilitate the sharing of best practices while balancing learners' cognitive load. Participants reported that a virtual community enables a safe environment for individuals to engage in learning through collaboration. Virtual instructor-led training provides new opportunities to make learning accessible to many learners and support them in developing their competencies, skills, and attitudes [33]. Garrison [18] argued that community and the social context of education are important to learning. He asserted that learning experiences must be prudently designed and socially supported for progressive intellectual development. Social constructivism emphasizes that learning is dependent on social interaction and context, where shared meaning is developed through discussion and negotiation [18]. The social constructivist approach highlights the significance of culture and environment on the learning process [40]. Knowledge is created from the interactions with peers and their environments, and meaningful learning ensues when learners are engaged in a discourse [40]. Education models based on the social constructivist approach emphasize the need for collaboration among learners and experts in the field [40].

Developing a virtual community of learners that is anchored in the 3 elements of educational experience will foster cognitive development through individual knowledge construction and collaborative discourse [41]. A virtual learning community should embrace the collaborative-constructivist notion, where the learning environment is cocreated, thus facilitating a critical dialogue within the digital space [41]. This enhances the key facets of social presence by providing critical feedback to members, respecting interpersonal relationships, and stimulating divergent thinking [41]. The Community of Inquiry framework subsumes a learner-centered approach, where learners are engaged in the exchange of knowledge, critical inquiry, self-evaluation, and deep learning [17]. Learners illustrate higher confidence levels, greater engagement, and stronger problem solving capabilities [41]. The virtual delivery design should foster transformative learning and strongly align with the Technology Acceptance Model and Community of Inquiry framework in order for the training to be effective, regardless of whether training is synchronous, asynchronous, or blended.

Several opportunities were identified in this study, including the adoption of a learner-centered approach for a meaningful learning experience and fostering a social nature of learning through the development of a virtual community of practice. It is imperative to integrate high interactivity and practice exercises throughout the sessions to reinforce specific knowledge and skills [36]. Thus, opportunities to practice with the system and the ability to reflect on the knowledge that is gained are critical in aiding knowledge translation [42]. However, interactions with members within a community of practice can go beyond the acquisition of knowledge, which contributes to better learner outcomes and meaningful use of health information systems [43]. The digital learning space allows participants to share their knowledge and engage in a collaborative discourse with colleagues and experts.

Limitations

The findings of our study must be examined in the context of the following limitations. The study is limited to a single Canadian health care organization in a large urban area, and though we attempted to be as inclusive as possible during purposive sample, not all areas of the organization were reached. However, this study offers perspectives from education specialists and learners, specifically, about the current challenges and future opportunities faced in implementing virtual instructor-led training in health care organizations in postpandemic conditions. Recognizing that researchers' positions and perspectives inevitably influence access to findings, we asserted research rigor and reflexivity through the triangulation of data from multiple perspectives and memo writing.

Conclusions

The COVID-19 pandemic is rapidly transforming the landscape of the health care system, affecting not only the delivery of care, but also, how health care professionals will acquire new skills and be educated in the future. Training is vital in enabling care providers and staff to navigate the health information system safely and securely while providing optimal care. Virtual training has significantly reshaped how we teach and engage with our learners to maximize the teaching experience and lead to better patient care [23]. Organizations can build on this change to create immersive virtual learning spaces that can achieve intended educational outcomes while ensuring optimal learning experiences. It is incumbent to understand the key functionalities of the platform and the challenges associated with it for successful integration of digital technologies into virtual training [24]. The pandemic has challenged the health care system in unprecedented ways, and the need for innovative solutions to optimize educational endeavors has increased significantly. Nonetheless, it is imperative to ensure that these changes can be sustained in the long-term. As we move into the future, the impact of this emerging educational paradigm must be scrupulously evaluated and expanded.

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Authors' Contributions

DW contributed to conceptualization, design, and data analyses and revised all drafts of this manuscript. TJ conducted qualitative interviews and transcribed data. TJ and CH conducted data analysis and interpretation. TJ and SA drafted the first version of the manuscript. SA and SM contributed to the development of ideas and also served as content experts in validating the findings and revising all drafts. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

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Abbreviations

UHN: University Health Network

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Viewpoint

Certified Examination Assistants in the Age of Telemedicine: A Blueprint Through Neurology

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Abstract

The optimal approach to a clinical physical examination via telemedicine is still being explored. The medical community has no standardized or widely followed criteria for telemedicine examinations, so a broad spectrum of approaches is used. Unfortunately, the need for telemedicine is outpacing physical examination validation research. Given that certain specialties have been using telemedicine longer than others, lessons from those specialties might aid in developing standardized protocols for telemedicine. Neurology has been at the forefront of telemedicine use, initially through stroke care and later in multiple subspecialties. We present a framework for optimizing the history taking and physical examination process via telemedicine based on our experience in neurology. This mainly includes remotely examining a patient unassisted or with an untrained assistant present on the patient side of the connection. We also discuss the need for trained, certified assistants to assist the off-site physician in history taking and physical examination. These certified assistants would be allied health professionals who perform high-quality cued patient examinations under direct physician supervision with no responsibility to diagnose or treat. This contrasts with the approach seen in advanced practice providers such as physician assistants and nurse practitioners who undergo years of training to diagnose and treat patients under supervision. This training process would serve as a stepping stone for the development of dedicated certification programs for neurology and other medical specialties; however, assessments of practical training, costs, implementation, and longitudinal quality are warranted.

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KEYWORDS

telemedicine; physical examination; neurological exam; telemedicine assistants; telemedicine implementation; telemedicine certification; telemedicine jobs; telemedicine education; telehealth; teleneurology

Commentary

The criterion standard for physical examination is in-person examinations; however, the quality of in-person examinations varies considerably based on the examiner’s education and experience, even for physicians and advanced practice providers (APPs) of different specialties. Widespread telemedicine implementation has facilitated access to medical care worldwide but not without particular challenges. For example, history taking is easily translatable to a virtual setting, but physical examination can be problematic. This is especially true in specialties with extensive physical examinations using telehealth models for some time, such as neurology [1]. We have had years of experience using in-person examinations in conjunction with laboratory data, neurophysiological studies, and imaging data to provide high-value neurological care.

Currently, a wide assortment of telehealth equipment exists to aid the remote health care provider. Generalized digital cameras can function variably as otoscopes, ophthalmoscopes, and dermatoscopes, and can be used to perform specialized examinations. Some telemedicine units are equipped with electronic stethoscopes to transmit data to be interpreted by the remote examiner [2]. These tools are a means of replicating the in-person clinical environment and decrease barriers to a comprehensive examination. Although technical equipment may vary, minimum requirements include high-speed internet, a good quality camera with zooming capability, and the space to adequately position the camera at appropriate distances from the patient to be able to see the body as a whole and to zoom in on parts such as pupils. However, although the technical equipment can be reproduced on a mass scale and become readily available, replacing the skills and intuition of a clinical examiner gained through years of training and in-person experience cannot be so easily replaced. Physicians are not the only providers assessing patients; nursing staff (including nurse practitioners, registered nurses, licensed practical nurses, and nursing assistants) tend to engage in more than 2.5 times the amount of direct bedside care than other medical staff (including physicians, physician assistants, and medical students) [3]. The presence of an additional health care provider represents an untapped valuable resource for telemedicine. These providers can exist in a variety of settings, including inpatient hospitals, outpatient clinics, rehabilitation facilities, long-term care facilities, and the patients' homes. Though resources vary depending on location, providing a general framework to performing a virtual examination can help create consistency across the board, and certified assistants can be used in any of these settings.

Certification programs geared explicitly toward physical examination skills are varied and still in the early adoption phase. For example, Thomas Jefferson University offers an online 5-week program to become a certified "Telehealth Facilitator" that imparts the skills necessary to manage the interface between the provider and patient, and to address any arising technological problems during the encounter [4]. The National School of Applied Telehealth has an online 3- to 5-hour course that provides telemedicine knowledge basics to allow students to properly present virtual patients to clinicians as a "Certified Telemedicine Clinical Presenter." However, this program does not teach physical examination skills and assumes the student is already proficient in this area [5]. An online course is not likely to equip a student with the skills and experience needed to perform a physical examination well. One study at a university hospital in China enrolled 72 fourth-year medical students in a formal 17-week training course for physical examinations and found an error rate of 1.097 errors per student per body system examined [6], which highlights the need for ongoing student-patient interactions to gain proficiency in performing physical examinations. There are other programs designed for APPs to specialize in various fields like neurology, but these programs focus on complete management and treatment and are time-consuming, expensive, and well beyond the scope required to assist a clinician for a telehealth encounter remotely.

Given that neurology relies heavily on detailed history taking and precise physical examination to localize lesions, its success in the telemedicine environment can serve as a framework for telehealth implementation in other fields. Initial applications of teleneurology included acute stroke care with validation of the National Institute of Health Stroke Scale performed remotely. General neurological examination via teleneurology research is ongoing to assess the reproducibility and reliability of remote neurological examination compared to in-person examinations. The adoption of telemedicine technology is outpacing the literature regarding accuracy and reliability, and although data are emerging, pragmatic models for implementation and use are needed now. The legal implications of relying on remote assistants are unclear. Causes of telemedicine litigation can typically be related to issues with informed consent, breaking state or federal laws, data breaches, diagnostic errors, and lack of policies and protocols. Trained assistants can facilitate informed consent and help provide a higher quality examination leading to fewer diagnostic errors. This would be expected to diminish litigation and improve outcomes.

The optimal way to perform a neurological physical examination and take a patient's history remotely has been a challenge since 1999 when it was first reported possible [7]. COVID-19 has created an urgent need for new attempts to educate the neurology community with instructional videos and implementation guides [8,9]. However, formal criteria for performing a neurological examination that uses a telehealth assistant have not been established to our knowledge. In a recent newsletter, The Joint Commission published important considerations in optimizing patient care via telehealth but left protocol structuring to local organizations and providers. One consideration mentions appropriately training staff and defining roles and responsibilities [10]. Additionally, following the outbreak of the COVID-19 pandemic, the American Medical Association released a telemedicine implementation guide highlighting the importance of familiarizing all essential health care team members with telehealth platforms. However, although the guide offered some practical generalizations, there were no specifications regarding assistance in a neurological examination [11].

The skill in performing and interpreting the neurological exam and the comfort level under various circumstances are arguably more important than whether the exam is in-person or remote. Additionally, the reliability of neurological exams will vary even among the best health care providers. Kappa statistics can measure test interrater reliability with higher scores indicating higher levels of agreement (ie, 0.01-0.20: slight agreement; 0.21-0.40: fair agreement; 0.41-0.60: moderate agreement; 0.61-0.80: substantial agreement; and 0.81-0.99: almost perfect agreement). For neurological examinations, kappa scores are better among observable signs than elicitable neurologic signs. In other words, parts of the examination with high reliability required the examiner to do less elicitation and observe [12]. One telemedicine study showed kappa statistics for assessing language, tongue movement, and finger-to-nose coordination were 0.82, 0.69, and 0.68, respectively [13]. However, maneuvers that required more skill on the examiner's part resulted in lower scores: reflex scores in that same study ranged from 0.38 to 0.52, visual field assessments were 0.56, and pinprick tests were 0.56 [13].

The teleneurology paradigm involves many elements, and this paper provides a logistical framework for the patient history and physical examination elements of the encounter. Importantly, these aspects can vary substantially based upon individual patient characteristics, the availability of remote assistance, and the assistant's training.

The acquisition of patient history should not be altered substantially due to the lack of in-person interaction. If a patient is cognitively intact, they may provide their history. If not, history may be obtained via a surrogate (eg, a family member or nursing staff), as would be the case during an in-person encounter. There is an opportunity to improve the history-taking process. During telemedicine visit preparation, the health care team can schedule coordinated group calls or video chats between the patient, family, and provider to optimize history taking. Geographically dispersed family members and caretakers can contribute to complex histories. This would add substantially to the patient history, as patients are often limited historians, and physicians must comb through the electronic medical records to piece together a story that is often documented asynchronously or even incorrectly [14]. Whether the latter is due to false patient recall or vague physician documentation, the matter is irrelevant—having key individuals sitting in on the same call may enable the acquisition of a single cohesive history.

Although the history gathering portion of the patient encounter is relatively straightforward, a teleneurology examination presents challenges. Nevertheless, all encounters (both assisted or unassisted) can still include the standard seven parts of a neurologic examination (ie, assessment of mental status, cranial nerves, motor system, sensory system, reflexes, cerebellar, and gait). Each subsection of the exam can be modified as needed based on the degree of assistance available (Table 1); however, a genuinely comprehensive neurological examination would require a well-trained assistant. Multimedia Appendix 1 [15] presents a detailed breakdown of the neurological examination elements.

Specially trained and certified examiners have an important role in helping to conduct specialty examinations in the telehealth setting. Although the certification process could potentially be streamlined for those who are already capable of performing adequately directed physical examinations (eg, physician assistants or nurse practitioners), full-scale physical examination–specific training and certification would be advantageous for other hospital and office staff and trainees, including nurses, hospital technicians (eg, those in neurophysiology and respiratory staff), medical trainees (eg, medical students and advanced practitioner students), and patient care assistants. This is important as the certified examiners would likely have other primary clinical responsibilities. Roles and titles must clearly be defined, as a lack of consistency in nomenclature across medical settings has led to false assumptions of tele-assistant capabilities when working with other health care staff [16]. Training would need to focus on multiple real patient physical examinations supervised by a board-certified specialty physician. Training must also focus on quality and reproducibility rather than the rote memorization and checklist-style grading often used by formal testing (eg, objective-structured clinical examinations). Subspecialty examination certifications can be considered. Importantly, unlike APPs trained over multiple years to treat patients under supervision, these certified health professionals would not be expected to offer assessment or provide treatment and function as a direct extension of the tele-examiner. This is a critical difference because training would focus solely on the examination and not the management aspect of the patient encounter, which would remain purposefully the exclusive responsibility of the telemedicine clinician.

Table 1. Neurological examination capabilities based on assistant availability and expertise.

Exam maneuver	TA[a]	UTA[b]	UA[c]	Comments
Mental status	✓	✓	✓	May be limited at times based on degree of cognitive impairment, regardless of etiology (eg, dementia, delirium, or static encephalopathy). Certain elements such as cortical sensory testing/diagnosis would require a trained assistant.
Cranial nerves				
Olfactory	✓	✓	X	Given assistant has access to scent.
Visual acuity	✓	✓	✓	Visual acuity mobile apps are readily available.
Extraocular movements	✓	✓	✓	Saccades, smooth pursuit, convergence can be assessed by all three levels. Oculocephalic maneuvers would need TA.
Pupillary response	✓	✓	✓	Direct pupillary reflex can be assessed with eye opening/closing. Indirect needs TA.
Facial sensation	✓	✓	X	Gross sensation only with TA and UTA. Multimodal sensation only with TA.
Taste	✓	X	X	N/A[d]
Audition	✓	✓	X	Weber/Rinne testing needs TA.
Vestibular	✓	X	X	N/A
Articulation	✓	✓	✓	N/A
Swallowing	✓	✓	✓	Via observing drinking and eating
Trapezius and SCM[e]	✓	✓	✓	Cannot assess strength unassisted but can assess symmetry
Tongue	✓	✓	✓	Strength only with TA
Motor				
Observation	✓	✓	✓	N/A
Tone/rigidity	✓	X	X	To observe arm tone, UTA can sway standing patient at the hip.
Test of subtle paresis	✓	✓	✓	Pronator drift, forearm rolling test, and velocity and cadence of movement
Muscle strength	✓	Limited	X	Can still note symmetry, velocity, and functional tests unassisted
Sensory				
Light touch	✓	✓	Limited	Unassisted patients can simultaneously touch both upper or lower extremities.
Pain/temperature	✓	X	X	N/A
Vibration/proprioception	✓	X	X	N/A
Spinal sensory levels	✓	✓	X	N/A
Reflexes	✓	X	X	DTRs[f], Plantar response, Hoffman's, abdominal reflexes, primitive reflexes, clonus
Cerebellar				
Appendicular	✓	✓	✓	Includes heel to shin, finger to nose, rapidly alternating movement
Truncal	✓	X	X	N/A
Gait	✓	X	X	Per physician discretion, standing and ambulation may be assessed unassisted or with untrained assistant, depending on perceived fall risk. TA may assess heel walking, toe walking, tandem gait, and Romberg safely.

[a]TA: tele-exam with trained assistant.

[b]UTA: tele-exam with untrained assistant.

[c]UA: tele-exam unassisted.

[d]N/A: not applicable.

[e]SCM: sternocleidomastoid.

[f]DTR: deep tendon reflex.

Conclusions

Adequate telemedical history taking and physical examination performance depend on the patient, availability of an assistant, and the assistant's level of training. A hands-on educational curriculum to train assistants has the potential to narrow the gap between in-person and telemedicine examinations. This could substantially increase access to higher-level expert evaluations across the United States and internationally. More research regarding training, costs, implementation, and outcome measures for such assistants is warranted. As telemedicine continues to grow rapidly, the field must remain proactive, flexible, and nimble in using all resources to improve quality, access, and value to our patients.

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Authors' Contributions

IB designed and conceptualized the paper and drafted and revised the manuscript for intellectual content. DTC drafted and reviewed the manuscript for intellectual content.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Detailed breakdown of the neurological examination elements laid out in Table 1.
[DOCX File , 15 KB - mededu_v7i4e28335_app1.docx]

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Abbreviations

APP: advanced practice providers

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Original Paper

The Use of a Formative Pedagogy Lens to Enhance and Maintain Virtual Supervisory Relationships: Appreciative Inquiry and Critical Review

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Abstract

Background: Virtual supervisory relationships provide an infrastructure for flexible learning, global accessibility, and outreach, connecting individuals worldwide. The surge in web-based educational activities in recent years provides an opportunity to understand the attributes of an effective supervisor-student or mentor-student relationship.

Objective: The aim of this study is to compare the published literature (through a critical review) with our collective experiences (using small-scale appreciative inquiry [AI]) in an effort to structure and identify the dilemmas and opportunities for virtual supervisory and mentoring relationships, both in terms of stakeholder attributes and skills as well as providing instructional recommendations to enhance virtual learning.

Methods: A critical review of the literature was conducted followed by an AI of reflections by the authors. The AI questions were derived from the 4D AI framework.

Results: Despite the multitude of differences between face-to-face and web-based supervision and mentoring, four key dilemmas seem to influence the experiences of stakeholders involved in virtual learning: informal discourses and approachability of mentors; effective virtual communication strategies; authenticity, trust, and work ethics; and sense of self and cultural considerations.

Conclusions: Virtual mentorship or supervision can be as equally rewarding as an in-person relationship. However, its successful implementation requires active acknowledgment of learners' needs and careful consideration to develop effective and mutually beneficial student-educator relationships.

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KEYWORDS

medical education; virtual learning; formative pedagogy; supervisory relationships; pedagogy; mentors; education; virtual education; teaching; online platforms; web-based

Introduction

Background

For centuries, learning has primarily been undertaken with both students and teachers physically present in a classroom, with the roles and responsibilities of both being fairly well defined. Although distance learning dates back to as early as the 18th century, many supervisors have had little opportunity to reflect on how their face-to-face pedagogical skills can be transferred on the web [1,2]. However, it has arguably gained more popularity since the *virtual explosion of web-based education* following the global COVID-19 crisis [3].

Mentoring and supervision describe two different but overlapping phenomena and are often used interchangeably [4]. Supervisory relationships tend to have a power dynamic parameter and exemplify a formal learning contract wherein deliverables, such as assessments, academic requirements, and program completion, need to be met [5]. Mentorship is seen as a one-to-one relationship, whereby a senior person voluntarily teaches, supports, and encourages another, with the main purpose of sharing knowledge, wisdom, and support [6]. For us, both roles require an element of discipline and support, playing a central role in the students' overall experience, satisfaction, retention, and research completion.

Despite the multitude of differences between face-to-face and web-based supervision and mentoring, it can be argued that most skills are similar regardless of the environment [7]. Theories, such as the concept of formative pedagogy by Jones [8], which underpins an approach at Dundee University, and *third space*—a component of learning spaces that promote human connections and interactions to cultivate holistic, interculturally enriched experiences—by Elliot et al [9], can provide key foundations for building successful virtual relationships. Both Jones [8] and Elliot et al [9] argue that during disruptive transitions into postgraduate environments, the explicit use of learning contracts generates clear expectations of each participant and can create safe spaces for discussion, support, and problem solving, arising from the tensions among the components of the students' reality. Formative pedagogy requires the development of reciprocal, trusting, and respectful supervisory relationships through negotiated student-centered *learning contracts*, as promoted by Anderson et al [10].

Transitions in learning are internal, ongoing processes in the mind [11] and happen when moving from one context to another [12,13]. Therefore, when moving from the known, face-to-face to the unknown web-based method, individuals can experience changes in physical, cultural, psychological, and social domains [12,13]. Thus, educators need to facilitate sense making of new rules and routines that operate in learning environments, such as on the web [14]. Benefits of remote learning include learning flexibility for students, more relaxed learning environments, low-cost delivery of courses, and the ability to access resources at a geographical distance from the campus [15-17]. Furthermore, the global accessibility and outreach of remote learning provides an appropriate technical infrastructure to connect academics anywhere to diverse groups of learners [18]. Given the potential pedagogical benefits of virtual learning, it is important to address the barriers that prevent an efficient educator-learner relationship from developing, thereby ensuring that the web-based learning experience is optimized.

In the era of pedagogical innovation, educators may feel under constant pressure to adapt their mentoring or supervisory strategies and embrace enhanced learning technologies that promote stimulating learning environments [19]. This surge in the use of web-based pedagogical activities has led to inquiry and debate into the attributes and skills required in an effective virtual educator. How can educators enhance the educational experience of web-based learners? It is thought that underpinning the role of mentors or supervisors is the capacity to form an appropriate pedagogical relationship, even within the confines of web-based learning. The aim of this study is to compare the published literature, through a critical review, with our collective experiences in an effort to structure and identify the opportunities (what works well) for virtual supervisory and mentoring relationships in terms of educator attributes and skills as well as provide recommendations to enhance virtual learning.

This paper starts by illuminating the relevant educational theories and frameworks of virtual education. It then draws on published literature and a small-scale reflective appreciative inquiry (AI) to understand the contributing factors identified by 5 authors engaged in successful supervisory and mentorship relationships, which have been conducted primarily on the web.

Educational Theory and Framework

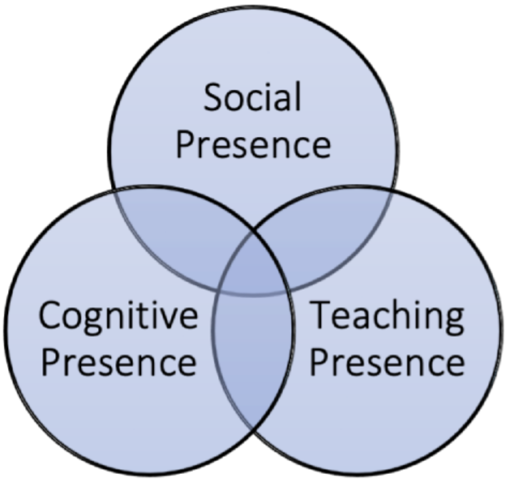
No single learning theory has arguably emerged for virtual education [20]. Researchers have recently sought to further develop and formalize models that capture the features of virtual pedagogy [20]. A model that has produced significant interest is the community of inquiry (COI) framework proposed by Garrison et al [21]. They argue that an effective web-based learning experience is best understood based on the concept of three overlapping circles, each representing a distinct *presence—social*, *cognitive*, and *teaching* [21]—as shown in Figure 1.

Social presence is our ability to establish personal and purposeful relationships encompassing open and effective communication as well as group cohesion [21]. It strives to create an environment for inquiry and quality interaction, including reflection and feedback, to collaboratively achieve educational targets [22]. In other words, it is the quality, not the quantity, of interactions that can lead to progressive discourses. *Cognitive presence* is a process of "exploration, construction, resolution and confirmation of understanding" that occurs through educational partnership and reflective thinking [21].

The final element, *teaching presence*, can be broadly categorized as the *virtual visibility* of the supervisor [23]. In the COI model, teaching presence incorporates the direction, organization, and facilitation of both cognitive and social processes to fulfill personally meaningful and educationally valuable learning outcomes [21]. A number of studies have attested to the importance of teaching presence for a successful virtual learning environment [24-26]. The general consensus in literature is that teaching presence is a significant determinant of "student satisfaction, perceived learning, and sense of community" [22].

The COI model conceptualizes effective virtual learning as a result of *interconnectedness* at the heart of learning experiences to deliver high-quality remote teaching [23,27-29]. There is a need to understand the importance of the supervisor-student relationship and how this can be enhanced and developed in a web-based environment. This small-scale study merges evidence-based literature with the authors' expertise and experience to suggest instructional recommendations that may enhance the effectiveness of distance learning.

Figure 1. Community of inquiry framework.



Methods

Overview

The methods include a critical review of published literature and thematic analyses of the authors' views developed through conversation and captured via a qualitative survey, as shown in Figure 2. The survey items, not formally validated, were developed and checked by the authors using the 4D model (discovery, design, dream, and destiny) of Cooperrider and Godwin [30]. The benefits of AI include avoidance of the traditional *deficit-based* paradigm of problem solving and, instead, adopting an *affirmative* approach "to look for what is good in the organization, its success stories" [31].

Figure 2. The study methodology pyramid embracing an appreciative inquiry approach.

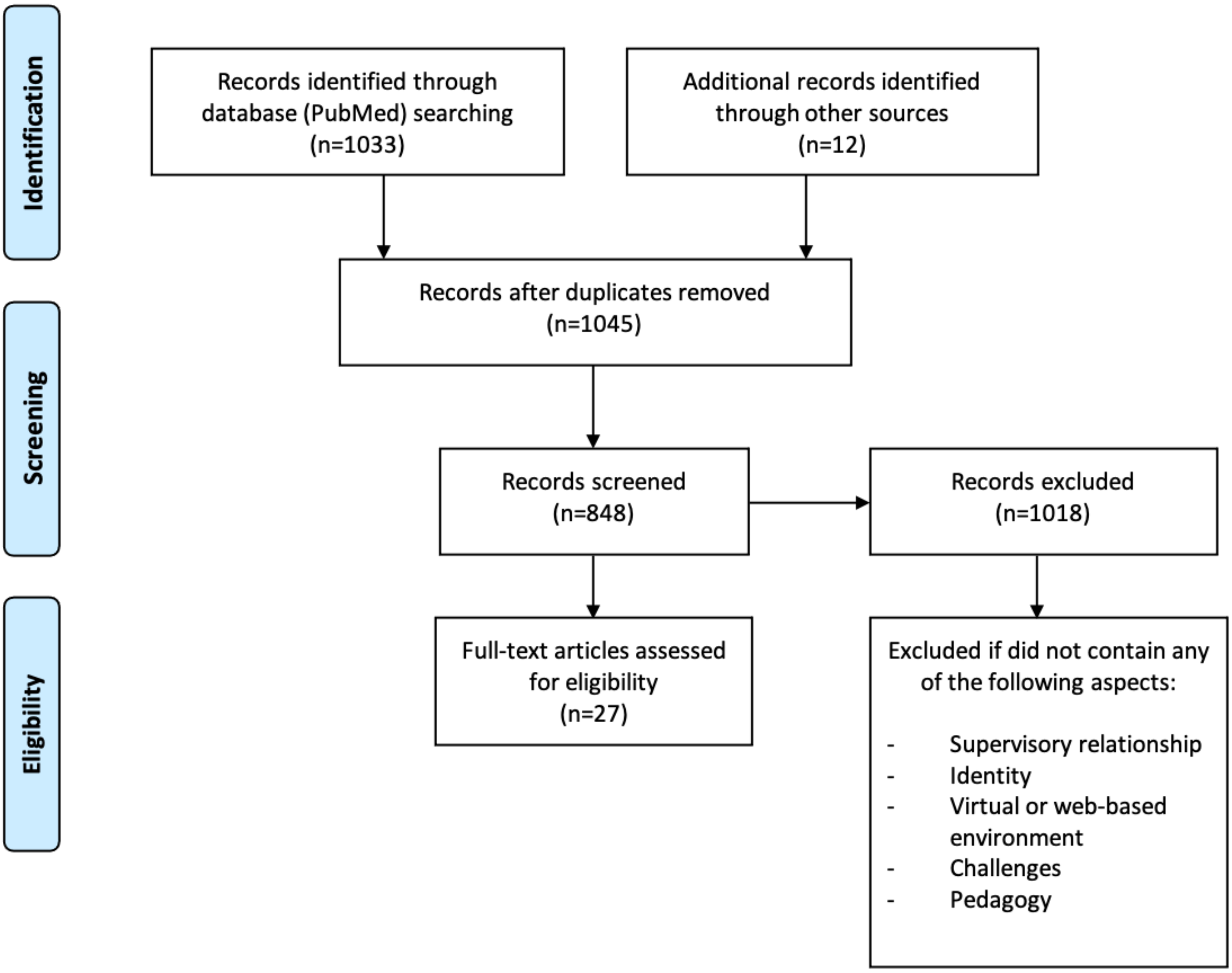
Literature Review

A review was performed to capture the published literature on remote supervisory relationships. The search was conducted in PubMed using the following search strategy:

1. Distance OR online OR remote OR virtual
2. AND Supervis*
3. AND relationship* OR guideline* OR strateg* OR tip*
4. NOT technological OR hardware OR software

Studies were screened for topics related to challenges and barriers in virtual learning and were included if they contained any of the following aspects: supervisory relationship, identity, pedagogy, virtual or web-based environment, and challenges. Figure 3 provides a visual summary of the scoping review.

Figure 3. Scoping review of published literature.



Appreciative Inquiry

This study embraces an AI framework, which draws significantly from storytelling [32]. Each author was asked to share their perspectives on five key questions (Textbox 1) regarding what works in their remote supervisory or mentorship relationships. The authors are all interconnected by roles and responsibilities and represent 2 supervisors (of undergraduate, master's, and PhD), 3 students, and 1 PhD mentor. The supervisory relationships are as follows:

1. Undergraduate: MAA (supervisor) and CJ (student); relationship transitioned from face to face to virtual.
2. Postgraduate masters: LJ (supervisor) and MAA (student); relationship included both face-to-face and virtual elements.
3. PhD: LJ (supervisor) and ST (student); relationship included both face-to-face and virtual elements
4. PhD: LC (mentor) and HA (mentee); relationship has been purely virtual.

Textbox 1. The appreciative inquiry questionnaire.

- Describe a high-point experience during your remote supervision—a time when you felt most alive and engaged, a moment that captures your supervisory relationship at its best.
- Without being modest, what is it that you most value about yourself and your role and participation in the supervisory relationship?
- What are the core factors that gave or give life to this supervisory relationship without which the quality of web-based supervision would be significantly reduced?
- What three wishes do you have to enhance learning opportunities from web-based supervision?
- On the basis of what worked for you, what advice would you offer to other supervisory dyads?

According to Richards [32], AI is a philosophy that aims to determine an organization's fundamental strengths instead of focusing on overcoming problems and then maximizes and builds on those aspects. This approach results in a greater holistic, unified, and successful process of change. Figure 2 illustrates the AI methodology used in this study.

It is argued that a large part of a successful supervisor-student relationship is deeply rooted in the human interaction between the participants in the relationship [33,34]. Thus, supervisory relationships in a virtual environment were explored using the personal accounts of the authors' experiences in web-based supervisory relationships. The participants explored their responses during a video-call, and recorded, transcribed and thematically analyzed them.

Results

The findings summarized below highlight the themes in the literature and from the AI approach (Figure 4). The major themes identified in the literature on virtual supervisory relationships were *overcoming the dislocation effect*, encompassing *effective communication strategies, and negotiating stakeholder roles and identities*. The richly descriptive themes that emerged from AI narratives linked closely to those identified in the literature and include motivation, rapport, integrity, and hierarchy. Figure 5 highlights the four key dilemmas related to virtual supervisory relationships as demonstrated in the author's AI.

Figure 4. Summary of thematic analysis from literature review and appreciative inquiry.

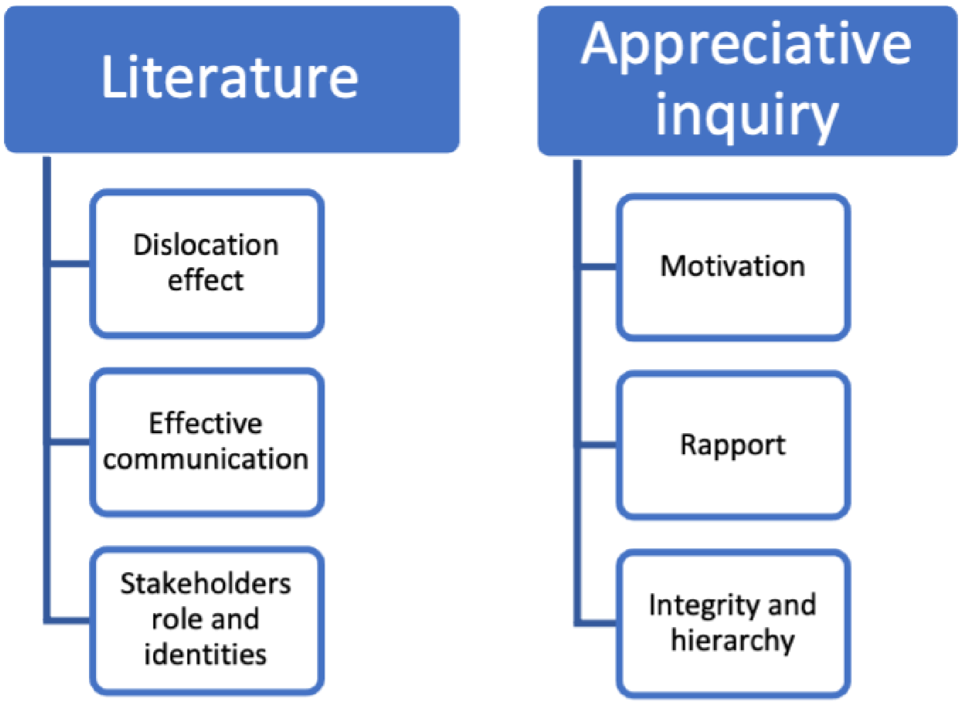
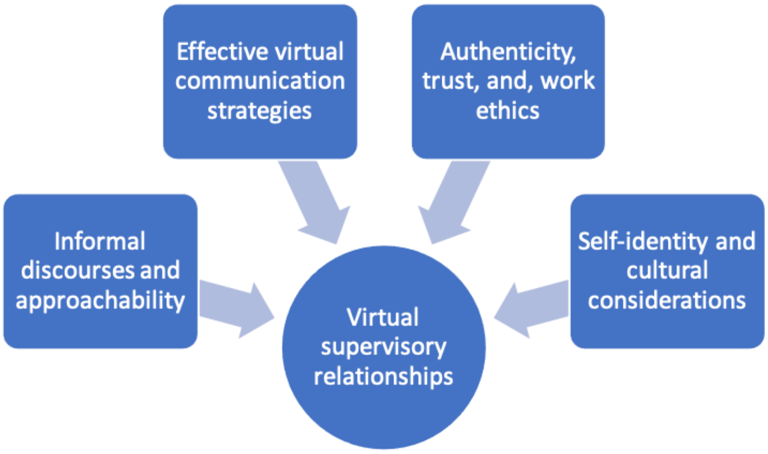


Figure 5. The 4 key dilemmas related to virtual supervisory relationships.



Discussion

Informal Discourses and Approachability to Overcome the Dislocation Effect

Nasiri et al [35] found that many of the challenges in web-based supervision arise from the spatial and temporal distance between supervisors and students. From a timing viewpoint, issues may arise in finding a mutually convenient meeting time for both parties to connect. Web-based learning involves experiences of dislocation [36]. As a result of this *dislocation effect*, students may tend to feel isolated, disorientated, and perhaps disengaged, all of which are barriers to forming a good supervisory relationship [37]. These feelings tend to drive the supervisory conversations towards a more formal format, with both parties lacking in personal knowledge about each other, making it more difficult to create an environment for informal discourse [35].

Previous studies have suggested that occasional informal social web-based interactions can contribute to effective virtual supervisory relationships [38]. The importance of informal supervisory relationships was echoed by all authors in the group AI, which suggested that learners may benefit from a combination of group and individual web-based meetings to help students feel engaged, encourage collaborative learning, and build peer relationships. This suggestion aims to cultivate a sense of belonging and community and represents a type of *social presence*, as seen in the COI framework. The authors suggest that sharing progress, experiences, and challenges with peers aims to combat feelings of isolation and disconnectedness. The AI framework further revealed that the extent to which the supervisor was perceived to be available to the student influenced the supervisory relationship. The authors agreed that supervisors who were perceived to have an approachable *web-based presence* seemed to have a more positive relationship with their students and helped in breaking down the dislocation effect:

> *Virtual platforms if anything helped me develop a stronger bond with my mentor, who is always accessible with a quick response. Our relationship dynamic shifted with time to more informal, and I felt that there was nothing that I couldn't discuss with my mentor. This helped us not only in building trust and confidence in our relationship but also we came up with new ideas—that's always an eureka moment.* [Views of MAA and LC, echoed by other authors]

One PhD dyad adapted the five-part temperature reading process of Satir [39] to "build a connection and learn to communicate on important topics," to facilitate congruent communication, cultivate meaningful relationships and to use as a conflict resolution tool if needed. The framework is based upon the supervisor and student taking turns to share information from five domains: appreciations, new information, puzzles, worries and concerns with recommendations for change, and hopes and wishes.

The PhD student found the following about this system:

> *it provided room to talk and openly share feelings, the structure generated dialogue and a sense of real and equal participation new to someone from a more hierarchical system.* [View of ST]

This combination of Satir's communication tool [39] with a shared commitment to Nodding's [40] 3R principles of reciprocity, relatedness, and responsiveness, and abiding to where "carer and cared for contribute appropriately" [41] to any student-teacher relationship and are well aligned with the concept of formative pedagogy developed by Jones [8], enhancing trust in and take up of formative assessment by the learner:

> *I worked with my supervisor face-to-face prior to the pandemic and we both worked on building an informal culture of mutual trust and interest. What enhanced this relationship further was knowing that my supervisor cared about my well-being through occasional informal calls once lockdown measures were in place [...] I felt valued as a student and knew that they were there for me to develop personally and professionally.* [View of CJ]

Specific examples that facilitated the development of good supervisory relationships included a preagreed framework for authentic checking in and catching up. One of the authors described the following:

> *When most countries went into lockdown, my supervisor took the initiative to organise daily group*

> *virtual workout sessions with his team across the globe. I believe this was an opportunity to check in on each other and allowed me to strengthen my sense-of-belongingness to my supervisor and his research family [...] I had first-hand experience of him genuinely caring about everyone in his team in a supportive and friendly environment.* [View of MAA]

In comparison with the author's findings, a number of studies from the literature search highlighted that differences in technological literacy between students and supervisors exacerbated the dislocation effect by disrupting the exchange of information, thereby reducing the desire for interaction [42-45]. This was not highlighted as an issue for the authors, whereas the AI framework highlighted that these differences aided in breaking down formal barriers by encouraging greater informal discourse, thereby building a greater rapport. Furthermore, the studies that highlighted an increase in dislocation effect investigated students and supervisors who were located in different countries with imbalanced resources, which was not the case for the supervisory relationships in this study [1,37]. Therefore, although the authors of this paper experienced differences in technological skills in their supervisory relationships, the main differences in a large number of published articles were in the availability of resources and infrastructure [1,7]. A challenge that was not heavily experienced by the authors but was predominately referenced in the literature related to time zone differences contributing to problematic synchronous communication [46].

Effective Virtual Communication Strategies

Virtual environments provide ease of communication and global outreach [1]. With the advent of web-based technologies, it is now possible to be mentored or supervised by any chosen individual worldwide. It may also minimize time, cost, hierarchy, and stress related to commuting or being physically present in an unneutral workplace environment [47]. However, studies have shown that, unlike in classroom-based teaching, distance students are limited in the quantity of interaction they have with their supervisor, thus limiting the amount of guidance and feedback the student receives [42,48].

However, the perceived drawbacks of virtual learning are arguably issues with in-person learning as well [42,48,49]. Communication difficulties are thought to be individual-specific, and the same people who have difficulties with in-person mentoring may experience challenges with virtual mentoring.

All authors highlighted the importance of relationship building and trustworthiness in supervisory relationships, whether in person or virtual:

> *I am genuinely committed to creating a relationship with my students and build trust within the confinements of the relationship. I try to convey that I am a trustworthy person, and my aim is to help them succeed. The relationship is an opportunity for meeting of minds; I may be different to my students, but it doesn't mean I'm better than them, I occupy a hierarchical position in terms of the task but not as a human being.* [LJ view]

Communication of feedback has been highlighted as a difficulty in a web-based environment [50]. It can be argued that with fewer interactions, it is harder to maintain quality feedback. For instance, with the accessibility of services such as the tracking facility of Microsoft Word, there is a tendency for students to accept additions and amendments from the supervisor, thereby eliminating potential reflection and constructive discussion [42]. This method of feedback does not promote the motivation, engagement, and independence of the student and can lead to an overreliance on the supervisor. The limitations of verbal or nonverbal cues from the student may reduce the opportunities for supervisors to check the students' understanding of feedback and risk a more hierarchical system of feedback in comparison to a mutual, bidirectional learning experience [35,49].

As a result, giving and receiving quality feedback can be challenging and require an empathetic and reassuring skill set to achieve [42]. It is important for faculty members to learn how to give web-based feedback and understand the nature of their students' emotional and academic needs [49]:

> *Most faculty are not taught how to conduct online relationships, give online feedback, or how to compensate for the lack of body language cues. If I want to feel sad, then I have to show you that I'm feeling sad. There is a real need for faculty development to shift towards the space between us, help people understand the nature of feedback, to internalize things and avoid future errors.* [View of LJ, echoed by other authors]

When communicating, it is important for supervisors to be aware that feedback has emotional connotations, and thus, it should be structured in an appropriate manner [50,51]. Feedback is affective, and the literature [52] suggests making use of Hyatt's [53] *phatic* comments, where the aim is to create and maintain a good social and academic relationship between the supervisor and the student [53]. This type of comment is used to express praise, register interest, or encourage, for example, "This is a well presented and well written assignment." Similarly, Hyland and Hyland [54] documented ways in which educators can mitigate their criticism. This strategy is reflected by using hedges such as *might*, *possibly*, and *maybe* or asking questions and suggesting points for reflection such as "have a think about [...]", as opposed to direct comments [54].

The collective experience from this AI survey highlighted that virtual meetings work best when characterized by negotiated agendas, when a safe environment is created, and where disagreements are looked for and can be constructive:

> *Once a student enters my academic bubble, I make it clear to them that we both have equal power dynamics; we both need to agree on agendas and next steps, and I welcome feedback from my learners. Just like the student, I love a challenge and a disagreement—this is how we can come up with innovative ideas and reflections.* [View of MAA]

> *I value having an agenda prior to meetings while maintaining an open relationship with my supervisor. I see it as a system of appreciation, puzzles and criticisms with recommendations based on behaviours and if there is an issue it will naturally come up [...]* [View of ST]

The literature proposes, as agreed by the authors [55,56], that the main priority in a new supervisory relationship is establishing communication. A proposed method for achieving this is by developing a communication strategy that includes who, when, and how [57]:

1. *Who*: Watt [58] suggested that "maintaining effective communication is the responsibility of the supervisor."
2. *When*: A balance needs to be struck between student independence and an overreliance on the supervisor. It has been highlighted in the literature that regular meetings reduce the potential isolation of students and encourage them to be motivated and feel supported in a web-based environment [49]. Studies have shown that a student's progress and satisfaction with web-based learning are influenced by the frequency of virtual meetings [59-61].
3. *How*: Research has shown that supervisors and students should choose technologies based on their familiarity and how appropriate they are to the specific meeting goal [62,63].

The consensus from the authors is to encourage an approach where supervisors *ask questions rather than tell* and *have a conversation* when providing feedback. It is recommended to allocate time to scaffold the student to *feed forward*; this not only allows the student to structure their next steps but also agree to a plan so that the advice and suggestions can be acted upon.

Authenticity, Trust, and Work Ethics

Trust is a key factor in social relationships and has been described as an important determinant of achievement within organizations [64]. Numerous definitions of trust have been put forward with the commonalities referring to expectations, beliefs, or attitudes towards the other person and the willingness to trust, in addition to the degree of vulnerability that results from the risk of trusting another person. Trust forms an integral part of building successful academic relationships, and it grows when supervisors and students allow themselves to be vulnerable and when tensions arise between the two parties [56]. As opposed to seeing these challenges as issues, they may be seen as opportunities for trust to grow. Arguably, trust and relationship building in virtual settings require a different framework and may be better positioned than their traditional counterparts [65]. A few studies have highlighted that trust becomes ever more important in virtual environments to minimize the psychological distance among team members and to create unity [66,67].

According to prior work [68,69], trust is the core variable and one of the most influential factors for all aspects of team work and success. Trust has a significant effect on performance [70] and can be considered as the binding unit that facilitates collaboration [71]; it is of particular importance in web-based education, where interactions may lack contextual and nonverbal cues [72,73]. The literature search highlighted that trust results in greater team collaboration, including commitment, motivation, and communication [74]; however, it is more difficult to establish and maintain trust virtually [75,76]. Maurping and Agarwal [77] highlighted that early trust building in virtual relations is crucial to developing a functional working relationship. When early trust is established, team members gain confidence to participate in behaviors and actions that improve team performance [71].

The results from the authors' AI are supported by published literature that reported that adopting a social approach when working in a virtual environment, such as encouraging social discourse early in the collaboration [66] or creating opportunities and time for informal, casual and non–work-related interactions [75], can all improve trust. One study investigated the challenges associated with trust in a web-based environment and found that the absence of nonverbal cues, such as body language, reduced tone of voice and inflections, along with a lack of facial expressions and difficulties inferring the intentions of others, delayed the participant's decision to trust a new team member or not and reduced the expression of their own trustworthiness. The results of this study are reinforced by Olson and Olson [75] who state that the use of a webcam during communication aids in instances where team members do not know each other.

One trait identified from the AI survey is that supervisors and students valued authenticity and the ability to be their *true-self* within a supervisory relationship. It highlighted the belief that being able to authentically engage with one another creates an environment conducive to building trust and personal connections. The authors recommend that in order to establish trust at the beginning of the supervisory relationship, an introductory ice breaker or a trust-building exercise can be used to increase student participation, self-esteem and also nurture and foster the supervisory relationship:

> *For me, the core factors that give life to this supervisory relationship are trust, knowing that this person cares appropriately, capacity to solve problems and authenticity (true-self). Trust encompasses personal, emotional and practical trustworthiness and if someone says they will do something, they will [...] Appropriate level of challenge both ways as this is where critical thinking emerges-depends on clear trust.* [View of LJ, agreed by all authors]

In our experiences, for trust to grow, the supervisor may need to acknowledge the student's individual needs and circumstances and offer guidance. Relationships in which the student feels truly valued and their supervisor has their best interests at heart may lead to more trusting relationships. Work ethics and maintaining a shared goal between the mentor and the learner, as well as a willingness to be open and embrace different ideas and cultural strategies, may all be successful ways to establish trust:

> *Shared interest in the project and in an output that will contribute to the knowledge base is a quality*

> *without which online supervision may be significantly reduced.* [View of LC]

Measuring trust quantitatively is difficult because of the complexity of the construct. The literature on building trust within virtual environments is particularly focused on trust within a team setting as opposed to individual relationships [78,79], which was the focus of our AI; hence, it may be difficult to compare apples with pears. However, similarities were identified, including a study by Marlow et al [80], who reported that the development of trust is improved by initial face-to-face contact at the start of the relationship. In addition, the concept of *true-self* that arose within the AI framework has been echoed in other studies exploring the development of trust in web-based environments of which personal traits and characteristics of team members were identified to play a role in establishing trust. These characteristics included ability, integrity, competence, fairness, honesty, and openness in addition to each individual having a level of autonomy [69].

Sense of Self, Self-identity, and Cultural Differences

A further, more complex theme highlighted is *identity*. Personal variables tend to be crucial in the supervisor-supervisee dyad: age, gender, personality, ethnicity, and culture can all pose challenges and have implications on supervisor-student interactions [42]. The learners' sense of self may not be a fixed entity but undergoes a process of continuous transformation during their educational experience [81,82]. This construction and deconstruction of self through a continuous process of interacting with self and educational communities may buffer the self-creativity of graduates and harness their resilience and academic success [83,84]. Educators may benefit from an awareness of the learners' self-identities:

> *I think it is quite vital to recognise learners' prior experiences and different personal and professional identities. One of my students, though a medical student, took a year to undertake an intercalated science degree. Recognising and valuing their identities helped me guide their talent and creativity* [View of MAA]

This is in line with studies by Costello [85] and Monrouxe [86], who conceptualized professional identity formation for health care professionals to be as important as skill and knowledge acquisition and advised integrating graduates into various social settings to optimize their sense of self [85,86].

Linked with the theme of identity is *role ambiguity*, identified as a learning barrier in a virtual learning environment [87]. This phenomenon highlights inconsistency and lack of clarity between student and supervisor expectations in a virtual relationship. This ambiguity can lead to disengagement and unsociability because of the lack of an agreed agenda, expectations, and standards on role behaviors and functions [56,88]. Methods that worked for the group were defining and developing a mutual understanding of individual roles and responsibilities within the supervisory relationship, which could be formalized via a learning agreement or contract.

The AI highlighted that the authors concur with the consensus in literature regarding the configuration of the traditional definition of canonical knowledge, the power and expertise of the teacher, and the passivity and role of the students that has resulted from the virtual environment [89]. Despite the AI framework highlighting the challenges faced by students as a result of the dislocation effect, it failed to address the challenges faced by supervisors. In the literature, the dislocation effect and self-identity have further been described from the perspective of the supervisor and not solely the student. It has been argued that because of virtual learning, the role of the educator has shifted from "gods of knowledge to directors of or leaders in the pursuit of knowledge," which has the potential to result in professional or self-disorientation [43,90]. Educators may experience a sense of dislocation and a loss of self-identity as their role has changed from the traditional perception regarding their authority, subject knowledge, and expertise. A potential reason as to why this challenge was not experienced by the authors could be that all the supervisors in the group were accustomed to adopting an open and egalitarian approach to the supervisory relationships, as evidenced in the quote below. In addition, in this instance, all supervisors had previous experience with virtual supervision before the pandemic whereas a large proportion of the reported studies emerging as a result of COVID-19, both supervisors and students were novices to the web-based environment:

> *Given my extensive experience in virtual pedagogy, I believe that formalising a learning contract where the student plays an active partner role is important to enhance their online learning opportunities [...] I would like the student to share who they are, what they need from me and what they want from me.* [View of LJ]

Remote supervision tends to bring together parties from different geographical regions and cross-cultures; thus, there is a growing realization that cultural differences and intercultural communication are important factors in supervisory relationships. The literature has highlighted that social and cultural differences may influence interactions between students and supervisors [35]. From the authors' experiences, it was evident that in some South Asian cultures, students are more reserved and less likely to proactively communicate their emotions, opinions, or views because of interpersonal politeness; in some instances, this led to miscommunication and conflict. The findings from the AI framework are supported by the work of Venter [91], who conducted a distance-learning study investigating the role of culture in students. Venter [91] highlighted that there are differences in attitudes regarding authority, which showed varying expectations of the student and supervisor role. The study concluded that differences in expectations arise between students from cultures that view the supervisor-student relationship through a collectivist model (supervisor-centered approach) and those from other cultures who uptake an individualistic model (student approach) [91].

In one student-supervisor relationship, the student (ST) was more accustomed to a teacher-centered approach and initially found it difficult to engage in conversation and discuss their opinions with the supervisor as this was not culturally acceptable for them. Therefore, it required an open discussion regarding their roles in the relationship and management of expectations.

Although it has been suggested that students who adopted a collectivistic model of learning experienced greater isolation [92,93], this was not the case in this study. A potential reason for the differences between our study and literature is that most studies in the literature that assessed the role of culture involved undergraduate learners; however, ST is a doctoral student who has been accustomed to working individually in previous degrees and is a senior lecturer in his native country, Sri Lanka. Furthermore, language barriers have been reported to contribute to students' isolation [94]; however, this cannot be implied in this study, as this was not a barrier in any of the authors' relationships. This experience of adopting a collectivist model was only experienced by one author and, therefore, may not be representative of other students. However, group AI revealed how their supervisor-student interactions were experienced as dynamic, engaging, and reflective while embracing cultural and background differences.

> *In my hierarchical culture, Tamil, students are expected to be passive. When I was invited to express my opinion by my supervisor, it was the first time a teacher asked me to do this. I felt that was the best moment of my educational journey and motivated me to be more interactive in the supervision.* [View of ST]

Both parties in the relationship may find it helpful to have an awareness of the other member's cultural norms and any differences that may potentially cause conflict. The authors recommend that both parties adopt an inquisitive nature and an acknowledgment that learning does not take place in people's heads alone; it takes place in people's hearts and in their lives.

Limitations and Future Work

There are a few limitations to this study. Although the AI study design was not aimed at generalizing our findings to other educational contexts, this study triangulated the experiences of students, mentors, and supervisors at 3 different institutions in the United Kingdom and the United States. We hope our approach is better assessed by what it conveys in terms of plot, participants, and place while convincing readers of its representativeness. Our small-scale questionnaire, although not validated, was designed to highlight themes and provide preliminary data for more inclusive research in the future.

Further larger scale research using a validated questionnaire across a greater number of institutions is needed to demonstrate whether themes identified are common among supervisory relationships and present in those beyond these authors and their respective institutions. In addition, future studies could usefully address disparities in access to technology, the influence this is likely to have on supervisory relations, and ways in which digital inequalities can be addressed.

Conclusions

Drawing on published literature and a small-scale AI, our study identified key dilemmas that enable us to perceive our virtual supervisory and mentoring relationships as effective and beneficial. Virtual environments can be as rewarding as in-person relationships and provide innovative opportunities, including global outreach and flexibility, ease of communication, and the potential ability to reduce time, cost, hierarchy, and stress related to physical presence in the workplace.

Our findings propose suggestions to enhance web-based learning experiences, which actively acknowledges learners' needs, especially in areas related to effective communication, cultural differences, self-identity recognition, and trust building. Careful consideration of these key dilemmas, all of which can act as barriers to an effective supervisory relationship, should be encouraged and recognized for the successful development of effective and mutually beneficial virtual student-educator relationships. However, future inclusive research on ways to manage and address these key dilemmas of virtual pedagogical relationships is needed.

The rapid proliferation of distance learning poses an excellent opportunity for institutions to invest in developmental activities that not only inform but also engage and prepare both students and supervisors for the web-based environment. By investing in formative web-based pedagogy and faculty development initiatives, institutions can empower both learners and faculty to reach their full potential [95].

Conflicts of Interest

None declared.

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Abbreviations

AI: appreciative inquiry
COI: community of inquiry

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Viewpoint

Coproduction, Coeducation, and Patient Involvement: Everyone Included Framework for Medical Education Across Age Groups and Cultures

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Abstract

Medical education, research, and health care practice continue to grow with minimal coproduction guidance. We suggest the Commons Principle approach to medical education as modeled by Ostrom and Williamson, where we share how adapting these models to multiple settings can enhance empathy, increase psychological safety, and provide robust just-in-time learning tools for practice. We here describe patient and public coproduction in diverse areas within health care using the commons philosophy across populations, cultures, and generations with learning examples across age groups and cultures. We further explore descriptive, mixed methods participatory action in medical and research education. We adopt an "Everyone Included" perspective and sought to identify its use in continuing medical education, citizen science, marginalized groups, publishing, and student internships. Overall, we outline coproduction at the point of need, as we report on strategies that improved engagement. This work demonstrates coproduction with the public across multiple settings and cultures, showing that even with minimal resources and experience, this partnership can improve medical education and care.

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KEYWORDS

medical education; coproduction; public and patient involvement; education; patient; involvement; age; demographic; model; framework; culture; exploratory; engagement

Background

> *Co-creation and community nurture engagement to invite the public inside, so that they can influence and co-create healthcare, research and community. The public is the sensor that powers influence. The public can bring evidence into practice (Amy Price, 2014 [1])*

It is time to use the growing public thirst for knowledge about health interventions to benefit public health and the continuing professional development of health professionals. This is already happening, as individuals who thought about how to meet a need have partnered with researchers to deliver 3D limbs, pancreatic cancer tests, inexpensive microscopes made of paper, and brain valves to relieve cranial pressure [1]. In this viewpoint, we provide a background of prior work in coproduction and patient involvement in health care. Examples of how such work applies to continuing professional development of health professionals are provided, along with summaries of some key insights to use in practice. Readers may find examples that worked for others in this paper. The examples of scaffolding and knowledge sharing might be adapted for use in new programs or to revise otherwise effective programs to feature more patient inclusion for education.

> *The patient is not an entity, but a person and that person can be a medical problem solver (Amy Price, 2014 [1])*

The Commons: An Opportunity for Coproduction

Health care literature is limited [2] as it tends to focus on patient values and experience [3] rather than on the active adoption, implementation, and application of medical education. Economists faced similar problems in their field as they considered how to distribute resources (the commons) with limitations in administration and in procuring labor and expertise. Ostrom and others define *the commons* as the cultural and natural resources accessible to all members of society, including raw materials such as air, water, habitable earth, information, and, specific for this paper, medical knowledge and production. These resources are common and not privately owned. Elinor Ostrom and Oliver Williamson are economists and Nobel laureates, whose research demonstrated that ordinary citizens are capable of managing and sustaining resources without outside control. They assert that coproduction occurs by combining professional expertise with the energy expenditure, wisdom, experience, and skills of end users [4] nurtured through the core standards of love, empathy, watchfulness, care, reciprocity, and willing instruction [5]. This does not imply equality in skills or ownership but rather equity in regard to respect, voice, and access to shared resources. In health care, as in life, partnerships are seldom equal, likewise with the distribution of skills and access to resources. Shared and equitable access to skills and knowledge in health care can multiply influence and scaffold community members to enrich commonly held resources (the Commons Principle). The examples in this paper employ such "*Commons Principles*" through coproduced real-world teaching at the point of care, training in empathy, and coproduced research, as stated by the Ostrom Law: "A resource arrangement that works in practice can work in theory" [6].

The Commons: Basic Education and Scaffolding

As medical educators adopt the Commons Principles, they can also make use of technical scaffolding by deploying computers as expert learning reservoirs that learners can use to scaffold each other [7,8]. Scaffolding is described as a temporary structure used to support and protect others as it aids in the navigation, learning, construction, maintenance, or repair of a structure or system. The Hole-in-the-wall Education Limited (HiWEL) project used technical scaffolding to operationalize learning. Specifically, HiWEL placed computers inside selected village walls in rural India. Curious but previously illiterate children taught themselves and each other to read, and acquired math and science skills while exploring together through computers [9]. These examples might be applied to virtual community medical education in a pandemic and within communities where learners of all ages can work together to solve medical problems and to increase health literacy.

Health Care Commons and Coproduction

Although coproduction in medical education is an emergent practice, in medicine more generally, the principles of the commons can be adapted through self-management and self-care initiatives in health care. Self-management is associated with reduced costs and increased quality of life. For example, patients remotely manage complex conditions such as diabetes [10], anticoagulation therapies [11], home kidney dialysis, tube feeding, pain pumps, thyroid care, and asthma [12]. These interventions are potentially lethal when misused, and yet results show patients and the public are competent partners with clinicians in their health care [12]. We argue that commons and coproduction principles can be strengthened through adopting an "Everyone Included" framework:

> *where everyone is trusted and respected for the expertise they bring, where openness and experimentation is the norm, people have personal ownership of health, individual stories have a global impact, and the patient voice and choice is a part of all stakeholder decisions* [13]

Examples of Coproduction in Health Care

Coproduction and Continuing Professional Development in Health Care

Continuing medical education (CME) consists of educational activities that serve to maintain, develop, or increase the knowledge, skills, and professional performance and relationships that a physician uses to provide services for patients, the public, or the profession. The content of CME is the body of knowledge and skills generally recognized and accepted by professions within the basic medical sciences, the discipline of clinical medicine, and the provision of health care to the public.

Patients have traditionally seen minimal involvement in the CME process as curriculum creators, educators, or participants. Although research has shown that patient inclusion does indeed enrich CME, many CME creators are still unsure as to *how* they might meaningfully engage with patients. In 2017, the Accreditation Council for Continuing Medical Education (ACCME) collaborated with Stanford Medicine X, a patient-inclusive health care innovation program at Stanford University, to create a set of design principles for patient engagement in CME.

The Stanford Medicine X design team worked directly with the president of the ACCME, Graham McMahon, to lay out a strategic plan for the design initiative. After defining the challenge, which was to make the CME process more inclusive of patients in an effective and meaningful manner, Medicine X organized a design workshop at the 2017 Medicine X | ED Conference.

A group of 50 providers, patients, educators, and health care administrators convened at Stanford University in April of 2017. During the half-day workshop, participants shared experiences, success stories, and challenges with CME. With the help of design facilitators, they documented key themes and future opportunities for success in CME.

Following the workshop, the Medicine X team documented, archived, and uploaded the thousands of insights generated from the workshop. The Medicine X team worked to consolidate and organize the contributions into insight statements or learning opportunities [13].

One recurring theme identified in the workshop was the affective component of fear as a roadblock to the involvement of patients in continuing professional development. When the participants looked at ways to mitigate such features, they reached a fascinating insight: the opposite of fear is not courage but curiosity. With this information, the team explored a novel design question: How might we foster a culture of curiosity in CME? Sifting through the thousands of notes from the workshop, they structured three key insights (Textbox 1):

- Curiosity: Medical students, patients, and providers are more likely to retain information if they are inherently curious about the material and each other.
- Safety: CME learning is more highly optimized when patients and providers have a safe space to learn from each other.
- Diversity: Patients and providers involved in CME are most engaged when learning from individuals from different backgrounds, cultures, expertise, and ages.

Textbox 1. Key learnings and insights from the Medicine X | ED Conference.

Build trust by cultivating empathy and shared vulnerability through the power of storytelling, and by permitting others to be human

The team observed that the diverse group of patients, clinicians, researchers, and technologists found that storytelling is a potent tool to cultivate both empathy and shared vulnerability. The Stanford Medicine X program uses storytelling as a tool at their cross-stakeholder convenings. In the process of creating a safe space for storytelling, the team learned that storytelling creates a culture of openness, understanding, empathy, and shared vulnerability among the participants.

Cocreate with patients early in the curriculum development process by actively involving them in the development, delivery, and assessment of continuing medical education

The inception of the Stanford Medicine X conference, a convening run by the Medicine X program, exemplifies these principles. Medicine X began as a serendipitous conversation on Twitter between the Executive Director, Larry Chu, MD, and a Stanford Health Care patient, Hugo Campos. Their conversation and relationship in the planning of the first Medicine X conference matured into a culture of cocreation among patients, providers, educators, and all stakeholders in health care. Involvement of patients in the development of the curriculum and planning of convenings broadens the research agenda and increases the relevance of outcome measures that matter to patients [14].

The convenors worked in partnership with patients to identify emotional, physical, financial, and logistical barriers to participation through a wide variety of programs. The Medicine X ePatient Scholarship Program, accessibility surveys, and conference are all codeveloped with patients to correctly identify and address barriers to participation. These methods create equity by respecting patients as peers, and by acknowledging their contributions in ways that are meaningful to them.

At Medicine X, there is a concerted and deliberate effort to elevate respect hierarchies by hearing and applying the knowledge shared by patients across medical practice and by acknowledging patients' time and effort. We explore ways to return value to patients for their contributions. In the past, we have found that thoughtful gifts of appreciation, acknowledgements of support, and other creative forms of gratitude have come a long way in making patients feel genuinely respected and valued. As others have noted, financial compensation to patients for their time is essential and complex [15].

It is vital to create a diverse, open, and welcoming culture by promoting diversity in continuing professional development activities. We note that diverse patient contributions require measures of inclusivity that maintain respect for all forms of diversity, some of which may include disability/ableism, gender nonconformity, race, and disadvantaged background, among others.

Health Care Commons and Online Pulmonary Fibrosis

The Pulmonary Wellness Foundation assembled clinicians, healers, patient engagement experts, researchers, caregivers, patients, and patient advocates to develop "LIVE YOUR LIFE with Pulmonary Fibrosis, A Peer Support Program." We offered the 8-session curriculum to 10 individuals living with pulmonary fibrosis (PF). The main objectives were to explore the physical and mental challenges imposed by PF and to form new leaders in the PF community. The community adopted the "Everyone Included" framework [13] for health care innovation, based on principles of mutual respect and inclusivity.

The program adopted psychological safety strategies to emphasize participants' unique skills and viewpoints. This program implemented an empathic, lightly facilitated, hierarchy-flattened model with collaborative workshops sessions, alternated with sessions led by subject matter experts, which were attended by patients and experts for live questions and answers.

The program launched using the "Welcome, YOU matter!" package which contained an honor code, best practices for online support groups, biographies of facilitators, and a self-evaluating instrument. Before each session, they shared topics and objectives, a library of resources, and a summary of the previous session's findings. Postprogram evaluations were distributed to measure learning. Participants shared the following key differentiators from other support initiatives: a space created for patients in collaboration with patients; prereadings and summaries of discussions helped with organization of thoughts in advance of each session as well as with the practice of new concepts after each session, once they were alone; the lightly moderated format allowed for spontaneity and authenticity, while brainstorming on potential solutions in a nonthreatening environment was uplifting and empowering.

The program resulted in the development of coproduced strategies to help problem solve PF-related struggles. The 2017 Ultimate Pulmonary Wellness online textbook [16] will be updated and published with coproduced program findings, practical experiences, and patient-led suggestions (Textbox 2).

Textbox 2. Key learnings and insights from LIVE YOUR LIFE with Pulmonary Fibrosis, A Peer Support Program.

Identify patient partners within your expert network community and seek their collaboration to coproduce shared resources

Patient partners can be influential experts and allies to coproduce shared resources for health care professionals; they can identify the practical experiences and needs of patients, approaches for quality improvement, and key clinical program findings in professional development.

Commons and Coproduction Among Deaf, Deafblind, and Hard of Hearing People

The deaf, deafblind, hard of hearing, and signing communities are marginalized from access to health-related resources. This marginalization drives health disparity among the deaf, deafblind, and hard of hearing populations. Coproduction and coeducation through commons resource-sharing principles can reduce disparity. Dr. Kushalnagar, a deaf individual who is a health researcher, and her team were inspired by the collective resource-sharing commons in the Everyone Included framework [13]. They engaged in several conversations with the leaders and emerged to engage deaf patients in coproducing research, storytelling videos, and more. The inclusion of deaf patients in public coproduction helps promote not only diversity in perspectives but also engagement in health-related decision-making between deaf patients and physicians [17,18].

The Everyone Included initiative increases visibility and accessibility to a diverse group of deaf, deafblind, and hard of hearing patients who can help, through user experience testing or human-computer interaction research, improve the digital health experience for everyone (Textbox 3). As we work to promote the Everyone Included model, the quality of health care research, health technology products, and patient experiences will improve. For example, Gallaudet University collaborated with Google to test and improve the user experience for its Google Live Transcribe speech-to-text app [19]. This app is now used by not only deaf people but everyone with a wide range of communication needs [20].

Textbox 3. Key learnings and insights for applying the Everyone Included principle among deaf, deafblind, and hard of hearing people.

Work with marginalized groups of people who have health disparities and include them in your coproduction process

Marginalized people bring unique insights into the health care system. Including them in the coproduction of continuing professional development activities helps to improve health disparities in community health populations.

Parkinson Disease and Intergenerational Coproduction

Summer Brunoe is one of our Stanford Science, Technology, and Medicine Internship (SASI) [21] alumni, who focused on the following question: Could intergenerational dancing impact those with Parkinson disease (PD) and older people? She participated in the undergraduate learning opportunity “Artists and Scientist as Partners” at Brown University, led by Rachel Balaban and taught by Julie A Strandberg. Dance for All People (DAPpers) [22] was created in 2013, inspired by the Dance for PD program developed by the Mark Morris Dance Group. DAPpers is designed for individuals with PD and other movement challenges. The classes provide placements where students can build intergenerational community and experience through the power of dance. The relationships formed are meaningful for all participants and reduce feelings of isolation and loneliness in both populations [22].

The students show up, dance, and get to know the people as individuals. Although COVID-19 restrictions went into place while Summer was taking this course, DAPpers chose to be resilient and they continued virtually. She found that the exposure, the need to adapt to meet online needs, and the requirement to listen brought unexpected opportunities to learn from vulnerable people. She notes communicating and learning together are actionable principles of empathy and empowerment (Textbox 4).

Textbox 4. Key learnings and insights from the Dance for All People program.

Including intergenerational participants in a professional development program reduces feelings of isolation and loneliness

As the current COVID-19 pandemic increases social isolation of our health care populations, older populations are at increased risk for isolation. Including intergenerational participants in professional development programs can increase engagement and decrease feelings of social isolation and loneliness for both groups.

Coproduction and Mentorship in Young People

SASI [21] brings together students from different backgrounds and assigns them to small groups led by SASI alumni who trained as Mentors-In-Residence (MiR). The program was developed by necessity due to COVID-19 withdrawals of face-to-face programs at Stanford and lockdown restrictions worldwide.

The MiRs were coached in the Everyone Included principles of coproduction [13]. MiRs were catalysts to ignite creativity and collaboration among SASI students. Before the start of the program, MiRs completed a workshop on how to provide feedback and be empathic. The training prepared them to communicate with students to mentor them throughout the program. Empathy can be somatic (sensory), affective (emotional), and cognitive (thinking); it is the quality that allows us to acknowledge and identify with the feelings, intentions, limitations, and beliefs of others, while maintaining a distinct sense of self [23].

MiRs found that the insights from older mentors with established careers and decades of practice would sometimes fall on deaf ears of young students. It was the MiR's job to take the information given to them by the program leaders and alter it so that it could be appropriately understood by young students who were only beginning their careers. Furthermore, MiRs also oversaw and facilitated group interaction and worked with students to complete the program's capstone projects. This form of mentorship involved daily check-ins on progress, office hours for questions, and simply providing an ear to listen to the students. Due to COVID-19 and lockdown restrictions, international students were often in difficult situations with regard to their finances and home lives. In addition to program leadership, it was a MiR's role to simply listen to the students and work to find solutions to improve their program experience. Mentorship moves beyond defining career trajectories to encompass emotional support, encouragement, and guidance (Textbox 5). Students completed substantial projects, including prototypes for personal protective equipment infographics for school reopenings. They also prototyped new technology in Mercedes Benz cars to prevent child deaths, and developed, produced, and submitted videos to teach children healthy lifestyles; Sutter-Health published three of these videos [24].

Textbox 5. Key learnings and insights from the Mentors-in-Residence program.

> Continuing medical education can encourage mentoring and train multimedia production online by moving beyond defining career trajectories to encompass emotional support, encouragement, and guidance, and is applicable across age differences, groups, cultures, and countries.

Coproduction and Mentorship in Professional Development

Ujwal Srivastava, who attended the inaugural SASI [21] session, valued hearing from patients, doctors and mentors; meeting new friends; and the opportunity to develop clinical and nonclinical medical skills. He shares:

> *The most important thing I learned as a SASI participant was the Everyone Included model for health care that promotes empathy, trust, and open communication between all stakeholders in health care.*

The following summer, Ujwal volunteered as a teaching assistant for SASI, where he evaluated before-and-after changes in students during the SASI program. Specifically, he considered how empathy levels change in SASI students through coproduction. All SASI students complete a group capstone project in which they consult with an actual patient (remotely) about their medical condition, and they use this information to codesign solutions with them. Based on their interactions, patients were asked to evaluate each SASI participant's empathy individually, using the validated Consultation and Relational Empathy (CARE) measure [25], in which scores can range from 10 to 50. Preinstruction, students averaged a 31.3 CARE score. By the second interaction, the CARE score was 36.3, and by the end of the SASI program, the average CARE score was 40.8. These findings show that preclinical students can increase empathy through coproduction (Textbox 6).

Textbox 6. Key Learnings and Insights from the Stanford Science, Technology, and Medicine Internship program.

> The process of including trained patient experts in a professional development program could remove hidden biases that professionals may have about the knowledge patients possess and can lead to more engaged and productive conversations. Such coproduction empowers patients to be cocreators in their treatment and transforms the patient-physician dynamic by producing innovative, holistic care.

Conclusion

Many years ago, one of the authors (AP) worked as part of the Red Cross disaster team for Hurricane Andrew [26]. One of her tasks was to mark and report the dead and to mark properties with an "X" that were beyond reconstruction. It seemed so little. She learned that the most challenging emotion was not fear, anger, or sadness but rather helplessness, and the most destructive behavior was blame. Teams were admonished not to look back as other groups would follow to meet the needs for which they were not equipped. Relief teams were encouraged to focus on the living without respect to their current state or behaviors and to prepare them to receive benefit. Being stewards for the diverse patient communities and medical education networks, and preparing them to receive benefit is critical to maintaining the stability of health education, health technology, and health-related production work in empathy as a "public good" or "commons" for these communities, while at the same time creating research and commercial value that benefits Everyone Included.

In keeping with coproduction practice and the Everyone Included framework, we report that three of our authors (AB, SB, US) are students and members of the public one (PK) is a deaf researcher, and another researcher (AP) sustained disability and brain injury through trauma.

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Authors' Contributions

AP and LC conceived of the paper, wrote the initial draft, and worked through the edits suggested by coauthors. All authors supplied the content, and edited and refined the document to improve it and approve its final version.

Conflicts of Interest

AP is an Editor (Research and Evaluation) at The BMJ; all authors have a participatory interest in the areas where they have contributed.

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Abbreviations

ACCME: Accreditation Council for Continuing Medical Education
CARE: Consultation and Relational Empathy
CME: continuing medical education
DAPpers: Dance for All People
HiWEL: Hole-in-the-wall Education Limited
MiR: Mentors-In-Residence
PD: Parkinson disease
PF: pulmonary fibrosis
SASI: Stanford Science, Technology, and Medicine Internship

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Original Paper

Assessment of Entrustable Professional Activities Using a Web-Based Simulation Platform During Transition to Emergency Medicine Residency: Mixed Methods Pilot Study

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Abstract

Background: The 13 core entrustable professional activities (EPAs) are key competency-based learning outcomes in the transition from undergraduate to graduate medical education in the United States. Five of these EPAs (EPA2: prioritizing differentials, EPA3: recommending and interpreting tests, EPA4: entering orders and prescriptions, EPA5: documenting clinical encounters, and EPA10: recognizing urgent and emergent conditions) are uniquely suited for web-based assessment.

Objective: In this pilot study, we created cases on a web-based simulation platform for the diagnostic assessment of these EPAs and examined the feasibility and acceptability of the platform.

Methods: Four simulation cases underwent 3 rounds of consensus panels and pilot testing. Incoming emergency medicine interns (N=15) completed all cases. A maximum of 4 "look for" statements, which encompassed specific EPAs, were generated for each participant: (1) performing harmful or missing actions, (2) narrowing differential or wrong final diagnosis, (3) errors in documentation, and (4) lack of recognition and stabilization of urgent diagnoses. Finally, we interviewed a sample of interns (n=5) and residency leadership (n=5) and analyzed the responses using thematic analysis.

Results: All participants had at least one missing critical action, and 40% (6/15) of the participants performed at least one harmful action across all 4 cases. The final diagnosis was not included in the differential diagnosis in more than half of the assessments (8/15, 54%). Other errors included selecting incorrect documentation passages (6/15, 40%) and indiscriminately applying oxygen (9/15, 60%). The interview themes included psychological safety of the interface, ability to assess learning, and fidelity of cases. The most valuable feature cited was the ability to place orders in a realistic electronic medical record interface.

Conclusions: This study demonstrates the feasibility and acceptability of a web-based platform for diagnostic assessment of specific EPAs. The approach rapidly identifies potential areas of concern for incoming interns using an asynchronous format, provides feedback in a manner appreciated by residency leadership, and informs individualized learning plans.

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KEYWORDS

simulation; graduate medical education; assessment; gamification; entrustable professional activities; emergency medicine; undergraduate medical education

Introduction

In 2013, the Association of American Medical Colleges conceptualized and developed 13 activities that all incoming residents should be entrusted to perform without direct supervision on the first day of residency [1]. These 13 entrustable professional activities (EPAs) aimed to establish uniformity in skills expected of medical school graduates in the United States [2]. EPA assessment across medical schools, however, remains inconsistent [3]. Residency program directors observe significant variability in skills among incoming interns. This may result in the need to create introductory level curricula to *remediate* interns on arrival and increase faculty supervision demands in the clinical learning environment in order to bolster patient safety [4-6].

The transition from undergraduate medical education (UME) to graduate medical education (GME) continues to challenge trainees and educators, making it an important target for medical education reform [7]. The EPA framework is designed to establish a continuum from UME to GME in US-based medical education settings. As UME continues to adopt competency-based medical education, EPAs offer a complementary assessment system based on holistic, observable, and behavioral determinants of performance [8,9]. Current approaches to EPA assessment leverage existing medical school clerkships, simulation centers, or capstone programs [10,11]. Although convenient, these traditional methods of student assessment often fail to collect adequate data for competency decisions across all 13 EPAs. For example, Colbert-Getz et al [12] analyzed the content of over 400 free-text comments by physician assessors and found limited evidence supporting a student's ability to interpret diagnostic tests (EPA3), enter orders or prescriptions (EPA4), or recognize patients requiring urgent intervention (EPA10). This assessment gap threatens the use of EPAs and calls into question whether a new approach for collecting assessment data is warranted.

One of the primary challenges to closing the EPA assessment gap is the lack of standardization across all medical schools. The EPA framework was intended to address this challenge, yet there remains significant variability in assessment methods and reporting [3]. Studies have demonstrated a trend toward using digital adjuncts for medical education [13]. The ability to use these virtual platforms has not been fully taken advantage of in assessing learners during this transition period.

The objective of this pilot study was to examine the feasibility and acceptability of asynchronous EPA assessment using a virtual platform. We report the use of this web-based interface for a selected number of EPAs in a cohort of entering emergency medicine interns during the transition between medical school and residency.

Methods

Study Design, Setting, and Population

This was a single-center, cross-sectional pilot study of simulation cases on a web-based EPA assessment platform using an exploratory mixed methods design, which entailed a quantitative analysis followed by a qualitative approach. We obtained a convenience sample of 15 incoming first-year interns of a 4-year postgraduate emergency medicine residency program at an academic institution. We purposively sampled these interns and program leadership for subsequent interviews. This study was approved by our institutional review board (protocol 49712).

Conceptual Framework and Development

We used Kolb's experiential learning model as the framework for developing our assessment [14]. The integration of active experimentation and concrete experience described by Kolb was achieved through web-based simulation [15]. Reflective observation and abstract conceptualization occurred during stakeholder interviews, as well as during the use of the assessment results to design individualized learning plans. The process of developing these learning plans is outside the scope of this study and therefore not reported.

We used the My Sim Cases web platform [16] to customize an assessment for participant skills based on 5 EPAs. We selected EPAs that are well suited for virtual assessment: EPA2: prioritize a Differential Diagnosis Following a Clinical Encounter; EPA3: Recommend and Interpret Common Diagnostic and Screening Tests; EPA4: Enter and Discuss Orders and Prescriptions; EPA5: Document a Clinical Encounter in the Patient Record; and EPA10: Recognize a Patient Requiring Urgent or Emergent Care and Initiate Evaluation and Management [17]. To assess feasibility, participants were asked to access the platform asynchronously anytime between their medical school graduation and the start of internship. Participants viewed a 5-minute tutorial that explained the interface prior to completing 4 virtual clinical cases.

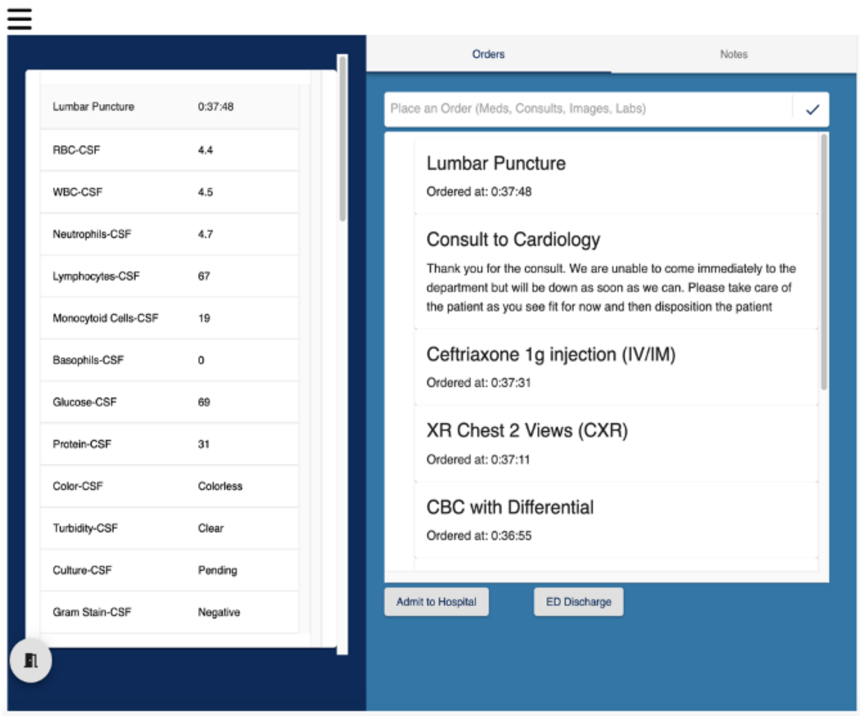
A panel of 6 education assessment experts, residency program faculty, and clerkship leaders convened to design these 4 clinical cases. First, we proposed virtual cases based on chief complaints in common emergency medicine, including chest pain, shortness of breath, vomiting, and altered mental status. One author (CP) then drafted the cases and the corresponding appropriate clinical actions. In order to optimize content and internal structure evidence, the same panel reconvened to review and revise drafts thrice across several months until consensus was achieved. Then, a second panel of trainees (medical students and residents) and faculty members (clinical and nonclinical staff) provided feedback on the cases as well. These responses were cross-checked for consistency, as evidence of response process validity. From that review, a critical actions checklist and corresponding performance report was developed for each case. These reports use "look for" statements that help guide supervisors' attention to aspects that need to be reassessed in the clinical environment or for which feedback should be provided. A "look for" statement based on expected history and physical examination techniques, missing actions, and harmful actions might read as follows: *look for incomplete or missing information in documentation*. The cases were implemented in the customized assessment platform. The web-based platform was pilot-tested by the second panel in 2 rounds, to further evaluate the cases for functionality, matching of item construct and content, optimal item phrasing, and overall quality control.

Final pilot testing was performed by 6 emergency medicine faculty members with expertise in medical education.

The platform features 2 user interfaces that simulate the electronic medical record (EMR) and bedside evaluation (Figure 1). In the bedside interface, the participants engaged in a clinical encounter in which they clicked through questions to obtain the patient's history, obtain additional information from prehospital providers, and request bedside clinical actions (eg, ask the nurse to display vital signs on the monitor, insert a peripheral intravenous catheter, and administer oxygen by nasal cannula). In the EMR interface, the participants placed orders for medications, imaging, labs, and requests for consultant advice (Figure 2). Participants chose the documentation of the history and physical exam using a multiple-choice prompt. They utilized an open textbox and a dropdown menu to record a differential diagnosis. The results for labs and imaging were withheld until all orders and documentation were completed. To close the encounter, the participants chose a disposition of "admit to hospital" or "discharge home" and entered a final diagnosis. A composite score report of "look for" statements was generated after completing all 4 cases; reports included between 0 and 4 "look for" statements per case with the desired score being 0.

Figure 1. Example screenshots of web-based entrustable professional activity assessment interface.

Figure 2. Dashboard of web-based entrustable professional activity assessment interface of electronic medical record.



A postassessment survey (using Qualtrics XM) captured demographic and previous training data. Following the quantitative portion of the study, we individually interviewed a subset of residents and residency program leaders about their experiences and perspectives of the assessment program and resulting data reports.

Data Analysis

EPA Assessments

To evaluate feasibility of the platform, we examined participant score reports. Outcome measures included participation rates, frequency of the number of "look for" statements generated for each participant per case, frequency of the overall number of dangerous actions or missed critical actions reported per case, descriptions of the performance of each case, and overall performance per EPA. Descriptive statistics were performed using SPSS (version 27.0; IBM Corp).

Stakeholder Interviews

To explore acceptability of the platform, we performed qualitative interviews with key stakeholders using an interpretive phenomenological framework with thematic analysis to examine the contextual influences of their experiences [18,19]. The first author (CP) conducted individual, semistructured video conference interviews with a convenience sample of volunteer participants and the members of our residency leadership team between July and October 2020. All residency program leaders received a 15-minute presentation regarding the platform and the aggregated results prior to their interviews.

Interviews ranged from 10 to 45 minutes in length, and each was digitally recorded. Each recording was transcribed, verified, and anonymized prior to analysis. Analysis was performed by 2 independent coders (CP and CT). A codebook was established by the first coder (CT), who was blinded to the participant identities, then subsequently coded by the second coder (CP). Disagreements were discussed until consensus was reached. A Cohen kappa value was calculated using SPSS (version 27.0) to evaluate intercoder reliability [20]. Subsequently, the thematic structure of the data was analyzed based on frequency of similar content and meaning, and overall themes were determined.

Reflexivity

We acknowledge the potential biases that may result from previous training and experiences of our author team. Our investigators include 4 emergency physicians (CP, KS, HCW, and MAG) and 2 education researchers (SSS and CT), all of whom have experience in medical education and qualitative research methods. Two authors have served in residency leadership as emergency medicine residency program directors (MG) or associate program directors (HCW), and the other two are medical simulationists (CP and KS). All of these authors have extensive experience in training emergency medicine residents in clinical and nonclinical settings. We also had a nonclinical, but emergency medicine (EM)–focused, assessment expert (SSS) who has experience in developing several assessment innovations. Five of our authors (CP, KS, HCW, SSS, and MAG) participated in case development and the analysis meetings to ensure our individual biases were made explicit and addressed. We also sought expert panels of other EM educators who were not involved in the study design or case development for case review and pilot-testing. Interface testing also included several trainees from different post-graduate year levels.

Results

EPA Assessments

All 15 eligible subjects consented to participate in the study, and 13 (87%) provided demographic data. Of these, 54% (7/13) were women, with an average age of 28 (range 25-38) years. Only 85% (11/13) of the participants reviewed the tutorial about the interface, and 31% (4/13) of them reported use of a cognitive aid during the assessment (which is defined by any resource outside of the virtual case such as other websites or applications). The mean time to complete all 4 cases was 48.6 (range 16-91) minutes.

Table 1 summarizes the aggregated cohort score reports by EPA. All participants (15/15, 100%) generated the *look for* statement pertaining to the "ability to enter critical orders and avoid inappropriate or unnecessary orders," which relates to EPA3 and EPA4. Moreover, all participants (15/15, 100%) had at least one incorrect action or order placed. The average number of missing, but not harmful, actions across all cases was 13.5 (range 8-25), and 40% (6/15) of the participants performed at least one harmful action.

Furthermore, over half (8/15, 54%) of the participants did not include the final diagnosis in their initial differential in at least one of the cases. At the conclusion of the case, 38% (3/8) input at least one incorrect final diagnosis. The participants were most successful in documentation, with only 40% (6/15) generating this "look for" statement (Table 2). The "look for" statement regarding "[the] lack of recognition of most likely urgent/emergent diagnosis and appropriate initial management" was generated most often when the learners indiscriminately applied oxygen to all cases (9/15, 60%).

Overall, participants performed the best on *Case D: Shortness of Breath* (median of 1 "look for" statement, range 1-2). For all other cases, a median of 2 "look for" statements was reported, with a higher range reported for Case B: Vomiting (range 1-4) and Case C: Altered Mental Status (range 1-4).

Table 1. Composite generated "look for" report based on 4 simulated cases for all learners (N=15).

Diagnostic statement	Corresponding EPA[a]	Frequency, n (%)
Look for learner ability to enter critical orders and avoid inappropriate or unnecessary orders.	EPA3: Recommend and Interpret Common Diagnostic and Screening Tests EPA4: Enter and Discuss Orders and Prescriptions	15 (100)
Look for ability to generate and prioritize a list of relevant differential diagnosis with inclusion of the most likely diagnosis.	EPA2: Prioritize Differential Diagnosis Following a Clinical Encounter	8 (54)
Look for incomplete or missing information in their documentation.	EPA5: Document Clinical Encounter in the Patient Record	6 (40)
Look for lack of recognition of most likely urgent or emergent diagnosis and appropriate initial management for stabilization.	EPA10: Recognize Patient requiring Urgent/Emergent Care and Initiate Evaluation and Management	9 (60)

[a]EPA: entrustable professional activity.

Table 2. summarizes the raw score reports for each case and participant. The median number of "look for" statements per participant was 2. Only 1 participant scored a perfect 0 "look for" statements for 1 case, and only 2 participants scored a 4—each for a different case.

Case description	Participant														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Case A: chest pain	1	0	1	3	2	3	1	2	1	2	2	2	1	2	2
Case B: vomiting	2	1	3	2	2	2	1	2	1	2	4	2	1	2	2
Case C: altered mental status	3	1	1	2	2	2	1	2	1	4	3	2	1	2	2
Case D: shortness of breath	1	1	1	1	1	1	1	1	1	1	2	2	1	2	1
Median	1.5	1	1	2	2	2	1	2	1	2	2.5	2	1	2	2

Stakeholder Interviews

We conducted 10 stakeholder interviews, 5 with intern residents (L1-L5) and 5 with residency leadership (L1-L5). The two coders achieved excellent interrater reliability for the resident transcripts (Cohen κ=0.92) and for the residency leadership transcripts (Cohen κ=1.00), with the unit of analysis being responses to questions.

We identified 90 unique content areas for both cohorts. We refined these to 3 major themes in relation to the acceptability of the web interface and our method of asynchronous EPA assessment (Table 3). These themes included (1) psychological safety, (2) assessment for learning, and (3) value of interface fidelity. Topics most commonly discussed by the participants pertained to psychological safety, user experience, and usefulness of formative feedback, whereas the focus of the faculty interviews was individualized learning and potential uses of assessment results.

Table 3. Themes and representative quotes from stakeholder interviews.

Theme	Trainee	Residency leader
Psychological safety	"It's really odd for someone to tell someone critical feedback or give them bad criticism in front of your other peers, because you're going to leave the room and [then] hang out together. And people are just more hesitant to [be together]."	"I want them to see this as an opportunity for growth, and I worry that if we have different cohorts, they're going to feel singled out from their peers...psychological safety is key to actually fostering growth, which is key to individualized learning. So, if we take away their sense of belonging, all of a sudden we've jeopardized the success of individualized learning."
Assessment for learning	"It can be used as a way to...judge if [the learner] has tendencies to, say, order X, Y, and Z labs when maybe you should've [done] this first."	"This tells us areas of topics that we need to highlight more and cover more in intern orientation and be more deliberate about it."
Value of interface fidelity	Positive: "There was an interesting variety [of cases] and that they were fairly bread and butter EM. And that the interface worked fairly well and let me go through the correct order of operations that I would typically do in ED as far as assessing the patient and then getting studies and working on my diagnosis and treatment plan." Negative: "I did feel that sometimes the diagnoses were restrictive, or some of the things that we could do were a little restrictive."	"The ordering practices and the items that they choose to order or not order are probably the most helpful.... the students haven't had to actually put in orders until they reach residency."
Cohen Kappa	0.92	1.00

Psychological Safety

Most participants reported that the web-based assessment platform had potential to obtain individualized feedback while maintaining psychological safety. The trainees reported that privacy is not always prioritized when they receive in-person feedback. One participant (L2) noted "[feeling] odd…[hearing] bad criticism in front of...other peers." In contrast, they felt that security and privacy of our web-based interface could offer targeted, individualized feedback without the need for normative comparisons to peers.

Although diagnostic assessment can group individuals according to different strengths and weaknesses, one faculty member (L1) stressed that "psychological safety is key to fostering growth, which is key to individualized learning." The residency leaders identified individualized learning as the ultimate goal for use of this platform. Safety in the score reports was also emphasized by faculty, and they suggested several instructions for how to interpret the reports. Score reports should ensure a trainee's "sense of belonging" (L1) in their new program, irrespective of performance. Another faculty member (L3) suggested deliberate statements such as "everybody will have areas they need to develop" in order to normalize the results of the assessment.

Assessment for Learning

Trainees found that immediate feedback provided by the interface was the most important feature to leverage for learning. These learners (L1-L5) cited that the "biggest difference" in learning was having "really specific feedback [...] in real time." This assessment for learning was more important to the participants than the assessment of the EPAs themselves. In addition, one participant (L1) suggested adding more cases to the platform to allow exploration of a range of diagnoses prior to their residency start date, from "common chief complaints...to rare ones." They also suggested that the assessment interface could become an adjunct to the residency curriculum if paired with specific clinical rotations.

Faculty participants agreed that the ability to "assess where [the interns] are...from day one" (L1) would offer valuable information needed to begin tailored training. They believed that the assessment would allow for just-in-time curriculum redesign of residency orientation topics based on the cohort performance. Aside from "identifying areas [of deficiency]," the residency leaders (L2 and L4) reported that the information could be used for "remediation" of individuals who might otherwise make similar patient care errors early in training.

Value of Interface Fidelity

Overall, the trainees found the simulation to be representative of their clinical experiences. One intern (L3) noted that it "really made [him] think" about the "order of operations" in a case and by "forc[ing him] to go step by step." Furthermore, they agreed that the interface helped them (L2) "understand the workflow, the efficiencies, the logistics of dealing with a patient," leading them to think about "how to be efficient" (L2 and L4).

Our current interface has certain limitations. One trainee (L3) cited that the experience of inputting the diagnoses felt "restrictive" due to prompts and preset options and that participants would have preferred to "[free] type in answers." Others (L2) noted that the interface required many nonessential navigation clicks that "weren't really changing management." These issues represent important threats to fidelity.

The residency leaders valued the use of "look for" statements regarding missing and incorrect actions, in contrast to a numerically scored option. "Look for" statements were reported as representative of the kind of feedback one might expect in the clinical unit. They cited the interface as being particularly beneficial for evaluating the ordering practices of the trainee. One participant (L5) noted that the ability to see "the critical actions and harmful actions component of the online platform […] the most valuable component."

Discussion

Principal Findings

The use of a web-based simulation platform for EPA assessment is feasible and acceptable to key stakeholders (ie, residents and program leadership). EPA assessment using simulated cases that were customized to common emergency medicine chief complaints may have increased fidelity for incoming interns and relevance of the score reports to their program directors. Trainees found that asynchronous, individual testing provided psychological safety, and residency directors believed that the score reports could guide the development of individualized learning plans early in residency training. Psychological safety and targeted, individualized feedback are desirable outcomes consistent with other EPA-based studies [21-23].

Importantly, no single participant was competent across all 5 EPAs. These findings are somewhat troubling yet promising that our virtual assessment detected such information. Our study also highlights the need for medical schools to better use the EPA framework to guide curriculum decisions and assure the quality of their graduates upon summative entrustment for preparedness to enter into residency training. These findings are neither surprising nor novel, and they are consistent with other EPA literature to date [3,24,25].

Acceptability of this assessment approach was strengthened by the use of "look for" statements rather than numerical scores. Rigorous EPA assessment by medical schools would use multisource feedback and standardized testing to achieve defensible decisions about student competence. "Look for" statements mirror high-quality clinical feedback that is familiar to most students. It also operationalizes the EPA assessment for program directors beyond a construct of *competent versus incompetent* that might be offered in a summative report at the end of medical school. Moreover, these statements provide trainees and educators with understandable and achievable learning goals and align better with the culture of feedback rather than a punitive approach to learning, while simultaneously highlighting significant educational gaps.

Another important factor to consider with a customized design is the physician order entry interface that could simulate the EMR used in the local clinical environment. Consistency between the simulated platform and the local EMR could result in early adoption of systems at the sponsor institution and reduce cognitive load once interns begin clinical rotations. Outcomes of EMR training have shown a reduction in self-reported medical errors, and similar benefits could be observed with this assessment for learning during orientation [17,26].

Limitations

The limitations of this study include a small sample size, a single institution pilot, a single specialty cohort, implicit biases noted in the study methods, and the use of a convenience sample of stakeholders. Although all residency directors or associate directors in our department were interviewed, we sought volunteers from the trainee cohort; these could be individuals who may have had a favorable opinion of the pilot study and thus offered to volunteer, which could affect their responses. Similarly, the stakeholders may have inferred that the interviewer had a favorable opinion of the project and therefore softened any potentially negative responses. Our cases are aligned with our specialty to increase response process validity; thus, further testing is required to explore generalization of these results across students entering any field. Finally, this assessment is meant to be formative, not summative; we cannot fully assess student competence for any EPA with a single test and absence of multisource data. Therefore, the results of this assessment are best used by trainees and residency directors, not medical schools seeking a single examination of EPA competence.

Future study of our platform will include the logical expansion of testing to all medical school graduates to ensure this observation remains consistent. Customization of EPA assessments using specialty-relevant cases is also desirable for fidelity; as such, specialty boards might be the logical third parties to oversee development of such interfaces. This would bookend a resident's interaction with their future boards, with incoming assessment and certification exams at either end. Further investigation should also include a longitudinal evaluation of clinical learning outcomes at various intervals during residency training. Finally, it is critical to examine the design of individualized learning plans based on assessment results. Although the benefits of individualized learning and development plans have been previously demonstrated, their implementation has been difficult in the absence of pragmatic guidelines [2,27].

Conclusions

Asynchronous, individual EPA assessment using this web-based platform is feasible and acceptable to key stakeholders. This offers a psychologically safe and yet practice-relevant way to diagnostically assess incoming interns and will assist with transitions to residency.

Acknowledgments

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Conflicts of Interest

WL retains creation rights to the study website, with no declared financial interest as well as a disclosure of personal relationship to primary author CRP.

Multimedia Appendix 1
Interview questions for qualitative analysis.
[DOCX File , 14 KB - mededu_v7i4e32356_app1.docx]

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Abbreviations

EMR: electronic medical record
EPA: entrustable professional activities
GME: graduate medical education
UME: undergraduate medical education

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Original Paper

Interpretation of a 12-Lead Electrocardiogram by Medical Students: Quantitative Eye-Tracking Approach

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Abstract

Background: Accurate interpretation of a 12-lead electrocardiogram (ECG) demands high levels of skill and expertise. Early training in medical school plays an important role in building the ECG interpretation skill. Thus, understanding how medical students perform the task of interpretation is important for improving this skill.

Objective: We aimed to use eye tracking as a tool to research how eye fixation can be used to gain a deeper understanding of how medical students interpret ECGs.

Methods: In total, 16 medical students were recruited to interpret 10 different ECGs each. Their eye movements were recorded using an eye tracker. Fixation heatmaps of where the students looked were generated from the collected data set. Statistical analysis was conducted on the fixation count and duration using the Mann-Whitney U test and the Kruskal-Wallis test.

Results: The average percentage of correct interpretations was 55.63%, with an SD of 4.63%. After analyzing the average fixation duration, we found that medical students study the three lower leads (rhythm strips) the most using a top-down approach: lead II (mean=2727 ms, SD=456), followed by leads V1 (mean=1476 ms, SD=320) and V5 (mean=1301 ms, SD=236). We also found that medical students develop a personal system of interpretation that adapts to the nature and complexity of the diagnosis. In addition, we found that medical students consider some leads as their guiding point toward finding a hint leading to the correct interpretation.

Conclusions: The use of eye tracking successfully provides a quantitative explanation of how medical students learn to interpret a 12-lead ECG.

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KEYWORDS

eye tracking; electrocardiogram; ECG interpretation; medical education; human-computer interaction; medical student; eye; tracking; interpretation; ECG

Introduction

Background

The electrocardiogram (ECG) is a graph that represents the electrical activity of the heart. The 12-lead ECG showcases this activity from 12 different "viewpoints" called leads. Although more than 300 million ECG tests are performed annually in the United States [1], relatively little is known about how these ECGs are interpreted among medical professionals. Despite the fact that an ECG is a standardized medical test, procedures and processes to interpret it significantly vary from country to country, let alone from one medical institution to another [2].

Several professional organizations, including the American Heart Association (AHA), the American College of Cardiology (ACC), and the Heart Rhythm Society (HRS), proposed recommendations for the standardization and interpretation of the ECG in 2007 [3]. The aim behind these recommendations was to "establish standards that will improve the accuracy and usefulness of the ECG in practice." However, despite efforts of standardization, there still exists a variation amongst health care practitioners in their ability to accurately and quickly read ECGs. Understanding the origins of these differences in interpretation is important for improving and correcting training practices. Among the causes of this variation in the accuracy of ECG interpretation is how medical students are trained to perform the interpretation task while in medical school [4,5]. Understanding the chasm between how medical students are trained for ECG interpretation versus how they actually perform the task after receiving their medical training is important for improving and correcting training practices in the medical curriculum.

We present a quantitative study of ECG interpretation by 16 medical students. We requested from them to interpret 10 ECGs each while we collected their eye-tracking data using the eye-tracking methodology. We based our study on related works that looked at similar behavior in the general medical population. We sought to find a confirmation of our hypothesis that the order and the duration with which medical students look at specific areas across the ECG directly affect their final interpretation. We based our data analysis on understanding ECG interpretation within medical students using a number of different features, mainly areas of interest (AOIs), fixation count, fixation duration, time to first fixation (TTFF), and fixation revisitations. The results of the study uncover ECG interpretation insights among the population of medical students that confirm our hypothesis.

Related Works

When eye tracking was first used to understand ECG interpretation, the aim was to gain insight into experts' interpretation procedures. Bond et al [6] noticed that emerging trends in training practices delivered through medical schools and training centers seem especially tedious, rigorous and time-consuming [6]. Yet medical professionals find alternative ways of interpretation to keep up with the fast-running pace of the medical setting driven by detecting abnormalities rather than systematic interpretation of an ECG [7]. Thus, Bond et al [6] adopted eye tracking in order to understand how the collected eye gaze data may be used in order to unveil insights into how expert annotators proceed with ECG interpretation. Bond et al [6] collected the eye gaze data of several expert ECG interpretations. This was done with annotators viewing different ECGs each across different studies [4,6,8]. The authors then applied an objective quantitative approach to analyze the data. Bond et al's [4,6,8] major findings were in quantifying the fixation duration over each lead of a 12-lead ECG. This provided an opportunity to compare the time spent fixating over leads in the frontal plane compared with leads in the transverse plane. Bond et al [4,6,8] also succeeded in ranking the leads that are looked at the most versus the least-looked-at leads. Bond et al's [4,6,8] studies were insightful in facilitating the quantification of experts' interpretation of an ECG.

However, a quantitative study alone might not be enough to unveil complex visual behaviors, such as ECG interpretation. Davies et al [2,5,7,9] therefore proposed additional studies that used mixed methods, combining both quantitative and qualitative components. Although the authors followed a similar eye-tracking study design as Bond et al [6], they improved their analysis by adding some quantitative and qualitative methods to better understand the eye-tracking data, such as computing the difference between eye transitions across the ECG. For the qualitative component of the study, however, Davies et al [2,5,7,9] aimed at better understanding the applied cognitive processes that expert interpreters refer to when interpreting ECGs. The authors interviewed and surveyed a set of medical practitioners. The authors found that medical experts develop their own style and system to quickly and efficiently interpret ECGs. Moreover, Davies et al [2,5,7,9] found that expert interpreters switch between their personally developed style of interpretation and a systematic method of interpretation, depending on the ECG and the severity of the symptoms it conveys.

Other studies, such as the studies done by Wood et al [10] and Breen et al [4], investigated eye-tracking interpretation of novice medical students as opposed to cardiology experts. The experiments resulted in quantifying the average time required by this sample of medical students to reach a final ECG interpretation. The results of Breen et al's [4] study indicated that health care science students require between 13.2 and 59.5 seconds before reaching a final interpretation. Health care students rely mainly on lead II, as it was fixated on the longest. Wood et al [10] aimed through their study to understand the perceptual-cognitive mechanisms giving expert ECG interpreters an advantage over their novice counterparts. The authors found that expert interpreters are significantly faster, more accurate, and more confident in giving correct diagnoses. This difference in the accuracy of interpretation was also reflected upon the eye movement behavior of the consultants.

Research Questions and Hypothesis

We asked our research questions based on the reviewed body of work. We then formed our hypothesis accordingly. We based our hypothesis on the results of previous related studies, as well as on our experience in teaching ECG interpretation to medical students.

Research Questions

Research question 1: *Can we recognize any eye-tracking patterns for ECG interpretation within the medical student population?*

Identifying patterns that medical students follow to interpret an ECG may explain the correct/incorrect interpretations they provide. Bond et al [6] observed that the majority of misinterpretations within expert interpreters are due to practitioners adopting only an initial first impression or pattern recognition approach to the ECG, without following a conventional systematic protocol to ECG interpretation.

In their study, Bond et al [6] used the accuracy of interpretation, the average fixation duration per lead, the average duration of individual fixations, and the TTFF as eye-tracking parameters to uncover the methodology followed by expert interpreters. We used similar parameters to quantify ECG interpretation behavior within the medical student population.

Research question 2: *How does the presence of waveform abnormalities across the ECG affect the eye movement behavior within medical students' interpretation? Does it also affect their final diagnosis?*

Davies et al [5] observed that alterations in the normal shape of the ECG waveform, whether these alterations are due to an artifact or an abnormal heart rhythm, may diverge the attention of expert interpreters to certain hotspots in the ECG image. Davies et al [5] also concluded that experts who do not follow up the overall pattern recognition process triggered by these alterations with a formal medical systematic method for ECG interpretation are more likely to provide a wrong diagnosis. Expertise plays an important role in differentiating between waveform abnormalities that are less relevant and leads of critical importance that contribute to the accurate interpretation of the ECG, according to Wood et al [10].

Research question 3: *What is the most suitable level of granularity to analyze the eye-tracking data for the interpreter? Is it at the level of a single ECG lead or at a more granular level?*

Several studies have analyzed the eye-tracking data at the ECG lead level [6,8,10]. However, Davies et al [2] later suggested that using a more granular level of data analysis would be worth exploring, as it may enable more insight. This is especially important as the suggestion echoes Wood et al's [10] observation that expert medical interpreters operate at both the ECG lead level and the level of the specificities of waveform abnormalities.

Hypothesis

Our hypothesis is that *the order with which and the duration for which medical students look at specific areas across the ECG directly affect their final interpretation*.

As commented above on research questions 1 and 2, waveform abnormalities catch the attention of the interpreter. We speculate that these abnormalities certainly catch the attention of medical students, and especially that recognizing them is at the foundation of the ECG interpretation curriculum. What then differentiates an accurate interpretation from an inaccurate one is whether students focus on the right abnormalities. This therefore influences the order with which students look at different areas of the ECG across their interpretation period, as well as how much time they spend fixating on these areas. Choosing the right data analysis tools and methodologies would be critical in obtaining accurate results to confirm or deny our hypothesis. As commented above on research question 3, finding the most suitable level of specificity to analyze the eye-tracking data for the interpreter is also part of the analysis. This is especially pertinent to understanding the dynamics of attention at the ECG lead level as well as the waveform level.

Methods

Materials

ECG Data Set Acquisition

We curated 10 ECGs of different heart arrhythmias with the assistance of a cardiology consultant. Since the experiment was designed for medical students, we made sure that these arrhythmias were all studied in traditional medical school curricula. Although some ECGs may be difficult to interpret, the students participating in the study had all the necessary medical background to make the correct diagnosis. The ECG set included in the experiment was either from the personal collection of the cardiology consultant involved in the design of the experiment or from the open ECG data set available from the PhysioNet database [11]. The 10 ECGs included are defined in Multimedia Appendix 1.

Experiment Design

We involved an expert in ECG interpretation as well as an expert in human-computer interaction in designing the experiment. We also referred to similar experiments described in the Related Works section. Involving these stakeholders in the design of the experiment ensured the refinement and fine-tuning of certain parameters important to lower its inherent bias. The experiment design was in the form of a digitized, short multiple-choice-question (MCQ) miniquiz, whereby medical students were exposed to the 10 ECGs on a computer screen one after the other, followed by the respective diagnosis question. This format is important as medical students are accustomed to it in their examinations. The exchange between the stakeholders involved in the design of the experiment yielded the following critical points in the experiment design:

- Randomizing the order in which the ECGs are displayed for each participant. This contributes to offsetting learning effects. This was fundamentally pertinent since (1) the task was brief (as discussed in the next point) and (2) there were many repetitions of the same task (mainly 10 repetitions of the interpretation task) [12].
- Restricting the duration for which participants are allowed to look at the ECG to 30 seconds per ECG. Deciding on this timing stemmed from the following reasons:
- The primary aim of the study was not to measure participants' performance over the accuracy of interpretation but rather to unveil visual scanning dynamics that would explain the medical students' reasoning behind their final diagnosis provided after performing the ECG interpretation task.
- The time allowed for scanning an ECG was found to have no statistically significant effect over the accuracy of interpretation per Davies [5]. Moreover, per Bond et al [6], there was a negative correlation between the duration spent looking at an ECG and the accuracy of interpretation.
- The quality of the collected eye-tracking data: Restricting the time allowed for students to look at an ECG forces them to spend their allowed timespan wisely focusing on selected areas of the ECG. The students are therefore more attentive and wander less around the different areas of the ECG. This

improves the quality of the data obtained, as will be explained more in the forthcoming sections.

Recruitment Process

Medical students in the classes of 2022 and 2023 enrolled in the cardiology module within the 4-year medical program curriculum were invited to participate in the study. One of the main learning objectives was the 12-lead ECG interpretation in accordance with the US medical curriculum [13]. Recruitment for this study was advertised through emails sent to both classes, as well as word-of-mouth and announcements across the students' dormitories. Students who volunteered replied with an email to the study coordinator. Information regarding the study, including the research protocol and a consent form, was forwarded to each student following their voluntary engagement. The students were then emailed a date and time to participate in the 12-lead ECG interpretation study.

Task and Procedure

The students listened first to a 5-minute briefing, where they were introduced to the goal of the experiment, the number of ECGs they would interpret, and how they should interact with the interface. The interface was minimalistic in the sense that the 12-lead ECG image took up the whole computer screen and automatically changed to the next ECG after 30 seconds elapsed. The MCQ miniquiz asking about the ECG diagnosis was also minimalistic, whereby each question was centered in the screen and everything around it was grayed except the Next button to move to the next ECG. The students were allowed as much time as they needed to think about the ECG diagnosis, but in all cases, the time did not exceed 10 seconds to give their answer. The students were also encouraged to ask any question regarding the experiment or the setup. Once all the doubts were cleared, the students were set to familiarize themselves with the setup.

The students familiarized themselves with the setup by calibrating their eyes with the eye tracker's infrared sensors. Once their eyes were calibrated to the eye tracker, they proceeded to the interpretation task. The students were allowed 30 seconds to look at an ECG before being prompted for its diagnosis. Once they provided their diagnosis for the 10 ECGs, we performed an informal interview where we asked them about the overall difficulty of the interpretation task, the experiment design, and how they thought they did on the questions. Some of the students requested to check their answers.

Apparatus

A Tobii Pro X2-60 eye tracker and iMotions version 8.1 software (iMotions) were used to record eye movements with a sampling rate of 60 Hz (±1 Hz). Key strokes and mouse clicks were recorded to collect the students' responses to the MCQs. The eye-tracking experiment was conducted on a 25-inch diagonal laptop monitor with a resolution of 1366 × 768 pixels.

Ethics

The institutional review board approval for this study was granted by the ethics board of both the Qatar Biomedical Research Institute at Hamad Bin Khalifa University [14] under the IRB Protocol Reference Number QBRI-IRB-2020-01-009 and the Hamad Medical Corporation in Qatar [15] prior to the commencement of the study. All methods were therefore performed according to the guidelines and regulations of Qatar's Ministry of Public Health and several other international regulatory agencies [14].

Methods

Heatmaps

We generate fixation heatmaps using the collected eye-tracking data as a preliminary step of data exploration. Heatmaps helped us visualize the general trends in how medical students proceed with an ECG interpretation. The observation of heatmaps contributed toward finding an answer to both research questions 1 and 2, since they indicated where medical students focus more and what they ignore on an ECG. The heatmap images of all the ECGs are available in Multimedia Appendices 2-11.

AOIs

We defined two AOI types. These two types were informed by the previous work that Davies et al [7] conducted to find the optimal bias-free AOI distribution in 12-lead ECGs (refer to a detailed AOI definition in Multimedia Appendix 12). The authors found that for AOIs to be bias free when defined on top of an ECG image, they need to be equal in area. This allows for unbiased quantification of the analyzed eye-tracking metrics. Our two defined AOI types were the long versus short AOI and the grid-based AOI. Figures 1 and 2 show the same normal sinus rhythm (NSR) ECG divided into these two different AOIs. The six horizontal lines across the ECG represent the 12 leads from where the measurements of the heart rhythm are taken. In the grid-based AOI represented in Figure 1, the ECG image is divided into 24 equal squares (AOIs) plus the scale metadata area at the bottom. Figure 2 represents the AOI of long versus short leads. This distribution divides the ECG into two equal areas. The upper area (area 1) contains the 12 leads for the ECG represented by 1 to 12 in Figure 1. These leads represent the heart voltage for a duration of 2.5 seconds (deduced from the scaling metadata at the bottom of the ECG). The lower area of the ECG represented by area 2 in Figure 2 contains three long rhythm strips for leads V1, II, and V5. The long rhythm strip represents the heart voltage of the heart activity for a duration of 10 seconds instead of 2.5 seconds. We used both of these AOI distributions in our analysis.

Figure 1. Grid-based AOI applied to the NSR ECG. AOI: area of interest; aVF: augmented vector foot; aVL: augmented vector left; aVR: augmented vector right; ECG: electrocardiogram; NSR: normal sinus rhythm.

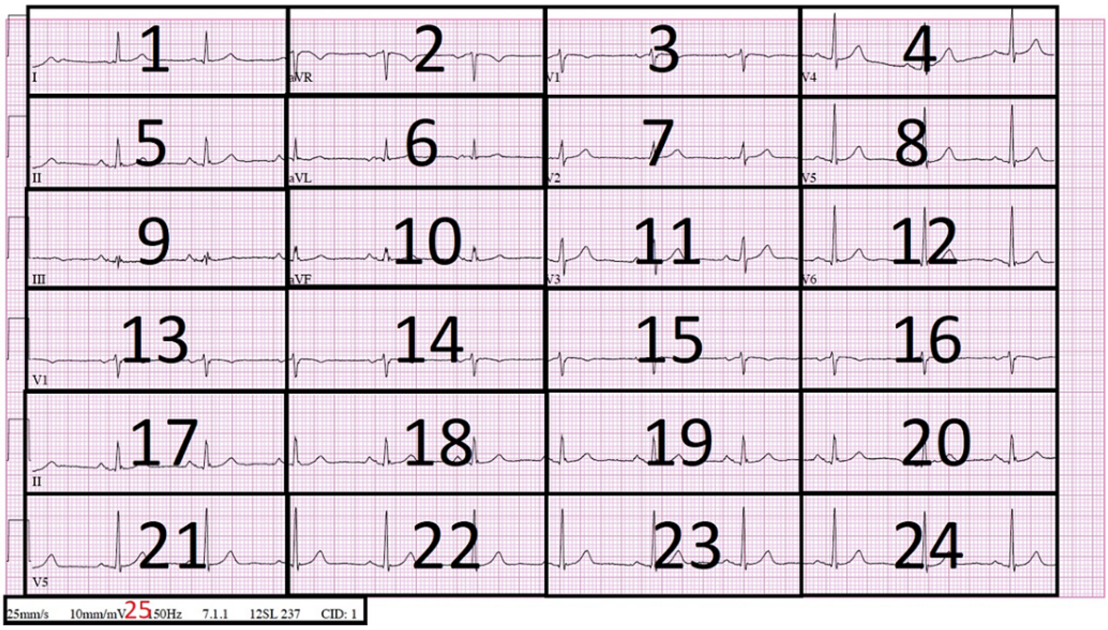
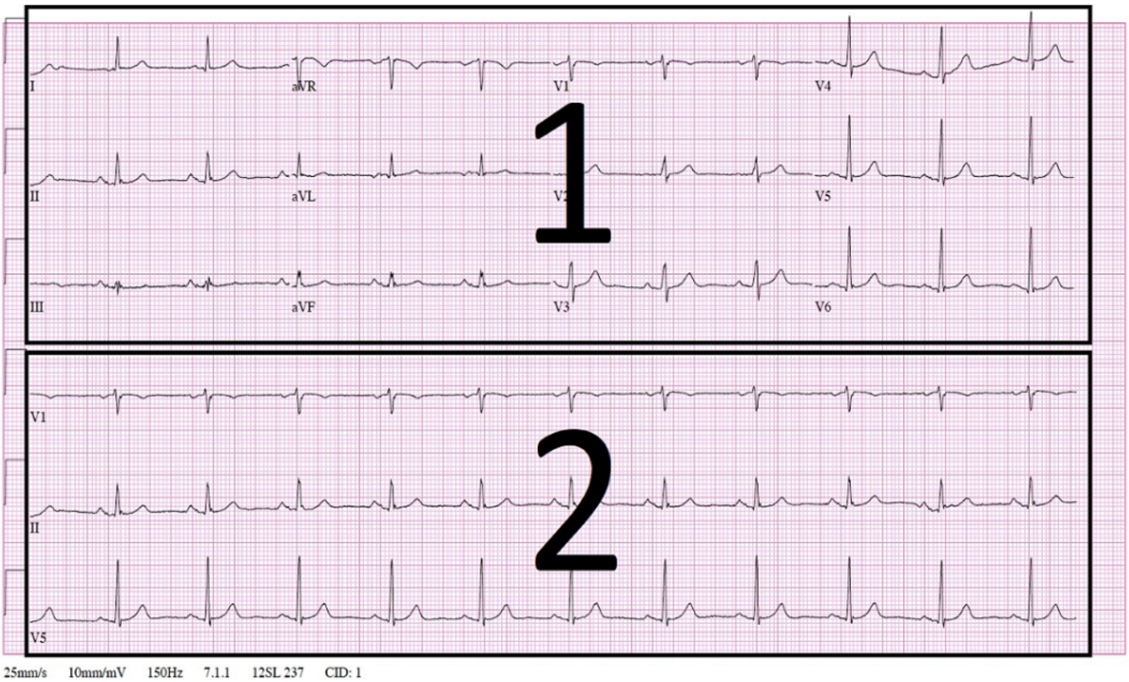


Figure 2. Long vs short AOI applied to the NSR ECG. AOI: area of interest; aVF: augmented vector foot; aVL: augmented vector left; aVR: augmented vector right; ECG: electrocardiogram; NSR: normal sinus rhythm.



Eye Tracking and Its Features

To systematically understand how medical students proceed to interpreting an ECG, we used eye tracking. Eye tracking is a methodology that aims to quantify visual behavior when performing a specific task in order to understand the nuances in locus and levels of attention of interpreters [16]. The parameters that the eye-tracking methodology collects were suitable to test our hypothesis. The eye fixation count as well as the fixation duration were independent eye-tracking variables that referred to the "duration for which medical students look at specific areas of an ECG," as mentioned in the hypothesis. The TTFF, as well as fixation revisitations, however, refer to the "order with which medical students look at different leads in the ECG," as mentioned in the hypothesis. The definitions for the used eye-tracking parameters are in Multimedia Appendix 12.

Statistical Analysis

To measure the significance in the fixation behavior of the medical students around different AOIs on the 12-lead ECG, we use two different statistical tests. These tests were curated in accordance with the nature of the collected eye-tracking data, as well as the areas being compared.

Comparison between the rhythm strip vs short-lead signals: Since the comparison was between two unpaired data sets (long rhythm strip and short-lead signals) in a nonnormal distribution of data, we use the Mann-Whitney U test [17,18] on 8 ECGs out of 10. This is because the remaining 2 ECGs did not have an equal area for the selected AOIs, which made the comparison biased. The excluded ECGs were hyperkalemia and atrial fibrillation (AFib). We use an α of .05 as the cutoff for significance.

Comparison between the 24 defined AOIs in selected ECGs: Since we were comparing between more than two unpaired data sets (24 defined AOIs) in a nonnormal distribution of data that had the same shape, we use the Kruskal-Wallis test [19] on 8 ECGs out of 10. This is because the remaining 2 ECGs did not have an equal area for the selected AOIs, which made the comparison biased. The excluded ECGs were hyperkalemia and AFib. We use an α of .05 as the cutoff for significance.

Correlation among eye-tracking features: We aimed to understand the correlation between the analyzed eye-tracking metrics through the Pearson correlation coefficient. The Pearson correlation coefficient is a statistical metric that measures the strength of a linear correlation between two variables [20].

Results

Demographics

Table 1 summarizes the demographics for the participants in the study. In total, 16 medical students were recruited. Of those 16, 10 were in the clinical phase of their curriculum (seniors); the remaining 6 were in the preclinical phase (juniors). In addition, 15 students were male, while 1 was a female. The age of the students was between 21 and 24 years. The students were from six different countries. Eligibility for inclusion in the study was therefore mainly based on the medical program curriculum design, whereby the main condition was that students should be in their junior or senior year and have received theoretical and practical training with regard to ECG interpretation.

Table 1. Demographics of the eye-tracking study participants.

Feature	Demographics
Age (years)	21 (n=5); 22 (n=1); 23 (n=5); 24 (n=5)
Gender	Male: 15; female: 1
Country	Palestine (n=4); Jordan (n=6); South Korea (n=1); Egypt (n=2); Lebanon (n=2); Libya (n=1)
Class	2023 (n=6); 2022 (n=10)

Eye-Tracking Features

We present the results for the fixation count, the time spent fixating, the average TTFF, and the average fixation revisitations on each ECG lead over all 160 interpretations (16 participants, with 10 ECGs to interpret for each student) in Table 2. The ECG Lead column is in decreasing order based on the fixation count.

Table 2. Results of the fixation count, the time spent fixating, the average TTFF,[a] and the average fixation revisitations on each ECG[b] lead for all interpreters.

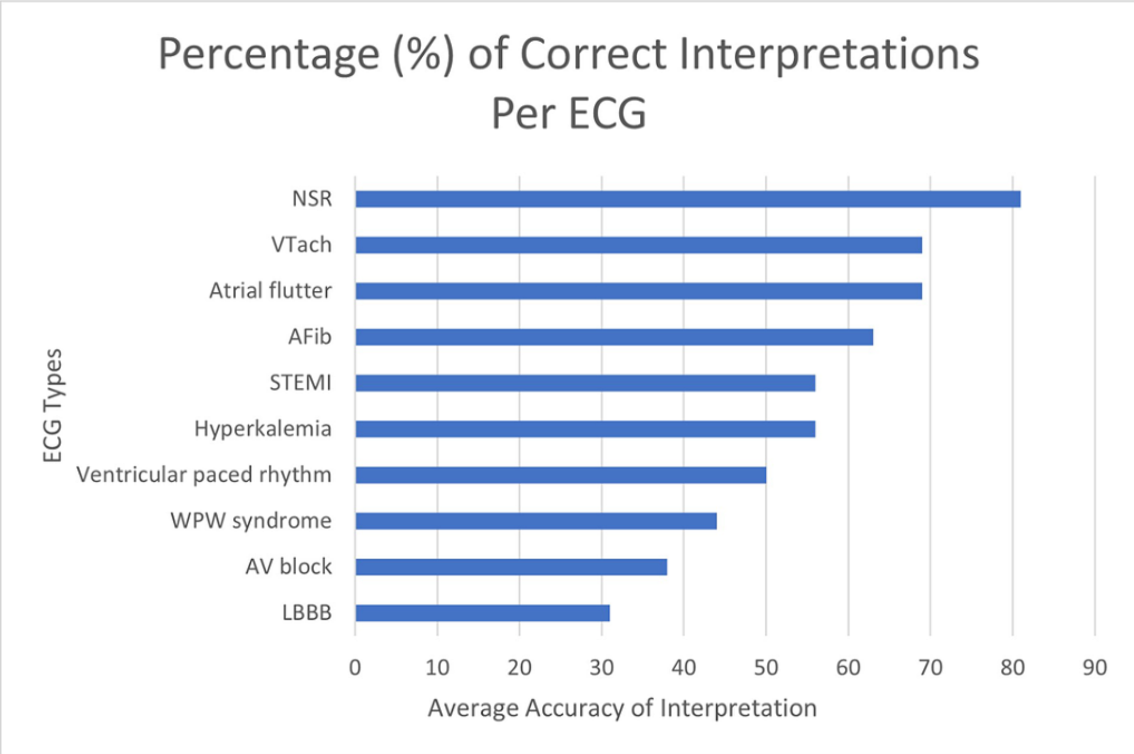
ECG lead	Fixation count		Time spent fixating (ms[c])		TTFF (ms)		Fixation revisitation count	
	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)
II	54	9	2727	456	4225	213	2	.85
V5	28	5	1301	236	12,639	447	1	.82
V1	24	6	1476	320	9552	557	2	.73
V3	16	5	974	103	10,634	557	4	.51
V2	15	3	904	54	9898	447	4	.65
aVF[d]	14	3	890	51	6233	88	4	.62
V4 right	13	2	972	66	7035	222	3	.14
3	11	1	886	54	9222	111	3	.86
V3 right	11	1	868	47	6064	93	3	.37
2	11	1	1017	199	8683	38	4	.47
aVL[e]	10	1	723	47	3602	103	3	.82
V7	8	1	437	48	10,513	601	2	.92
1	8	1	707	42	11,393	587	2	.80
V8	8	1	435	53	13,076	598	1	.51
aVR[f]	8	1	456	49	11,569	615	1	.85
V6	7	1	325	49	18,641	566	1	.59
V4	6	1	312	32	19,460	333	1	.20
Info (metadata)	4	1	64	16	20,394	887	0	.57

[a]TTFF: time to first fixation.
[b]ECG: electrocardiogram.
[c]ms: milliseconds.
[d]aVF: augmented vector foot.
[e]aVL: augmented vector left.
[f]aVR: augmented vector right.

Medical Students' Interpretation Results

Figure 3 shows the percentage of correct interpretations per ECG for all the medical students. Multimedia Appendix 13 summarizes the results of medical students' interpretations in more detail. The mean overall score of correct ECG answers was 55.63%, and the SD was 4.63%. The NSR was the ECG with the highest number of correct interpretations with an accuracy of 81%, while the left bundle branch block (LBBB) was the ECG with the lowest number of correct interpretations with an accuracy of 31%.

Figure 3. Percentage (%) of correct interpretations per ECG for all medical students. AFib: atrial fibrillation; AV block: complete heart block; ECG: electrocardiogram; LBBB: left bundle branch block; NSR: normal sinus rhythm; STEMI: ST-segment elevation myocardial infarction; VTach: ventricular tachycardia; WPW: Wolf-Parkinson-White.



Data Analysis

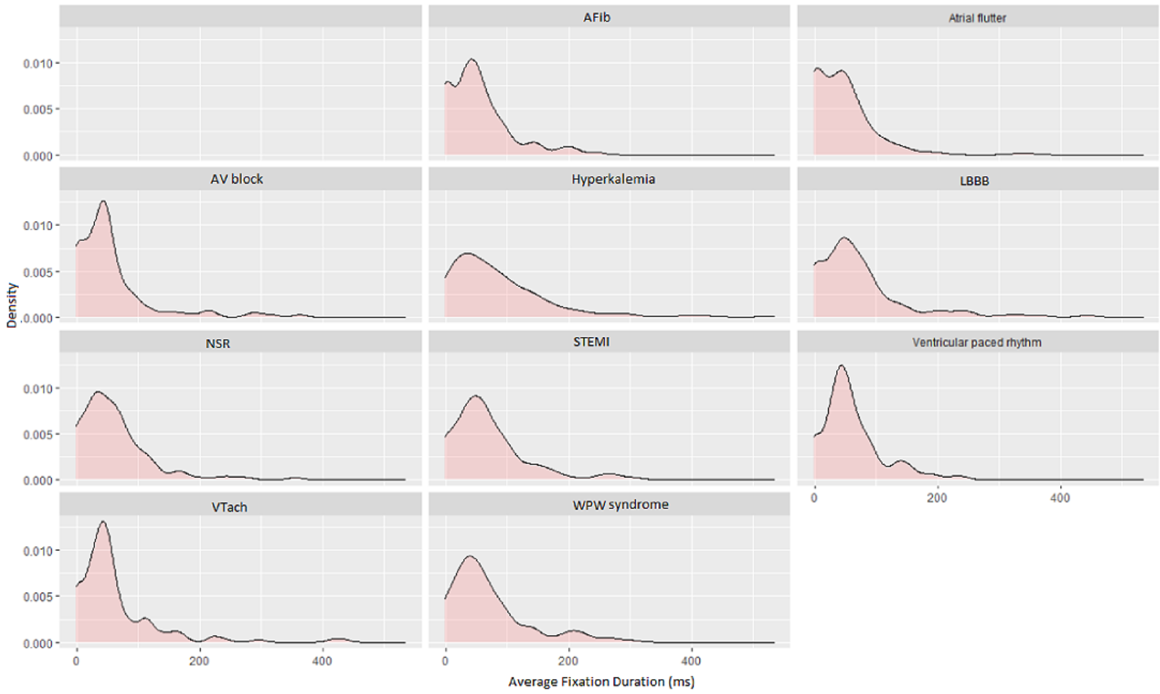
We analyzed the collected eye-tracking data. We started by defining key parameters on which the data analysis was founded, mainly AOIs. This contributed to answering research question 3. We then proceeded to find an answer to research question 1 by analyzing the eye-tracking parameters. These parameters are referred to in the hypothesis as the "duration for which medical students look at specific areas of the ECG." They are the fixation count and the fixation duration. "Specific areas of the ECG," as mentioned in the hypothesis therefore refer to the defined AOIs. We finally analyzed the correlation between these four eye-tracking features to test our hypothesis.

Selected Features

We selected the fixation count and the fixation duration as the main features guiding our analysis to answer research question 1.

Fixation duration: Figure 4 displays the density distribution of the average fixation duration for all ECG interpreters across each ECG. The distribution was left-skewed, centered at around 100 ms for all the ECGs. Moreover, some of the ECGs had a bi-modal distribution (like the atrial flutter distribution). The reason for these characteristics is the diversity of the fixation distribution across each defined AOI in the grid-based AOI distribution shown in Figure 1 and in Table 2. Additionally, for the ECGs that had a bimodal distribution, some of the peaks in the distribution graph were centered around the 0 ms value. This might be due to some AOIs in the ECG not being visited at all across the duration of the interpretation.

Figure 4. Density distribution of the average fixation duration for all ECG interpreters and all ECGs. AFib: atrial fibrillation; AV block: complete heart block; ECG: electrocardiogram; LBBB: left bundle branch block; ms: milliseconds; NSR: normal sinus rhythm; STEMI: ST-segment elevation myocardial infarction; VTach: ventricular tachycardia; WPW: Wolf-Parkinson-White.



Fixation count: We conducted statistical tests on the fixation count according to both defined AOIs in Figures 1 and 2. This was with the aim to better elucidate how significant the difference is in terms of fixation counts (1) between the rhythm strips versus the short signal timing leads and (2) within all the 24 AOIs in the ECG. Analyzing the fixation count according to those two defined AOIs contributed to providing an answer to research question 3.

(1) Between the rhythm strip vs the short-lead signals: We used the Mann-Whitney U test, as discussed in the Statistical Analysis section. As observed in Table 3, there were only two ECGs that had a *P* value less than the cutoff for significance. These ECGs were the NSR and atrial flutter ECGs. When we looked at the mean fixation count in the rhythm strips versus the mean in the normal leads, we observed the significance of the difference, whereby the mean fixation count over the rhythm strips was significantly larger than the mean in the normal leads. For the remaining ECGs, the mean fixation count was not significantly different between both AOIs. Translating this to eye-tracking behavior, medical students usually refer to all the leads, whether they are rhythm strips or only short 2.5-second leads. For the two cases mentioned, the medical students referred mostly to the long rhythm strips to reach to a diagnosis. For the remaining ECGs, the interpreters had to observe and analyze both long and short leads relatively equally in time in order to reach a diagnosis.

(2) Between the 24 defined AOIs in selected ECGs: We used the Kruskal-Wallis test, as discussed in the Statistical Analysis section. The results from applying the test indicated that all the ECGs had a *P* value significantly less than the cutoff for significance (<.001). Translating this to eye-tracking behavior, at the granular level, there was a significant difference in the proportion of fixations that the medical students interpreting the ECGs accorded to different AOIs. This means that the students' focus on different AOIs varied according to the ECG.

Table 3. Mann-Whitney U test conducted on the fixation count parameter of selected ECGs.[a]

ECG	*P* value	Mean fixation count in rhythm strips	Mean fixation count in shorter strips
NSR[b]	*.010**	169.875	98.750
Atrial flutter	*.015**	182.625	54.125
VTach[c]	1	118.000	131.875
WPW[d]	.958	144.500	145.625
Ventricular paced rhythm	.279	126.375	162.250
LBBB[e]	.161	143.250	115.75
STEMI[f]	.721	119.25	125.25
AV block[g]	.248	157.875	117.875

*Values in italic are significant.

[a]ECG: electrocardiogram.

[b]NSR: normal sinus rhythm.

[c]VTach: ventricular tachycardia.

[d]WPW: Wolf-Parkinson-White.

[e]LBBB: left bundle branch block.

[f]STEMI: ST-segment elevation myocardial infarction.

[g]AV block: complete heart block.

Correlation Among Eye-Tracking Features

We used the Pearson correlation coefficient, as discussed in the Materials and Methods section. Table 4 reports the coefficients among the selected eye-tracking features using the grid-based AOI described in Figure 1.

Table 4. Pearson correlation coefficient for eye-tracking parameters over the 10 studied ECGs.[a]

	Fixation count	Fixation duration	TTFF[b]	AOI[c] fixation revisitations
Fixation count	__[d]	.81	–.4	.78
Fixation duration	—	—	–.36	.53
TTFF	—	—	—	–.44
AOI fixation revisitations	—	—	—	—

[a]ECG: electrocardiogram.

[b]TTFF: time to first fixation.

[c]AOI: area of interest.

[d]Not applicable.

Table 4 indicates that the fixation count as well as the fixation duration reflect the same ECG interpretation behavior as they are strongly correlated. The remaining combinations of features indicated that each variable represents a distinct ECG interpretation behavior as the variables are weakly correlated.

Discussion

Here, we discuss the Results section. We mainly discuss the insights from the heatmaps as well as the analysis of the eye-tracking features.

Heatmaps

As observed in all the heatmaps, medical students tend to lean toward one of two distinct behaviors for ECG interpretation. The nuance lies primarily in the areas where the fixations are concentrated.

1. In some ECGs, such as the NSR and the atrial flutter, eye fixations are concentrated over the lower area. This area contains the three leads (V1, II, and V5) referred to as rhythm strips.

2. In other ECGs, such as the ventricular paced rhythm, eye fixations are concentrated in the upper half, precisely over leads V1, V2, and V3.

The generated heatmaps indicate how complex and different the ECG interpretation approach is depending on the heart pathology observed. They also indicate that medical students adapt their interpretation behavior, depending on the nature of the ECG. The preliminary observations from the heatmaps show that medical students fixate more on abnormal areas of the ECG, such as atrial flutter waves, wide QRSs, elevated ST segments, and V-pacing spikes, regardless of whether their interpretation of the ECG is correct. These observations provide an answer to research question 2.

Eye-Tracking Features

The eye-tracking features reported in the Results section and analyzed previously confirm the observations made when looking at heatmaps. The fixation count as well as the average fixation duration features demonstrate that medical students fixate the most on rhythm strips, mainly lead II, followed by leads V1 and V5. This might be because rhythm strips provide the best longitudinal analysis of the rate and rhythm over the entirety of the ECG. According to the TTFF and the fixation revisitations per lead, medical students' natural tendency is to start their interpretation from the middle of the ECG. They then move to whatever lead they believe guides them to a correct interpretation. Specificities of their interpretation changes from one ECG to the other. Amidst the interpretation process, waveform abnormalities may catch their attention and divert their attention from one lead to another, provoking an increase in lead revisitations. These observations answer research question 1.

Answers to Research Questions

Research question 1: We recognized two main eye-tracking patterns that medical students often repeat during the process of ECG interpretation. The first pattern is that they start from the leads in the center of the ECG. The second pattern is that across the interpretation period, they refer primarily to the rhythm strips as the guiding leads toward finding an indicator for the appropriate diagnosis, as they spend most of the interpretation time fixating on these rhythm strips. This behavior of interpretation was also found by Davies et al [5], who defined this pattern as a systematic way of interpretation. By "a systematic methodology of interpretation," the authors referred to a set of routinely repeated observations across all ECG types [5]. In a purely systematic way of interpretation, the interpreter examines the ECG thoroughly.

Research question 2: The presence of one or multiple abnormal waveforms in the ECG does affect the ECG interpretation behavior of medical students. The abnormalities may be due to an actual heart rhythm irregularity or due to noise. These abnormalities usually derail the students from a systematic approach of interpretation. The abnormal signs catch their attention and therefore make them fixate longer and often switch between leads where these abnormalities occur. Davies et al [5] defined this behavior of interpretation as a "reactive" one. Although this behavior was found among expert interpreters, it was found on rare occasions as opposed to our findings. A reactive way of interpretation refers to a methodology where the interpretation is driven by abnormalities in the ECG that catch the attention of the interpreter. Experts selectively react to these signs as opposed to beginner interpreters.

Research question 3: We could not identify one suitable level of specificity to analyze the eye-tracking data. This is because the ECGs' complexity of interpretation varies depending on the heart abnormality being tracked. However, the statistical analysis that we conducted offered an understanding of how to optimize AOIs to get meaning out of the eye-tracking data. The level of granularity varies between comparing rhythm strips against short-lead signals at one end of the spectrum. On the other end of the spectrum, the comparison is done by dividing the whole ECG into equal grid sizes in order to compare the eye-tracking feature among the grids. The challenge with grid-based analysis is that it is extremely granular and that the difference between grids is usually always significant. Grid-based analysis is suitable for understanding the-eye tracking behavior around specific waveform abnormalities.

Hypothesis Confirmation

We confirmed our hypothesis that the order with which and the duration for which medical students look at specific areas across the ECG directly affect their final interpretation. This was demonstrated through the distribution of the fixation count as well as the fixation duration across different AOIs over the ECG. Additionally, the TTFF as well as the AOI fixation revisitations proved that some ECG leads catch the attention of interpreters more than others. This is especially true when the lead contains an abnormal signal.

Limitations

A major limitation that affected our work was the confounding effect of a common training framework for all participants. This was because all the participants recruited to the study received the same ECG interpretation training. This effect needs to be acknowledged as influencing the results, and therefore addressed. The study conducted by Breen et al [4] could be used in our case as a starting point to address this limitation. The study provides a different perspective of how medical students with different educational backgrounds proceed to interpreting ECGs. Breen et al [4] found that the average time taken by medical students to interpret an ECG ranges between 13.2 and 59.5 seconds for similar ECG cases. This behavior supports our decision to limit the maximum time allowed for a student to look at an ECG to 30 seconds. Breen et al [4] also found that "the rhythm strip is the most common lead studied and fixated on for the longest duration, while lead I is studied for the shortest duration." These findings by Breen et al [4] echo the results of our experiment. Although the major findings of Breen et al [4] support our findings, the most appropriate way to address this limitation is to increase the sample size and diversify it by looking for participants with different educational backgrounds and different demographics in general.

Future Work

The reported results are considered the first phase of a larger study. In future works, we plan on expanding the study by directly addressing the limitations mentioned in the previous section. We aim to increase the number of participants to be more diverse in terms of their educational background, demographics, and expertise in ECG interpretation. We aim to include more medical students, nurses, technicians, cardiology fellows, residents, and consultants. This increase in the number of participants will enable the examination of nuances in interpretation behavior across the whole medical practitioners' spectrum. The prospects of this participant expansion include the ability to compare the results against related studies. This data will contribute to the development of a more detailed road map of how health practitioners proceed to interpreting ECGs.

Conclusion

We presented a quantitative analysis of the ECG interpretation behavior of medical students. We collected eye-tracking data of 16 medical students interpreting 10 ECGs each. This enabled us to analyze these data using a number of different eye-tracking features, mainly AOIs, fixation count, fixation duration, TTFF, and fixation revisitations. This was with the aim of answering three research questions: (1) whether we can recognize any interpretation patterns within the medical students' population, (2) what elements in the ECG catch the attention of medical students during their interpretation process, and (3) and, finally, what the most suitable level of granularity is to analyze the eye-tracking data for optimal insights. We found that medical students often start their interpretation by fixating at the center of the ECG. This may be due to the central bias tendency toward fixating at the center of the observed image. This bias is widely observed in eye-tracking research, as reported by Bindemann et al [21]. However, in some other cases, medical students focus on the central leads to find any abnormalities in the ECG waveform. Abnormalities divert their attention, which pushes them to transition across different leads. However, rhythm strips remain their guiding point toward identifying indicators, leading to the correct interpretation. These findings confirm our hypothesis that the order with which and the duration for which medical students look at specific areas across the ECG directly affect their final interpretation.

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Authors' Contributions

MTS contributed to conceptualizing, designing, and conducting the practical experimentation. MTS also contributed to analyzing the data and writing the paper. DAT, MBE, and ME contributed to participants' recruitment. DAT, MBE, and ME also contributed to the study's conception, research methodology, and validation of the results. Finally, DAT, MBE, and ME revised the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Electrocardiograms and their definitions.
[PDF File (Adobe PDF File), 60 KB - mededu_v7i4e26675_app1.pdf]

Multimedia Appendix 2
Heatmap for a Wolf-Parkinson-White syndrome electrocardiogram interpreted by medical students.
[PNG File , 1338 KB - mededu_v7i4e26675_app2.png]

Multimedia Appendix 3
Heatmap for a ventricular tachycardia electrocardiogram interpreted by medical students.
[PNG File , 1451 KB - mededu_v7i4e26675_app3.png]

Multimedia Appendix 4
Heatmap for a ventricular paced rhythm electrocardiogram interpreted by medical students.
[PNG File , 1605 KB - mededu_v7i4e26675_app4.png]

Multimedia Appendix 5
Heatmap for an ST-segment elevation myocardial infarction electrocardiogram interpreted by medical students.
[PNG File , 1693 KB - mededu_v7i4e26675_app5.png]

Multimedia Appendix 6
Heatmap for a normal sinus rhythm electrocardiogram interpreted by medical students.
[PNG File , 1611 KB - mededu_v7i4e26675_app6.png]

Multimedia Appendix 7

Heatmap for a left bundle branch block electrocardiogram interpreted by medical students.
[PNG File , 1528 KB - mededu_v7i4e26675_app7.png]

Multimedia Appendix 8
Heatmap for a hyperkalemia electrocardiogram interpreted by medical students.
[PNG File , 1840 KB - mededu_v7i4e26675_app8.png]

Multimedia Appendix 9
Heatmap for a complete heart block electrocardiogram interpreted by medical students.
[PNG File , 1417 KB - mededu_v7i4e26675_app9.png]

Multimedia Appendix 10
Heatmap for an atrial flutter electrocardiogram interpreted by medical students.
[PNG File , 1543 KB - mededu_v7i4e26675_app10.png]

Multimedia Appendix 11
Heatmap for an atrial fibrillation electrocardiogram interpreted by medical students.
[PNG File , 1629 KB - mededu_v7i4e26675_app11.png]

Multimedia Appendix 12
Eye-tracking parameter definitions.
[PDF File (Adobe PDF File), 51 KB - mededu_v7i4e26675_app12.pdf]

Multimedia Appendix 13
Interpretation answers by medical students.
[PDF File (Adobe PDF File), 89 KB - mededu_v7i4e26675_app13.pdf]

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Abbreviations

AFib: atrial fibrillation
AOI: area of interest
AV block: complete heart block
aVF: augmented vector foot
aVL: augmented vector left
AVNRT: atrioventricular nodal reentry tachycardia
aVR: augmented vector right
ECG: electrocardiogram
LBBB: left bundle branch block
MCQ: multiple-choice question
NSR: normal sinus rhythm
STEMI: ST-segment elevation myocardial infarction
TTFF: time to first fixation
VTach: ventricular tachycardia
WPW: Wolf-Parkinson-White

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Original Paper

Use of an Online Ultrasound Simulator to Teach Basic Psychomotor Skills to Medical Students During the Initial COVID-19 Lockdown: Quality Control Study

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Abstract

Background: Teaching medical ultrasound has increased in popularity in medical schools with hands-on workshops as an essential part of teaching. However, the lockdown due to COVID-19 kept medical schools from conducting these workshops.

Objective: The aim of this paper is to describe an alternative method used by our medical school to allow our students to acquire the essential psychomotor skills to produce ultrasound images.

Methods: Our students took online ultrasound courses. Consequently, they had to practice ultrasound exercises on a virtual simulator, using the mouse of their computer to control a simulated transducer. Our team measured the precision reached at the completion of simulation exercises. Before and after completion of the courses and simulator's exercises, students had to complete a questionnaire dedicated to psychomotor skills. A general evaluation questionnaire was also submitted.

Results: A total of 193 students returned the precourse questionnaire. A total of 184 performed all the simulator exercises and 181 answered the postcourse questionnaire. Of the 180 general evaluation questionnaires that were sent out, 136 (76%) were returned. The average precourse score was 4.23 (SD 2.14). After exercising, the average postcourse score was 6.36 (SD 1.82), with a significant improvement (P<.001). The postcourse score was related to the accuracy with which the simulator exercises were performed (Spearman rho 0.2664; P<.001). Nearly two-thirds (n=84, 62.6%) of the students said they enjoyed working on the simulator. A total of 79 (58.0%) students felt that they had achieved the course's objective of reproducing ultrasound images. Inadequate connection speed had been a problem for 40.2% (n=54) of students.

Conclusions: The integration of an online simulator for the practical learning of ultrasound in remote learning situations has allowed for substantial acquisitions in the psychomotor field of ultrasound diagnosis. Despite the absence of workshops, the students were able to learn and practice how to handle an ultrasound probe to reproduce standard images. This study enhances the value of online programs in medical education, even for practical skills.

(JMIR Med Educ 2021;7(4):e31132) doi:10.2196/31132

KEYWORDS

anatomy; computers in anatomical education; internet application in anatomy; medical education; ultrasonography; ultrasound; simulation; simulator; psychomotor; motor skills; medical students; teaching

Introduction

Background

Ultrasound in medical education is gaining more and more interest due to the motivation of medical students on one hand [1] and to the increasing accessibility of ultrasound machines on the other [2,3].

Ultrasound teaching is classically divided into two mains parts: theoretical lectures focused on physics, image acquisition, indications, limitations and hygiene, and practical exercises focusing on the acquisition of psychomotor skills necessary to get diagnostic ultrasound images [4]. Until today, this practical part has been an essential element in the teaching of ultrasound [5]. In the medical school of the University of Lausanne, Switzerland, these practical ultrasound skills are usually acquired in normal circumstances, during the ultrasound workshops set up by the Radiology Department during the first year of master's studies. These workshops combine practical work on ultrasound machines with tutors and practice on a simulator. Additional optional hands-on workshops offered by the Young Sonographers (a group of students teaching ultrasound to other students) aim to complement these practical skills [6]. Primarily, these courses focus on the learning of normal anatomy in ultrasound.

In 2020, the COVID-19 pandemic abruptly disrupted the habitual working/learning practices of many medical entities. The impact was felt from emergency departments [7,8] to interventional radiology [9]. Courses in our medical school were also affected by the pandemic as early as mid-March 2020, since live courses were annulled and students were prevented from attending the workshops. To fill this gap, we have turned to an alternative solution with the establishment of a complete online ultrasound course.

This method of teaching ultrasound has been structured into two parts. First, to make a detailed presentation of the ultrasound exploration of the different systems and to complete the theoretical teaching of the bachelor's years, we directed the students to the "Blended learning" site of the Institute of General Medicine of the University of Bern [10,11]. Five different modules were accessible for the students on this website to self-teach the basic foundations of medical ultrasound. The first module was dedicated to ultrasound physics and the manipulations of an ultrasound machine. The next modules focused on the ultrasound exploration of normal anatomy in the following order: thoracic and abdominal organs, the musculoskeletal system, and finally the lymph nodes and cervical organs. All modules dedicated to normal anatomy were organized in the same way: presentation of a clinical case, description of the normal sonographic anatomy, video demonstration of the sonographic exploration of the organ, description of tips and tricks, and finally solution of the clinical case. The courses offered on this website are part of the "Young Sonographers" training course for students in Swiss medical schools to validate the Basic Course in Abdominal Ultrasound at the Swiss Society of Ultrasound in Medicine (SSUM-SGUM). Second, the students were asked to carry out a series of practical exercises dedicated to learning psychomotor skills for the practice of ultrasound that is accessible on an online simulator.

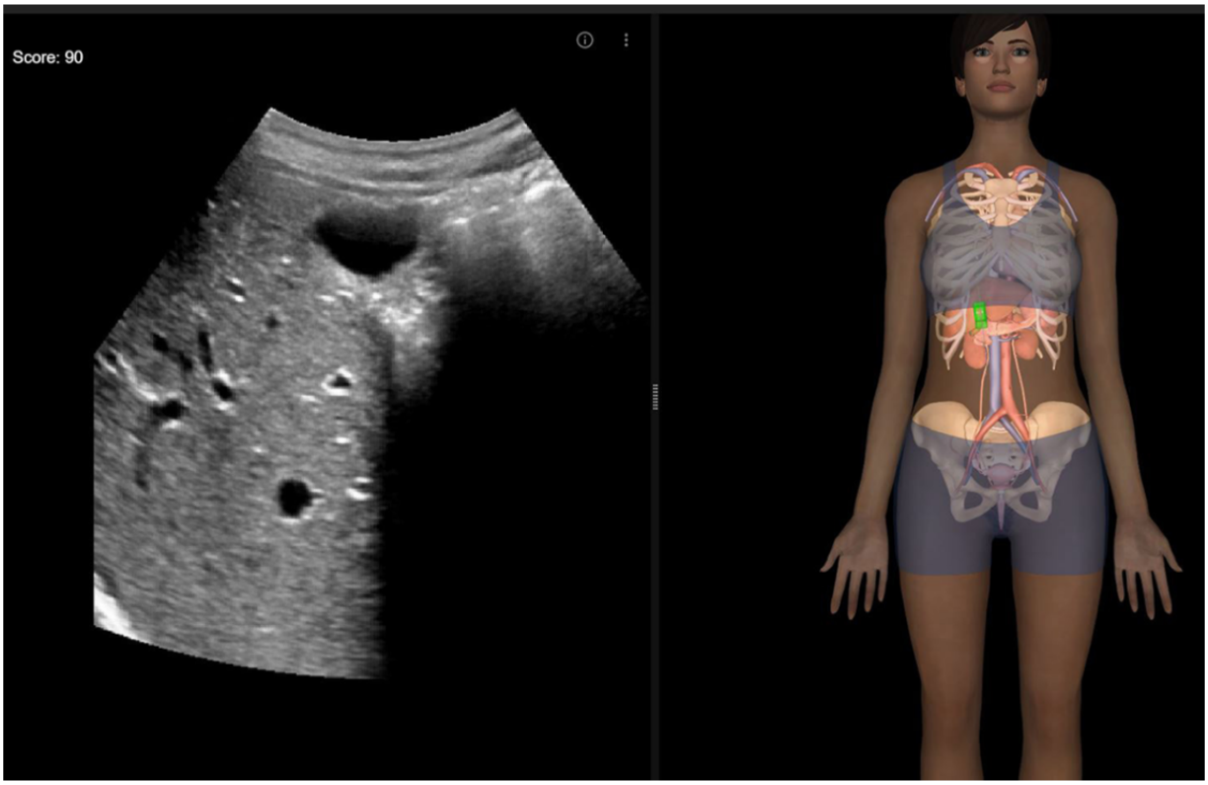
Objectives

The aim of this paper is to describe and evaluate this alternate online method we used to train our medical students in the acquisition of the visuospatial and visuomotor skills required to manipulate an ultrasound transducer and produce images of diagnostic quality without live workshop attendance.

Methods

The online simulator was provided by an Israeli start-up (Innoging, Tel Aviv; Figure 1). This start-up provided us with an empty virtual mannequin that we filled with volumes of ultrasound images acquired on site. These volumes of images were acquired from ultrasound exploration of a volunteer with a machine used for daily clinical work. We proceeded by manually sweeping an ultrasound probe (either convex low-frequency 1-5 MHz for abdominal images or linear high-frequency 4-18 MHz for superficial images) on the different regions of interest (liver, gallbladder, abdominal vessels, spleen, kidneys, bladder, uterus and ovaries, thorax, thyroid, axillary lymph nodes, groin, and Achilles' tendon). Video clips that were 20 seconds were obtained, each containing 350 images. One sweep along the short axis of the probe gave one volume in video/DICOM format. In that way, 30 volumes were produced and were sent through the internet to the simulator provider, which created a library of available volumes. We then placed the different volumes, by choosing in that library, at the right location in the virtual mannequin. From these different ultrasound volumes, we developed a series of 56 practical exercises related to the chapters of the "Blended learning" courses (bases of probe manipulation, large vessels, spleen, thorax, liver, pancreas, gallbladder, bile ducts, kidneys, urinary tract, bladder, uterus, musculoskeletal system, neck, lymph nodes; Textbox 1). Each exercise had the same structure: first, a brief comment on the structure to follow when scanning, the presentation of the image to reproduce, the place to store the reproduced image, and finally the initial image again with anatomical captions.

Figure 1. View of the simulator interface, with the generated ultrasound slice on the left and the probe on the mannequin on the right. As the probe is drawn closer to the reference position, it becomes green. At the same time, the counter (at the top, on the left) increases up to 100 (perfect matching).



Textbox 1. List of the different simulation exercises with their connection to the theoretical chapters of the "Blended learning."

Bases of probe manipulation

- Liver and right kidney
- Bladder and uterus
- Heart
- Pregnancy
- Right kidney
- Liver and gallbladder

Large vessels, spleen, thorax

- Aorta
- Aorta
- Aorta and inferior vena cava (IVC)
- Aorta and IVC
- IVC
- Spleen
- Spleen
- Spleen
- Spleen
- Thorax
- Thorax
- Thorax
- Thorax

Liver, pancreas, gallbladder, bile ducts

- Liver
- Liver
- Liver
- Liver and gallbladder
- Liver
- Liver and main biliary duct
- Liver and main biliary duct
- Gallbladder
- Gallbladder
- Gallbladder
- Left liver
- Pancreas
- Pancreas
- Pancreas

Kidneys, urinary tract, bladder, uterus

- Right kidney
- Right kidney
- Left kidney
- Left kidney
- Left kidney

- Right kidney
- Bladder
- Uterus
- Bladder and uterus
- Bladder and uterus
- Bladder and uterus

Musculoskeletal system, neck, lymph nodes

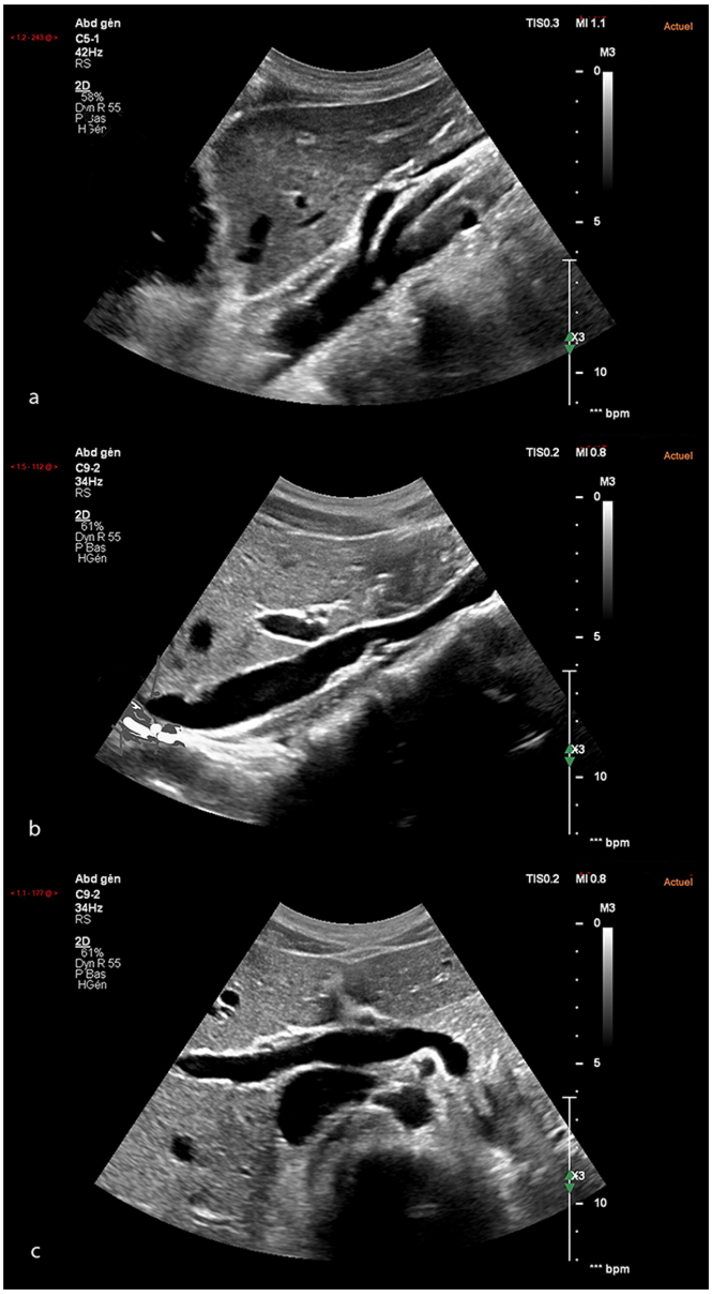
- Achilles' tendon
- Achilles' tendon
- Thyroid
- Thyroid
- Thyroid
- Cervical lymph nodes
- Cervical lymph nodes
- Thyroid
- Thyroid
- Cervical lymph nodes
- Groin
- Groin

Every student in the first year of master's studies in the medical school of the University of Lausanne, Switzerland received a personal code to access the simulator. They had to carry out the various exercises proposed, with the recommendation of practicing the exercises only after studying the corresponding chapter of the "Blended learning" course. Access was open from mid-May to the end of August 2020.

The completion of exercises was monitored. The precision obtained by the trainee during the simulator exercises, where a typical image had to be reproduced, was measured as a percentage of the reference position given at the beginning of each exercise.

A questionnaire targeting the manipulation of an ultrasound probe had to be completed by each participant at the beginning and at the end of the training (pre- and postcourse, 20 questions, maximum score 10; Figure 2). In addition, as with the other faculty courses, a final general assessment questionnaire was submitted to the students, using a qualitative scale. Students did not receive the results, neither at the beginning (pretest) nor at the end (posttest) of the educational process.

Figure 2. Example of a question of the pre-posttest: I have just got the previous images (images 2a and 2b). To get the image 2c during the same run, I have to make the following movement with my probe: (a) translation to the left, (b) anticlockwise rotation, (c) inclination to the right, (d) I don't know. Answer b: anticlockwise rotation.



The study was designed as a quality control for ultrasound teaching. As such, our ethical review board determined that the project did not fall within the scope of the Law on Human research (Req-2021-00589), and informed consent was waived. The data was anonymized to guarantee the privacy of participants.

The statistical analyses were carried out with *t* test, Wilcoxon rank sum test, or Spearman test on the STATA software (version 16.1, StataCorp). A *P* value<.05 was considered significant.

Results

A total of 193 students finished the precourse training during the allotted period. A total of 184 students performed all the simulator exercises and 181 performed the postcourse test. The faculty sent 180 evaluation questionnaires, of which 136 (76%) were returned.

Analysis of the target questionnaires determined that the scores had increased significantly after the completion of the simulator exercises (Figure 3). The mean precourse score was 4.23 (SD 2.14), whereas after completion of the exercises, it was 6.36 (SD 1.82; *P*<.001). The postcourse score for all students was related to the accuracy with which the simulator exercises were performed (Spearman rho 0.2664; *P*<.001; Figure 4). On the simulator, the lowest score was 43.68, the highest 99.67, with a mean of 76.11 (SD 11.29).

Figure 3. Differences between the posttest score and pretest score. The mean difference was 2.12 (SD 2.13), with a maximum of 8.5 and a minimum of –3. The comparison of the two tests showed a significant difference, with an improvement in performance after the simulation exercises (Wilcoxon rank sum test; *P*<.001). Note that for 20 students, the posttest score was worse than the pretest score.

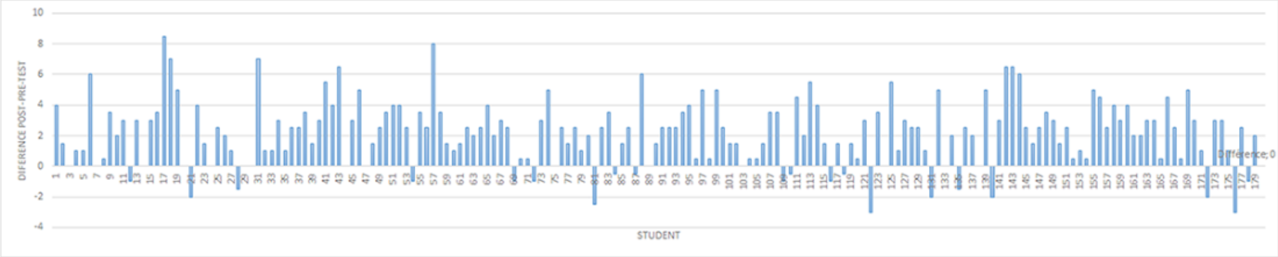
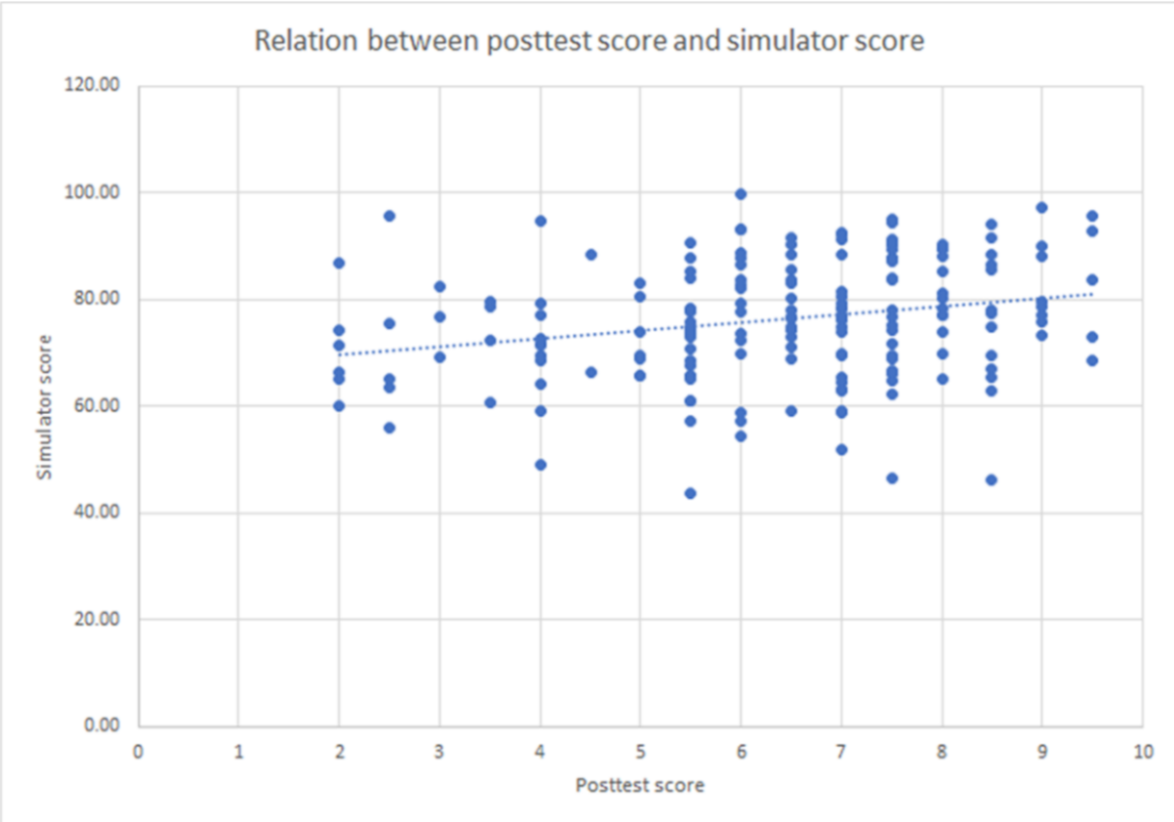


Figure 4. Relation between the simulator score (precision of the execution of the simulation exercises) and the posttest score (understanding of probe manipulation) for each student (Spearman rho 0.2664; *P*<.001).



A total of 20 students performed better during the precourse (mean score 6.75, SD 1.93) than during the postcourse (mean score 5.32, SD 1.97; *P*<.001). There was a nonsignificant difference between the precourse score of these students and the mean postcourse score including all students (*P*=.38). There was no significant difference between the simulator score of that group of students (mean 76.69, SD 10.66) and the score of all students (mean 76.11, SD 11.29; *P*=.70).

Nearly two-thirds (n=84, 62.6%) of the students said they enjoyed working on the simulator. A total of 79 (58.0%) students felt that they had achieved the course's objective of reproducing ultrasound images. A total of 115 (84.5%) estimated that, after that course, they were able to recognize the abdominal organs by ultrasound. A total of 83 (61.9%) students found that the exercises were adapted to their previous knowledge, and 68.6% (n=92) felt that they had progressed in understanding ultrasound anatomy. Inadequate connection speed had been a problem for 40.2% (n=54) of students.

Among the negative comments, difficulty in manipulation of the simulator probe and the mannequin from the computer mouse or trackpad were frequently cited. Another recurring remark was related to the "Blended learning" courses being in the German language.

Discussion

Principal Findings

Our study has demonstrated that the integration of an alternative teaching model during the pandemic lockdown for the practical learning of ultrasound with an online mode has allowed substantial psychomotor skill acquisitions for ultrasound diagnosis.

The COVID-19 pandemic has impacted medical education everywhere. Universities were forced to switch to online teaching [12]. These online methods, such as lectures, videos on websites, or webinars, are primarily focused on theoretical knowledge. The online teaching of clinical competencies or skills, particularly ultrasound, has not been reported in the literature to date. To our knowledge, we present here the largest study evaluating the effects of an online ultrasound simulator on the psychomotor performance of medical students. This is also the first report of a completely autonomous self-learning program for basic ultrasound learning [13].

Despite the limitations related to the urgency of its implementation (course of “Blended learning” in a foreign language, difficulties in manipulating the probe of the simulator with a mouse or trackpad, difficulties in orienting the mannequin, simulation with slow internet connection) nearly two-thirds of students were satisfied with the experience.

Simulation is a popular teaching method in health care education [14]. During simulation exercises, students may indefinitely repeat gestures and procedures without any influence on clinical workload or patient safety [15,16]. Many different kinds of ultrasound simulators are available on the market [17]. Some require a consecrated computer, a mannequin, and a fake probe; others only need a fake transducer with a downloadable software, or others are completely dematerialized on the web [18,19].

Whatever the technology and the price of the ultrasound simulator, many reservations are expressed about the real place of simulation in ultrasound teaching [13,20]. The main criticism rests on the scarcity of scientific studies analyzing the real impact of simulation-based ultrasound training on clinical practice. Indeed, the majority of available studies either analyze the effect of simulator training on the simulation experience [21,22] or use subjective evaluations to support their conclusions [23-26].

For 20 students, the posttest score was lower than the pretest score. However, their score on the simulator was the same as that of all the students.

Some students had already received an introduction to ultrasound before the project was launched. We did not specifically ask the question of previous training to the participants. Nevertheless, a closer look at this group of “negative” performers revealed that it consisted of many pupils repeating the grade and young sonographers and students in higher grades from other universities; in other words, students with previous exposure to ultrasound training.

Students had free access to the new learning method during the 3.5 months. They received the initial instructions and then they were free to proceed to the activities at their own pace and convenience. As for other medical students worldwide, lockdown did not mean enforced idleness. They were committed to different health care initiatives against COVID-19 [27]. As a result, they proceeded with the requested activities only when they had time during their busy schedule. That may explain the surprising results of the group of “negative” performers: at the beginning of the educational program, they had conscientiously fulfilled the pretest questionnaire and then carefully carried out the different exercises on the simulator. At the end of the process, as they had already experimented on this method and under the pressure of their other activities, motivation for repeating and for the completion of the questionnaire dropped. Indeed, motivation in medical education is important [28], particularly in a self-learning environment [29].

Difficulties with manipulations of the simulator probe and the mannequin from the computer mouse or trackpad were mentioned as a problem in the simulation’s experience. Gunabushanam et al [30] have recently proposed a smart solution for the virtual ultrasound simulator to resemble the ultrasound transducer: a user’s own smartphone [30]. Such a solution has the potential to give the realistic touch needed for a complete virtual ultrasound simulation experience. Interestingly, the main suggestion for improvement proposed by the group of users of the smartphone’s mock probe was to add an option allowing to scroll through images with a mouse [30].

Limitations

Unfortunately in our study, we could not evaluate the impact of online simulation training on real practical skills. Because of the completely virtual setup of the study, only simulator-based analysis and subjective feedback were available for analysis. A future part of the study will compare the ultrasound scanning performance of different groups of students: the young sonographers’ tutors, the medical students exposed to the simulator without additional supervised training, and the young sonographers’ students with traditional training. This later group is still in training with hands-on workshops. As soon as the present lockdown will be lifted, we will proceed with this additional study. Another limitation was related to the foreign language of the “Blended learning” course. This course is a part of the official program of medical students’ ultrasound teaching from the SSUM-SGUM. The translation in the other official Swiss languages has been planned, but as with many other projects this year, it has been delayed because of the pandemic.

Conclusions

We have observed that exposition of medical students to a completely virtual ultrasound simulation experience has enabled them to acquire substantial visuospatial and visuomotor ultrasound skills. Until today, these competencies were only acquired through practical work on site with tutors. With this study, we demonstrated the value of a dedicated online method to remotely teach practical ultrasound. Self-learning has the potential of substantially reducing the barriers to use ultrasound simulation and its potential costs.

Conflicts of Interest

None declared.

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Abbreviations

SSUM-SGUM: Swiss Society of Ultrasound in Medicine

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Original Paper

Using Instagram to Enhance a Hematology and Oncology Teaching Module During the COVID-19 Pandemic: Cross-sectional Study

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Abstract

Background: The COVID-19 pandemic necessitated the rapid expansion of novel tools for digital medical education. At our university medical center, an Instagram account was developed as a tool for medical education and used for the first time as a supplement to the hematology and medical oncology teaching module of 2020/2021.

Objective: We aimed to evaluate the acceptance and role of Instagram as a novel teaching format in the education of medical students in hematology and medical oncology in the German medical curriculum.

Methods: To investigate the role of Instagram in student education of hematology and medical oncology, an Instagram account was developed as a tie-in for the teaching module of 2020/21. The account was launched at the beginning of the teaching module, and 43 posts were added over the 47 days of the teaching module (at least 1 post per day). Five categories for the post content were established: (1) engagement, (2) self-awareness, (3) everyday clinical life combined with teaching aids, (4) teaching aids, and (5) scientific resources. Student interaction with the posts was measured based on overall subscription, "likes," comments, and polls. Approval to conduct this retrospective study was obtained from the local ethics commission of the University Medical Center Goettingen.

Results: Of 164 medical students, 119 (72.6%) subscribed to the Instagram account, showing high acceptance and interest in the use of Instagram for medical education. The 43 posts generated 325 interactions. The highest number of interactions was observed for the category of engagement (mean 15.17 interactions, SD 5.01), followed by self-awareness (mean 14 interactions, SD 7.79). With an average of 7.3 likes per post, overall interaction was relatively low. However, although the category of scientific resources garnered the fewest likes (mean 1.86, SD 1.81), 66% (27/41) of the student participants who answered the related Instagram poll question were interested in studies and reviews, suggesting that although likes aid the estimation of a general trend of interest, there are facets to interest that cannot be represented by likes. Interaction significantly differed between posting categories ($P<.001$, Welch analysis of variance). Comparing the first category (engagement) with categories 3 to 5 showed a significant difference (Student t test with the Welch correction; category 1 vs 3, $P=.01$; category 1 vs 4, $P=.01$; category 1 vs 5, $P=.001$).

Conclusions: Instagram showed high acceptance among medical students participating in the hematology and oncology teaching curriculum. Students were most interested in posts on routine clinical life, self-care topics, and memory aids. More studies need to be conducted to comprehend the use of Instagram in medical education and to define the role Instagram will play in the future. Furthermore, evaluation guidelines and tools need to be developed.

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KEYWORDS

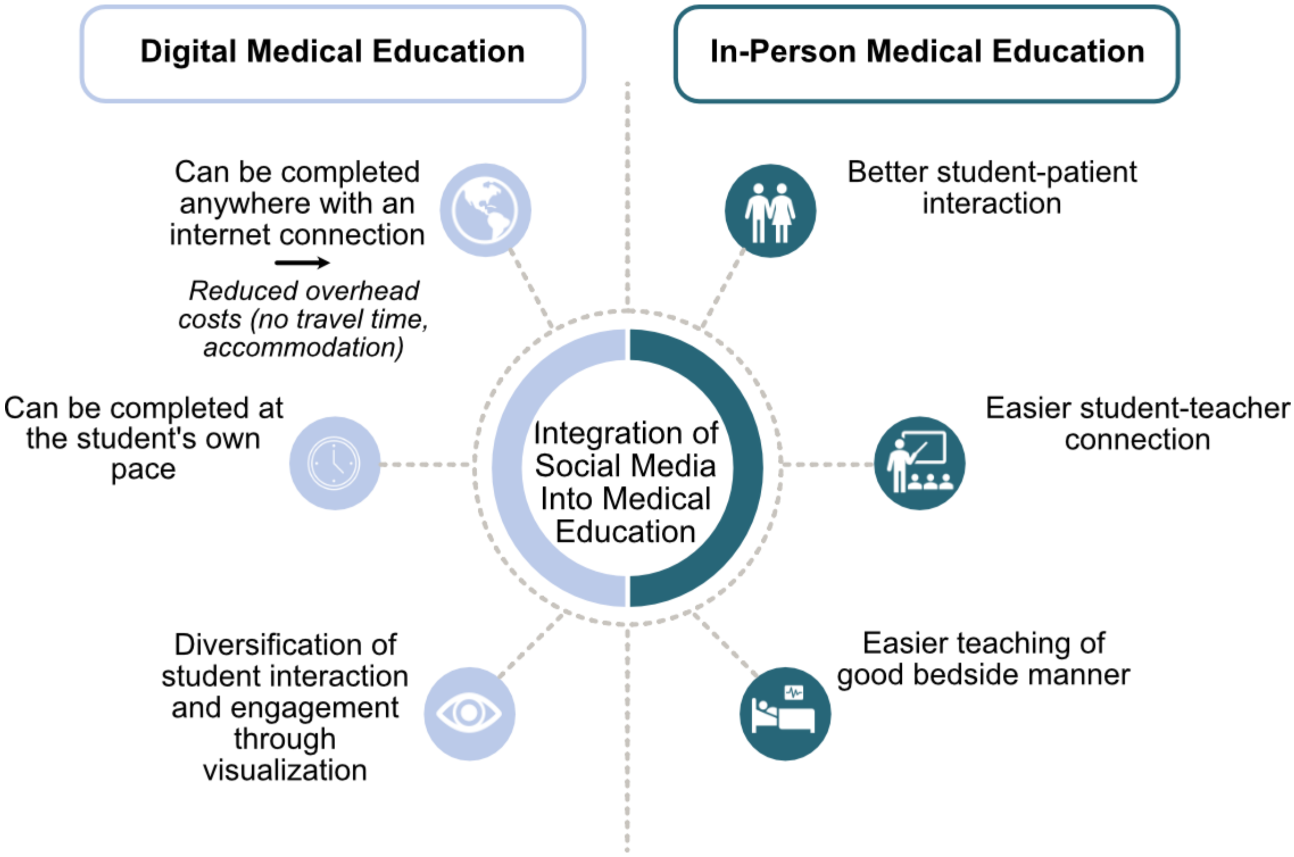
COVID-19; medical education; distance learning; undergraduate medical education; digital medical education; Instagram; hematology and medical oncology

Introduction

The COVID-19 pandemic continues to have a substantial impact on medical education worldwide. Necessary governmental measures to contain the pandemic have required a significant reduction of personal contact between students, their educators, and patients and have led to the transfer of most medical teaching into the web-based realm [1]. At the University Medical Center Goettingen, continuous albeit strongly reduced bedside teaching was enabled to uphold this integral part of medical education; however, most of the teaching was conducted exclusively on the web via tutorials and livestreaming of lectures.

Medical education strives to unite the teaching of scientific facts with the instruction of good bedside manner and adequate professional conduct. The relocation of medical education into the web-based realm leads to the conundrums of (1) including medical students in everyday clinical practice, (2) experiencing and learning about patient-physician interactions, and (3) establishing a sufficient student-teacher connection (Figure 1).

Figure 1. Integrating digital teaching tools: the advantages of digital versus in-person interaction.



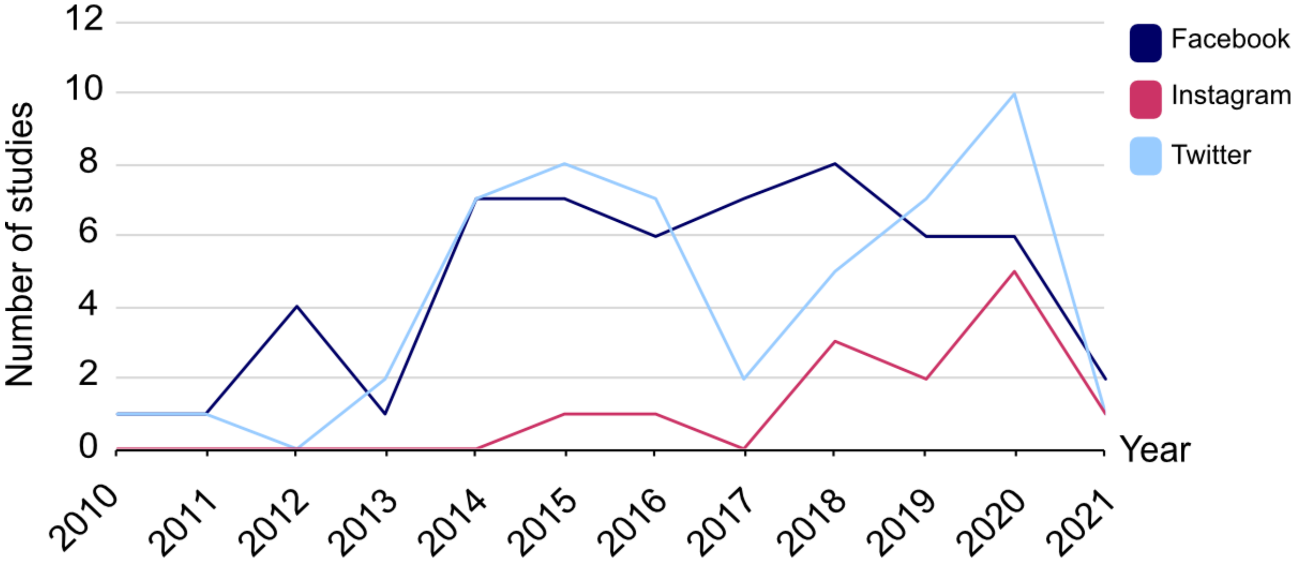
A recent study observed that most medical students already use smartphones and social media for education [2]. Furthermore, a growing number of clinicians utilizes social media for personal and professional purposes [3-5].

Students using social media benefit from learner engagement, customized learning, and opportunities for feedback [6]. Moreover, social media platforms allow diversification of interactions and engagements with students, as they are not limited to the written word as a medium. The COVID-19 pandemic highlighted the possibility of using social media as an effective way to deliver health care education [7].

The different social media platforms each have specific strengths and weaknesses.

Most research has focused on assessing the value of Twitter or Facebook as educational tools. The use of Instagram for medical education has not been extensively studied, especially in the field of hematology and medical oncology [8,9] (Figure 2). The unique selling point of Instagram lies in the strength of visualization and interaction with users, which makes the platform especially helpful for procedural training and imaging studies. To date, Instagram has been used in medical specialties such as pathology, plastic surgery, and radiology [7,8,10]. Furthermore, the platform allows insight into medical fields and physicians’ everyday routines that might otherwise only be gained during shadowing opportunities [7].

Figure 2. Increase in importance of social media platforms for medical education in the last decade, with a timeline of the numbers of original articles concerning specific social media platforms in the last decade.



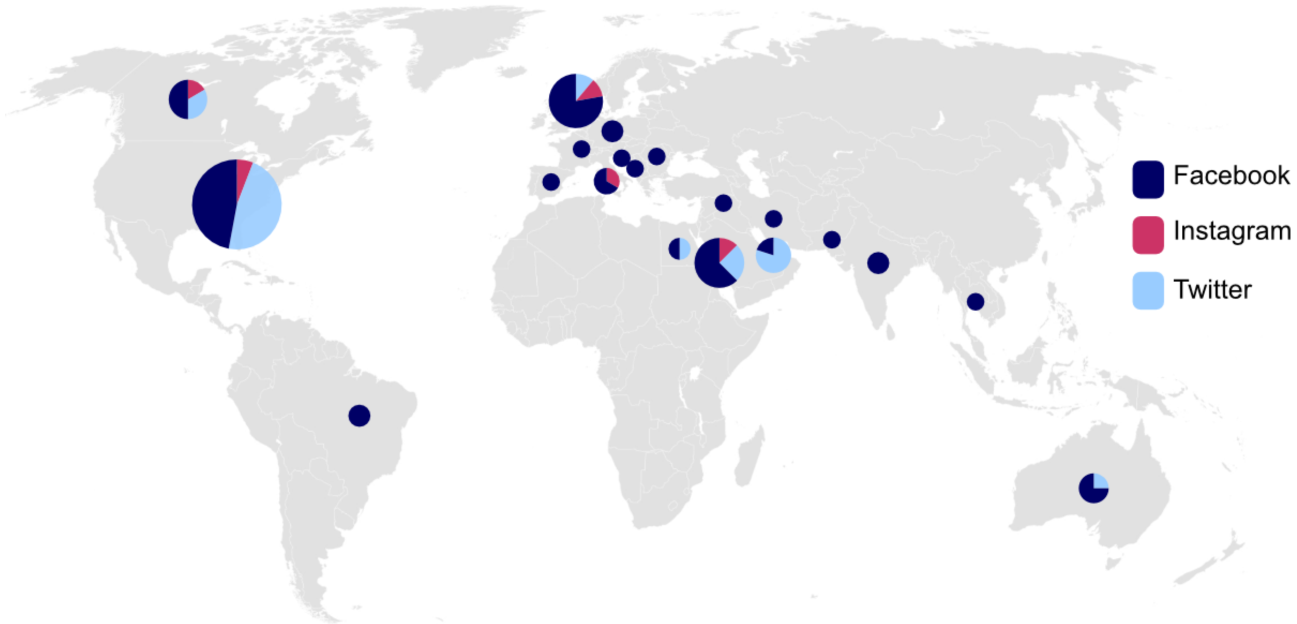
Our study aimed to explore the use of Instagram for educational purposes in the field of hematology and medical oncology to determine how to best use this platform effectively. We hypothesized that the usage of Instagram could possibly facilitate and improve interaction with medical students during this difficult time. To this end, we created an Instagram account as a tie-in for the hematology and medical oncology teaching module during the winter semester of 2020/2021.

Methods

Appraisal of Social Media in Medical Education

An appraisal of current literature on the use of social media in medical education was conducted by searching for original articles found under the Medical Subject Headings (MeSH) terms "medical education" AND "Twitter/Facebook/Instagram" on PubMed. Studies were sorted by year of publication and country of the first author for visual analysis with Affinity Designer, version 1.9.1 (Serif Ltd) (Figure 2 and Figure 3). Only original articles investigating the use of social media in medical education were included. PubMed was chosen because there is no access restriction and the platform provides abstracts.

Figure 3. Original articles concerning the use of social media in medical education by country. The total number of original articles is represented by the circle size, and the proportion of specific social media platforms is represented by color.



Account Setup and Design

During the winter term of 2020/2021, a private Instagram account was created as a supplement to the hematology and medical oncology teaching module of the University Medical Center Goettingen. The account was only made available to medical students enrolled in this teaching module, and the students were notified about the account via their web-based class schedule and during the introductory lecture. After the students requested to follow the account, they were admitted as followers. The uploaded content on the Instagram account was synchronized to the lecture curriculum.

Uploaded content included visual comics and mnemonics, introduction to major international hematological/oncological societies, links to web-based learning resources, clinical imaging (eg, blood slides, x-ray images), guidelines, scientific papers, and personal content in which the teaching staff shared scenes of their everyday clinical practice. At least 1 post per day was uploaded, except during the holiday season, when content was uploaded once every 2 days. Each post was composed of pictures and text, which sometimes included questions. If a student left a comment via the Comments section, the teaching staff uploaded a reaction. Overall, five categories for the post content were established: (1) engagement, (2) self-awareness, (3) everyday clinical life combined with teaching aids, (4) teaching aids, and (5) scientific resources. In the engagement category, the content included an introductory message to the account for the students, holiday greetings, and good luck wishes for the upcoming examinations. The second category (self-awareness) consisted of content on resilience and self-care. The third category (everyday clinical life combined with teaching aids) included bits of everyday clinical life, such as transfusion management, blood slides, and treatment of chemotherapy-related side effects. The fourth category included clinical findings, such as hematopathology images, visual memory aids, mnemonics, and computed tomography scans. The fifth category, studies, included scientific articles (original articles and reviews); also, hematological and oncological societies were introduced (eg, the European Society for Medical Oncology and the American Society of Hematology). Approval to conduct a retrospective data analysis was obtained from the local ethics committee of the University Medical Center Goettingen (date February 25, 2021; approval 19/2/21).

Determining Engagement

Engagement was defined as “likes” or comments and was calculated for each post separately using Excel (Microsoft Corporation) and the following formula: number of interactions per post ÷ number of followers.

Instagram Flash Poll

After the students completed the teaching module, an Instagram poll on how the content was received was conducted. The students were informed both orally at a lecture presenting the web-based teaching module iLearn Onco and in writing via our web-based iLearn Onco script about data collection, data storage, the investigators, and the purpose of the study before the poll was opened. Only anonymous data were collected. The survey was conducted as an open survey. No incentives were offered for completing the poll. Students could answer specific questions individually, explaining the divergent number of participating students for each question. The responses were manually entered into an Excel database and analyzed. The data were collected over a time frame of 24 hours.

The poll included the following questions, which could be answered with either yes or no:

- Would you prefer funnier content?
- Would you prefer more content on the everyday clinical life of hematologists and oncologists?
- Would you prefer more mnemonics?
- Would you prefer more content on reviews and studies?
- Would you prefer more content on sensitive/personal topics?

Statistical Analysis

Excel 2013 and GraphPad Prism, version 8.0 (GraphPad Software) were used for the statistical analysis.

Results

Social Media in Medical Education Is Gaining Importance

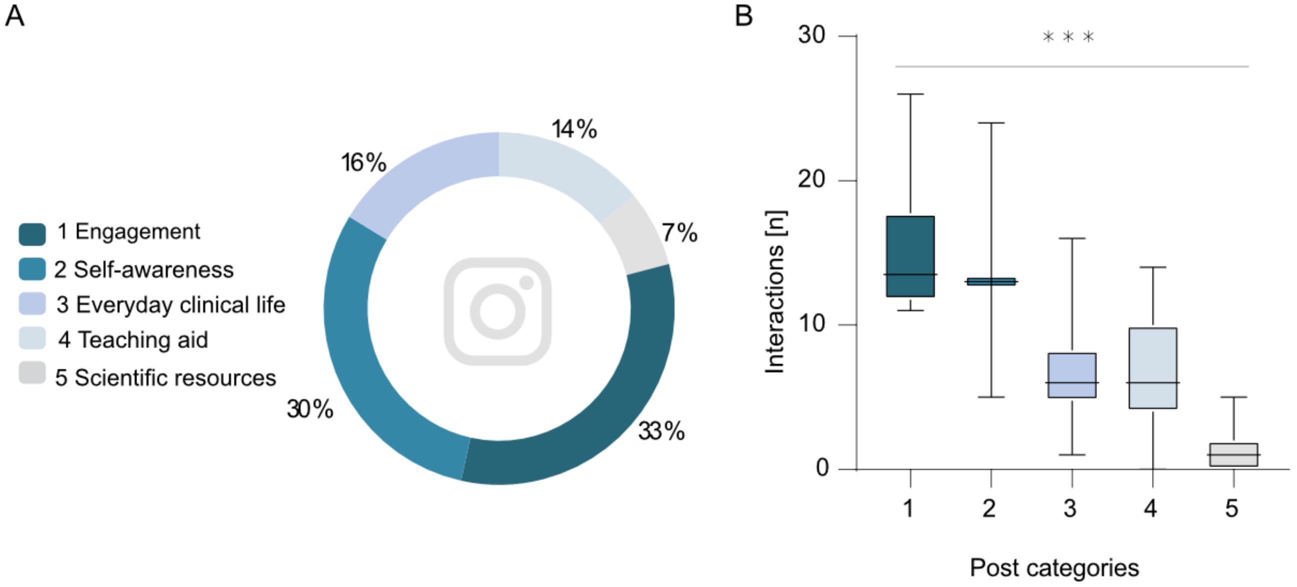
An appraisal of the current literature on the use of the social media platforms Twitter, Facebook, and Instagram for medical education showed that social media is gaining importance as an educational tool. The number of studies has slowly increased during the last decade, mirroring a shift from exclusively in-person teaching toward the integration of digital resources into medical education (Figure 2). Especially, the United States, the United Kingdom, and Arabic-speaking countries are leaders in the field, with the highest numbers of studies (Figure 3).

Account and Follower Characteristics

During the 47 days of the hematology and medical oncology teaching module, we uploaded 43 posts accompanying our faculty’s curriculum. Of 164 students enrolled in the teaching module on hematology and medical oncology, 119 (72.6%) subscribed to the iLearn Onco Instagram account.

The first category (engagement) consisted of 6 posts, the second category (self-awareness) of 3 posts, the third category (everyday clinical life combined with teaching aids) of 14 posts, the fourth category (teaching aids) of 13 posts, and the fifth category (scientific resources) of 7 posts (Figure 4A). Of our followers, 88 (73.9%) identified themselves as female, and 31 (26.1%) identified themselves as male.

Figure 4. (A) Categories and proportions of content uploaded to each category. (B) Interaction of students with specific categories differs significantly (Welch analysis of variance, *P*<.01).



Interaction

Our 43 posts generated 325 interactions, consisting of 315 likes and 10 comments. The mean number of likes per post was 7.33 (SD 5.71), and the mean engagement rate per post was 0.06 (SD 0.05). The most liked post had 26 likes and the highest engagement rate (0.22). Students used the comment section under the post 3 times spontaneously and answered questions asked in the comment section 7 times.

Interaction Characteristics

Of the five different content categories established in this project, we observed the highest number of interactions for the category of engagement (mean 15.17 interactions, SD 5.01), followed by self-awareness (14.00 interactions, SD 7.79). Posts in the teaching aids category (6.85 interactions, SD 3.90) had a slightly higher interaction rate than those in the category of everyday clinical life combined with teaching aids (6.71 interactions, SD 3.53). The fewest interactions occurred with posts belonging to the category of scientific resources (1.29 interactions, SD 1.67). Interactions significantly differed between posting categories (*P*<.001, Welch analysis of variance, Figure 4B). Comparing the first category (engagement) with categories 3 to 5 showed a significant difference (Student *t* test, Welch correction; category 1 vs 3: *P*=.01, difference between means –8.45±2.45, 95% CI –14.24 to –2.67; category 1 vs 4: *P*=.01, difference between means –8.32±2.51, 95% CI –14.15 to –2.49; category 1 vs 5: *P*=.001, difference between means –13.99±2.34, 95% CI –19.63 to –8.13). There was no statistically significant difference when comparing the second (self-awareness) category to any of the other categories (Student *t* test, Welch correction; category 2 vs 1: *P*=.86, difference between means –1.17±5.95, 95% CI –21.39 to 19.06; category 2 vs 3: *P*=.32, difference between means –7.29±5.59, 95% CI –30.02 to 15.44: category 2 vs 4: *P*=.32, difference between means –7.15±5.62, 95% CI –29.62 to 15.31: category 2 vs 5: *P*=.15, difference between means –12.71±5.55, 95% CI –35.92 to 10.50). The third category (everyday clinical life combined with teaching aids) and the fourth category (teaching aids) both showed a significant difference when compared to the fifth category (scientific resources) (Student *t* test, Welch correction; category 3 vs 5: *P*<.001, difference between means –5.43±1.19, 95% CI –7.93 to –2.93; category 4 vs 5: *P*<.001, difference between means –5.56±1.32, 95% CI –8.33 to –2.79). For the third and fourth categories, compared with each other, there was no significant difference in interactions (Student *t* test, Welch correction, *P*=.93, difference of means 0.13±1.15, 95% CI –2.93 to 3.19).

Instagram Flash Poll as a Tool for Obtaining Fast Feedback

A median of 46 (38.6%) of the 119 students who subscribed to the account participated in the voluntary Instagram poll (range 34-56). Questions could be answered individually; therefore, different numbers of participants answered each question. Of 34 students, 59% (20/34) stated they would prefer funnier content, and 66% (27/41) would have liked more information about reviews and studies. Of 56 polling students, 96% (54/56) wanted more posts about everyday clinical life, and 96% (49/51) wanted more mnemonics. All of the participating students who answered the question about sensitive/personal topics (49/49, 100%) were interested in more content on these topics. Overall, simple Instagram polls offer the opportunity for quick feedback on how content is received.

Discussion

Principal Findings

Although the medical community has shown increasing interest in the potential of Instagram, its role in health care has yet to be determined [8,11,12]. As a visual-based tool, Instagram offers unique possibilities for interaction. As a recent analysis illustrated [11], it can be used for patient education, patient support groups, accessibility, and medical education of either peers or medical students. We hypothesized that using Instagram as an addition to our web-based teaching curriculum could facilitate and improve interaction with our medical students during the COVID-19 pandemic. Overall, 119 (73.6%) of the 164 students in the teaching module subscribed to the Instagram account, which shows high acceptance and interest in the use of Instagram for medical education; this is in line with current data [11,12]. However, the acceptance of the account based on engagement rate, as measured in likes for specific posts, was low. Furthermore, the results of the Instagram poll were in part divergent from the number of likes, with students stating they would like more content pertaining to a category that had received few likes.

Because all students had access to the internet, either at home or provided by the faculty, and students were required to use the official web-based learning platform of the faculty, we surmise that the students who did not use Instagram actively decided against doing so.

With an average of 7.3 likes per post, interaction was relatively low [13,14]. The highest numbers of interactions were achieved for posts in the categories of engagement and self-awareness. Both categories featured content that emphasized educator and peer-to-peer connection and self-care. As this study took place during the COVID-19 pandemic, these results may reflect the current zeitgeist. A total of 3 posts addressed sensitive topics concerning the occurrence of depression and suicidal tendencies in medical students (23 likes), sleep deprivation in medical students (5 likes), and substance abuse among medical students (13 likes). These were the only contents with spontaneous positive feedback, either in the comment section or by a comparatively high number of likes. This finding may indicate that social media can be used to raise awareness for self-care and offer the possibility to advertise low-threshold services (eg, contact with the student counselor, counseling hotlines) for medical students.

The current literature on the use of Instagram in medical education and medicine in general measures interaction and engagement in likes [10]. The number of likes represents an estimate of how interesting the content is to the subscribers, and on this basis, administrators decide what content to upload [10]. In our analysis, the fifth category (studies), which contained information on current clinical trials, important reviews and studies, and web-based presentation of hematology and oncology platforms, had significantly less engagement and fewer likes than all the other categories. However, in a separate flash poll conducted on Instagram, 66% of the participating students were interested in more studies and reviews. Those findings suggest that although likes, as currently used in the literature and by industry as a measure of the interest of followers, help to estimate a general trend of interest, there are facets to interest that cannot be represented by likes [13].

Thus, to determine what types of content students are interested in, a more detailed evaluation needs to be conducted.

Limitations

There are a few limitations to this study. First, the sample size was relatively small, and the interaction rates were low. The account was kept private, ensuring a safe space for students to learn and interact. Thus, the number of students in the study was limited by the number of students participating in the teaching module. A reason for the initially low interaction rates may be that this was the first time Instagram was used as an addition to the normally used modes of medical education at the University Medical Center Goettingen; therefore, neither students nor teaching staff were familiar with this tool as a means of education in this context. We assumed that the students had a basic knowledge of how to use and interact with Instagram, as many students already use social media in their personal lives. However, we cannot completely rule out the possibility that the decision not to use Instagram was based on a lack of training on how to use the platform.

Another limitation is that the Instagram account was created with more than one intention in mind. On the one hand, the goal was to supplement the web-based teaching module; on the other hand, we aimed to connect with students in times of social distancing and give them a feeling of inclusion in everyday clinical practice. The uploaded content that aimed to achieve each of these two goals differed greatly; therefore, the evaluation is complicated.

There is also a limitation in the scope of the review of the current literature on social media in medical education. A more comprehensive overview would require searching additional databases, such as Medline and Scopus.

Conclusions

Instagram is a modern tool that can be easily integrated into medical teaching and allows continued personalized web-based contact between educators and students during the COVID-19 pandemic. To fully comprehend the role Instagram can play in medical education in the future, more studies need to be conducted. Furthermore, evaluation guidelines and tools need to be developed.

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Conflicts of Interest

None declared.

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Abbreviations

MeSH: Medical Subject Headings

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Original Paper

Audience of Academic Otolaryngology on Twitter: Cross-sectional Study

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Abstract

Background: Despite the ubiquity of social media, the utilization and audience reach of this communication method by otolaryngology-head and neck surgery (OHNS) residency programs has not been investigated.

Objective: The purpose of this study was to evaluate the content posted to a popular social media platform (Twitter) by OHNS residency programs.

Methods: In this cross-sectional study, we identified Twitter accounts for accredited academic OHNS residency programs. Tweets published over a 6-month period (March to August 2019) were extracted. Tweets were categorized and analyzed for source (original versus retweet) and target audience (medical versus layman). A random sample of 100 tweets was used to identify patterns of content, which were then used to categorize additional tweets. We quantified the total number of likes or retweets by health care professionals.

Results: Of the 121 accredited programs, 35 (28.9%) had Twitter accounts. Of the 2526 tweets in the 6-month period, 1695 (67.10%) were original-content tweets. The majority of tweets (1283/1695, 75.69%) were targeted toward health care workers, most of which did not directly contain medical information (954/1283, 74.36%). These tweets contained information about the department's trainees and education (349/954, 36.6%), participation at conferences (263/954, 27.6%), and research publications (112/954, 11.7%). Two-thirds of all tweets did not contain medical information. Medical professionals accounted for 1249/1362 (91.70%) of retweets and 5616/6372 (88.14%) of likes on original-content tweets.

Conclusions: The majority of Twitter usage by OHNS residency programs is for intra and interprofessional communication, and only a minority of tweets contain information geared toward the public. Communication and information sharing with patients is not the focus of OHNS departments on Twitter.

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KEYWORDS

Twitter; otolaryngology; residency; medical education; social media; internet

Introduction

Social media continues to be a growing and evolving aspect of daily life for the general population. Over the last 15 years, the percentage of US adults who use at least one social media website has increased from 5% to 72% [1]. Online resources and social media platforms hold significant potential as methods of communication and information dissemination between health care providers and their patients.

With the development of electronic medical records, many hospital systems allow for patients to contact their providers and access records through an online patient portal [2]. Younger patients are more likely than their older counterparts to use these portals in the orthopedic [3] and cancer [4] patient populations. There is a similar correlation of social media usage with age, as a higher proportion of younger adults are using social media (90% of individuals aged 18-29 years) compared to older adults (40% of individuals over the age of 65 years) [1].

With the ever-expanding role of telemedicine in patient care, particularly during the COVID-19 pandemic, we must be mindful of opportunities for patient engagement and education outside of the office. With its rising ubiquity, the utilization and audience reach of social media by medical professionals is an emerging field of research. Twitter is a popular platform that has proven to be useful in academic networking [5-8]. In the field of otolaryngology-head and neck surgery (OHNS), Twitter has been studied as a patient resource for information about tonsillectomy [9], cochlear implantation [10], and hearing loss [11]. However, there have been no investigations into the use of this social media platform by academic OHNS residency programs. Thus, the purpose of this study was to evaluate the content and target audience of academic OHNS residency programs on Twitter.

Methods

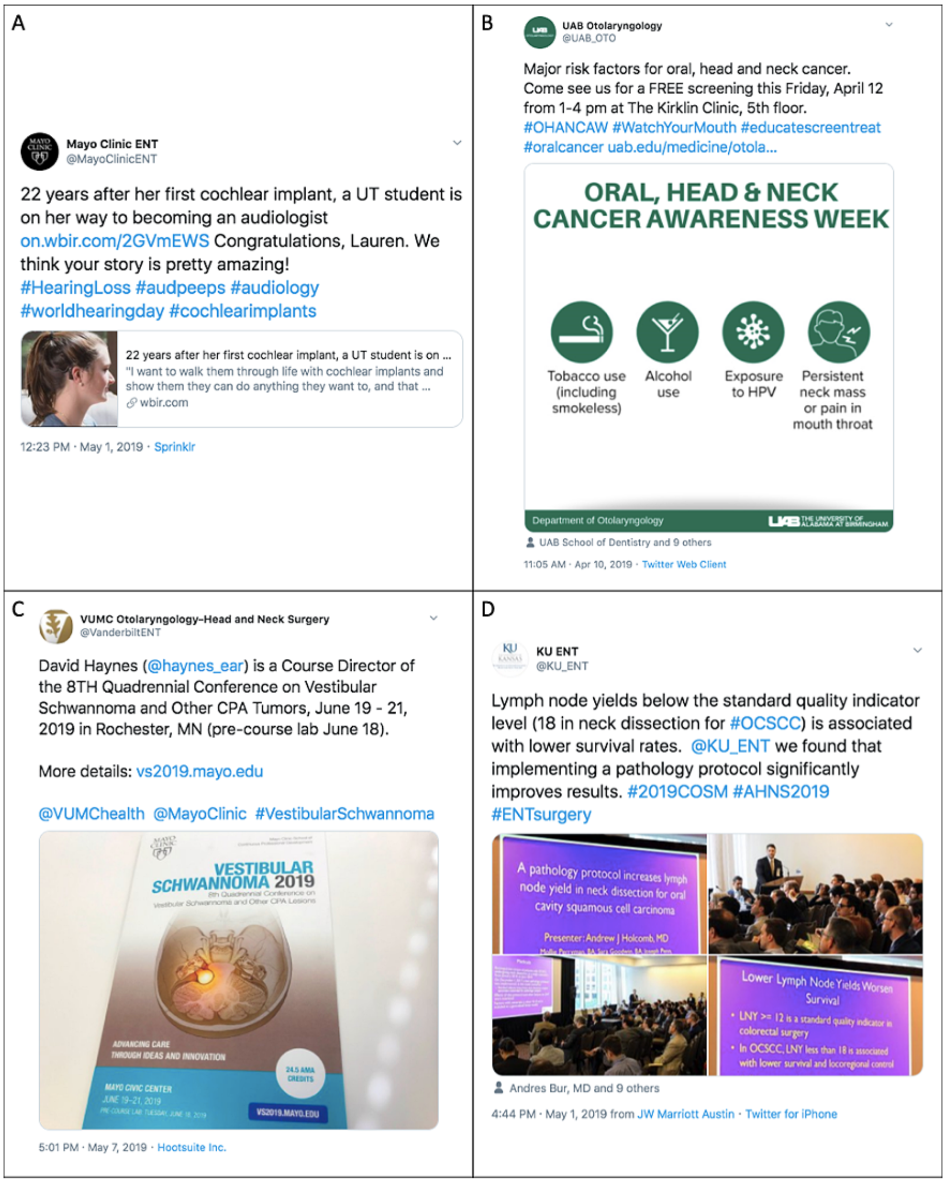
Data for this cross-sectional study were collected in August 2019 from Twitter (Twitter Inc, San Francisco, CA). OHNS residency programs were included if they were accredited by the Accreditation Council for Graduate Medical Education (ACGME). Twitter accounts were identified by searching each program's website for profile links as well as by searching for the name of the program directly on Twitter. Accounts that were division-specific were excluded.

Twitter metrics (number of tweets, number of followers, and accounts being followed by the program) and tweets from the last 6 months were downloaded with Twitonomy (Diginomy Pty Ltd, New South Wales, Australia). A content analysis of all individual tweets from these accounts during the 6-month period from March to August 2019 was also performed. The text of each tweet was categorized for origin of content (original text created by the account versus retweet of another user's content), level of information (directly informative, indirectly informative by providing a link or web address for additional information, or uninformative), and target audience (health care worker versus general public). For example, a tweet promoting a grand rounds session would be categorized as original content, uninformative, and targeting health care workers (Figure 1).

To further characterize the information communicated in the tweets, a sample of 100 tweets was analyzed to identify common themes, which was then applied to categorize additional tweets. This sample of tweets was selected with a random number generator. The total number of likes or retweets each tweet received by health care professionals was also quantified to characterize the population of users interacting with published tweets. Users were categorized as health care professionals if their Twitter profile listed their profession or if they were listed as an employee on an institutional website. These individuals included physicians, nurses, physician assistants, nurse practitioners, speech-language pathologists, and audiologists.

Data analyses and descriptive statistics were performed using R version 3.6.2 software (Vienna, Austria). Difference in social media metrics were determined by the χ^2 test.

Figure 1. Sample tweets demonstrating original content (A) targeted toward patients and contained no medical information (ie, uninformative), (B) targeted toward patients and directly containing medical information, (C) targeted toward medical professionals and uninformative, and (D) targeted toward medical professionals and directly containing medical information.



Results

Of the 121 ACGME-accredited residency programs, 35 (28.9%) had Twitter accounts (Table 1). Twenty-six (74.3%) of these were active during the study period. A total of 2526 tweets were published during the study period. Programs published a median of 69 tweets (IQR 34-157). Over half of the tweets (1330/2526, 52.65%) from the study period were written by four accounts (Vanderbilt University, University of Kansas, University of North Carolina, University of Nebraska). Tweets were retweeted a total of 14,970 times (range 0-2603; median 1, IQR 0-2) and liked 46,988 times (range 0-9014; median 4, IQR 1-8).

Table 1. Twitter metrics of programs that were active during the study period.

Program	Twitter handle	Total number of tweets	Number of accounts following	Number of followers
Baylor College of Medicine	BCM_Oto	560	340	839
Cleveland Clinic	CCF_ent_program	28	12	83
Duke University	Duke_Oto	155	55	150
Columbia University	ColumbiaOto	121	611	287
Georgetown University	georgetownOTO	6	147	55
Henry Ford Hospital	henryfordent	94	116	51
Mayo Clinic (Rochester)	MayoClinicENT	169	312	168
Medical College of Wisconsin	Mcwent	155	65	491
Northwestern University	NM_ENT	273	208	140
Penn State Health	WeAreOto	346	476	910
Southern Illinois University	SIU_ENT	60	58	156
University of California, Davis	UCDAVIS_OTOHNS	211	168	412
University of Alabama	UAB_OTO	287	144	244
University of Arizona	UofAENT	246	246	471
University of Arkansas	UAMSENT	147	9	65
University of Florida	UFOtolaryngolo1	56	28	66
University of Kansas	KU_ENT	1291	805	1060
University of Michigan	UMichOto	1128	186	757
University of Minnesota	ent_umn	88	75	326
University of Missouri	MizzouENT	135	20	147
University of Nebraska	EntUnmc	281	514	160
University of North Carolina	unc_ent	484	595	995
University of Virginia	uvaotohns	1356	23	712
Vanderbilt University	vanderbiltENT	1990	1697	2099
Washington University in St. Louis	WUSTL_ENT	111	125	158
Yale	Yale_ENT	101	221	166

Residency program accounts published 1695/2526 (67.10%) tweets of original content, and the remaining 32.90% (831/2526) of tweets were retweets or republication of another user's content. Original-content tweets were subsequently retweeted by other Twitter users 1362 times (range 0-15; median 0, IQR 0-1) and liked 6372 times (range 0-48; median 2, IQR 1-5). Medical professionals accounted for 1249/1362 (91.70%) of retweets and 5616/6372 (88.14%) of likes on original tweets. The majority of tweets (1283/1695, 75.69%) contained information targeted for health care workers, and included tweets describing recent publications, grand rounds, and new hires. The remaining 24.31% (412/1695) of tweets were targeted toward patients or the general public, and included tweets on recommended cancer screening protocols, patient testimonials, news stories, and cancer awareness months.

The majority of original tweets were uninformative and did not contain any medical information (1130/1695, 66.67%). Only 116 of original tweets (6.84%) directly contained medical information and an additional 449 tweets (26.49%) indirectly provided medical information by including links to external websites with medical information. Tweets targeted toward the general public were more likely to directly contain medical information (16.5% vs 3.7%, P<.001; relative risk [RR] 4.41, 95% CI 3.1-6.28). Conversely, tweets targeted toward physicians were more likely to be uninformative (74.4% vs 42.7%, P<.001; RR 1.74, 95% CI 1.55-1.96).

A random sample of 100 posts were analyzed to identify content themes (Table 2). Given that the largest sample of tweets (n=954) were targeted toward medical professionals and uninformative, these tweets were then coded into the identified themes. Trainees and education were the most common subject of these tweets, followed by participation at conferences and research publications.

Table 2. Content themes identified among tweets targeting medical professionals that were uninformative (n=954).

Tweet content category	Description	Tweets, n (%)	Representative post
Awards and grants	Tweets featuring recipients of grant funding or awards	56 (5.9)	Congratulations to @MichaelPitmanMD and his team for being awarded a $3M #R01 #grant by the @NIH for their research on vocal fold paralysis, "Mechanisms of axon guidance in laryngeal reinnervation following injury of the recurrent laryngeal nerve." Amazing!!! #laryngology #voice [@ColumbiaOto]
Conference attendance or presentation	Tweets sharing poster/oral presentations, panelists, or attendance at academic conferences	263 (27.6)	Dr Kathleen Yaremchuk is in Germany! She's presenting on Sleep Apnea at the 90th annual Germany meeting for Otolaryngologists. #medtwitter #Doctors #WomeninMedicine [@henryfordent]
Grand rounds and lectures	Tweets highlighting topics of grand rounds or lectures	85 (8.9)	Join us tomorrow at 7AM for our ENT Grand Rounds. Taylor Riall, MD will be presenting a talk entitled "Maintaining the Fire: Wellbeing, Resilience & Intentional Culture. Livestream here: https://t.co/6seb90cH82 #uofaent #otolaryngology [@UofAENT]
Networking and promotion	Tweets promoting the connection of individuals or departmental events	89 (9.3)	Lots of awesomeness @KU_ENT Here's a few more who are on Twitter: @Mollie_Perryman @amyjacks13 @jplepse @smchale3 @wichova_md @AndrewJHolcomb @MattyShews @syalamanchaliMD [@KU_ENT]
Research and publications	Tweets sharing research projects and publications	112 (11.7)	Dr Paul Russell has a new paper with two of @VanderbiltU's Mechanical Engineering researchers: "A multi-subject accuracy study on granular jamming for non-invasive attachment of fiducial markers to patients. [@VanderbiltENT]
Training and education	Tweets focusing on medical students, residents, fellows, and educational efforts	349 (36.6)	Resident training lights up our surgical simulation lab #temporalbonelab #ENT #otolaryngology #stateoftheart @ear_wick [@WUSTL_ENT]

Discussion

Principal Findings

In this study, we reviewed and analyzed the usage patterns of academic OHNS residency programs on Twitter. Thirty-five programs had accounts on Twitter at the time of this analysis, which represents more than double the 14 programs that were on Twitter in April 2017 [12]. Interestingly, 4 programs (11% of the programs on Twitter) were responsible for over half of the tweets produced in our 6-month study period. A recent investigation by the Pew Research Center found that the most active 10% of Twitter users produce 80% of all tweets [13]. These data are likely skewed by the number of inactive users or "bot" accounts (automated accounts that post content based on algorithms, as opposed to a human-run account). Although moderately imbalanced, the activity of the OHNS community is more equitable compared with the activity of the entire Twitter population. Approximately 25% of programs with Twitter accounts did not publish any tweets during the study period. It is possible that the individuals responsible for managing these accounts are no longer employed by the institutions, or perhaps the accounts have been neglected since their creation.

The current use of Twitter in the academic OHNS community is focused on intra and interprofessional communication. The content included in these tweets reflects topics of trainees and education, presentations at academic conferences, and research publications. These findings are consistent with previously published studies in other fields of medicine [6,7,14,15]. Medical professionals provided the majority of interactions with tweets by OHNS residency programs, accounting for 97.1% of retweets and 88.1% of likes. Even though approximately one-quarter of the tweets analyzed in this study were targeted toward patients and the general public, the overwhelming majority of interactions with the tweets were provided by health care professionals, suggesting that the general public is not interacting with the content that is curated for them. Additionally, very few of these tweets directly contained medical information that provides patient education. In a 2017 study, 43% of tweets by urology departments were directed at physicians [16], which was lower than the rate observed in this study for the OHNS community. This relationship may vary in each field of medicine, as Kloth et al [17] observed fewer interactions between pain patients and their providers on Twitter compared to oncology patients. These findings confirm that Twitter is not the currently preferred medium of communication for information dissemination to patients. The reason behind these patterns is unknown, although possible factors include patients preferring other online/social media platforms as medical resources, fear of misinformation, or personal privacy concerns. Future studies may focus on understanding patient preferences for the communication of medical information on social media.

Although Twitter does not seem to be a favorable network for patient communication, it efficiently serves as a professional networking medium. Twitter has been used to supplement academic conferences and disseminate information to a broader audience [18-20]. Moreover, maintaining an active social media presence to promote department activity may improve a department's reputation. Both US News and World Report and Doximity ranking systems include program reputation [21,22], and have previously been associated with program social media presence in OHNS and other fields [12,20,23]. In a multi-institutional survey of surgeons, 70% indicated they believe that social media benefits professional development [24]. This may be of particular importance for women and underrepresented minorities in medicine who face unique challenges in their academic careers, as Twitter provides a network of mentors and peers who may otherwise be inaccessible [25,26]. Moreover, these networks may be utilized by residency applicants to garner information about prospective programs, particularly as the COVID-19 pandemic has affected the residency application process [27-29]. Given the lack of away rotations or in-person interviews, students may be spending more time on social media searching for information compared to previous years. In a survey-based study, Oyewumi et al [30] reported that almost 60% of Canadian otolaryngologists utilize social media but most were unsure how to apply these tools to their practice. As our understanding of social media in medicine continues to develop, hospitals and OHNS departments may consider incorporating social media training into their educational curriculum to ensure that their health care providers are optimizing the use of these platforms.

Beyond Twitter, new social media platforms are constantly being developed and popularized, providing new methods to disseminate health information. For example, TikTok is an app that allows users to upload video clips up to 60 seconds long with music, text, and filters. A few physicians have turned to this platform, particularly targeting teenage populations, to provide health education and combat misinformation on topics such as birth control, vaping, and vaccination [31,32]. Additionally, there are patient-specific online networking sites such as PatientsLikeMe, which specifically attract patients with a common condition to connect with other individuals and gather information about their disease, available treatments, and treatment side effects [33,34]. Facebook groups have been shown to be useful platforms for patients with idiopathic subglottic stenosis to share resources, personal experiences, and emotional support [35]. These platforms highlight areas of information need, and may improve communication and information dissemination from health care providers. Social media platforms also hold promise to recruit patients for research endeavors [36].

Limitations

There are a few limitations to this study. Many individual otolaryngologists are active on Twitter; however, these accounts were not included in this analysis, as we focused on the activity of residency programs over individuals. Furthermore, private practice groups and academic institutions without residency programs were not included, and the content of their social media presence was not captured. To facilitate recruitment of medical students during the COVID-19 pandemic, some institutions have created separate, resident-led social media accounts distinct from preexisting departmental accounts, and these two groups have overlapping but separate target audiences. Patients may not be interested in the hobbies and social events of residents, whereas this is essential information for medical students. Conversely, departments may be able to advertise with testimonials or education materials to attract new patients. The data in this study were collected prior to the pandemic and, to our knowledge, no institutions had multiple Twitter accounts at the time of data analysis. However, future studies may consider how these groups utilize different social media platforms to effectively reach their target audience. When coding tweets based on theme, some tweets contained information that included more than one theme. For example, a tweet describing a resident's presentation at a conference describes both a trainee and conference participation. Each tweet was ultimately coded to only one theme based on the primary message conveyed in the tweet, and this must be taken into account when interpreting the data. Finally, given the cross-sectional nature of this analysis, we were not able to assess any temporal changes in social media presence.

Conclusion

Social media is ubiquitous and presents a unique communication medium within the health care industry. The majority of Twitter usage by OHNS residency programs is for intra and interprofessional communication. Only a minority of tweets contain information geared toward the general public, highlighting that communication and information sharing with patients is not the current focus of OHNS residency programs on Twitter.

Conflicts of Interest

None declared.

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Abbreviations

ACGME: Accreditation Council for Graduate Medical Education
OHNS: otolaryngology-head and neck surgery
RR: relative risk

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Original Paper

Augmented Reality in Pediatric Septic Shock Simulation: Randomized Controlled Feasibility Trial

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Abstract

Background: Septic shock is a low-frequency but high-stakes condition in children requiring prompt resuscitation, which makes it an important target for simulation-based education.

Objective: In this study, we aimed to design and implement an augmented reality app (PediSepsisAR) for septic shock simulation, test the feasibility of measuring the timing and volume of fluid administration during septic shock simulation with and without PediSepsisAR, and describe PediSepsisAR as an educational tool. We hypothesized that we could feasibly measure our desired data during the simulation in 90% of the participants in each group. With regard to using PediSepsisAR as an educational tool, we hypothesized that the PediSepsisAR group would report that it enhanced their awareness of simulated patient blood flow and would more rapidly verbalize recognition of abnormal patient status and desired management steps.

Methods: We performed a randomized controlled feasibility trial with a convenience sample of pediatric care providers at a large tertiary care pediatric center. Participants completed a prestudy questionnaire and were randomized to either the PediSepsisAR or control (traditional simulation) arms. We measured the participants' time to administer 20, 40, and 60 cc/kg of intravenous fluids during a septic shock simulation using each modality. In addition, facilitators timed how long participants took to verbalize they had recognized tachycardia, hypotension, or septic shock and desired to initiate the sepsis pathway and administer antibiotics. Participants in the PediSepsisAR arm completed a poststudy questionnaire. We analyzed data using descriptive statistics and a Wilcoxon rank-sum test to compare the median time with event variables between groups.

Results: We enrolled 50 participants (n=25 in each arm). The timing and volume of fluid administration were captured in all the participants in each group. There was no statistically significant difference regarding time to administration of intravenous fluids between the two groups. Similarly, there was no statistically significant difference between the groups regarding time to verbalized recognition of patient status or desired management steps. Most participants in the PediSepsisAR group reported that PediSepsisAR enhanced their awareness of the patient's perfusion.

Conclusions: We developed an augmented reality app for use in pediatric septic shock simulations and demonstrated the feasibility of measuring the volume and timing of fluid administration during simulation using this modality. In addition, our findings suggest that PediSepsisAR may enhance participants' awareness of abnormal perfusion.

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KEYWORDS

augmented reality; simulation; septic shock; children; pediatrics; simulation-based education; application; fluid administration

Introduction

Background

Augmented reality (AR) and virtual reality (VR) have been increasingly explored as tools for innovation in medical education in both medical and surgical subspecialties [1-3]. VR refers most broadly to the digital representation of an immersive world, whether novel or realistic [1,4]. In contrast, AR projects a digital overlay onto the physical environment, emphasizing task performance in the real world that is *augmented* by virtual elements [2]. AR and VR may be experienced through head-mounted displays using mobile devices or computers. In recent years, AR- and VR-based activities have become increasingly easy to scale and distribute widely [4,5].

AR and VR have been used most frequently for surgical training [6-8], anatomical study [9-11], and cardiopulmonary resuscitation (CPR) training [12-14]. To date, there is a relative dearth of studies exploring the incorporation of AR into medical resuscitation scenarios [2,15,16]. Studies evaluating AR enhancement of simulated procedural training indicate that learners respond favorably to its use [17-19]. In a recent medical simulation study, participants recognized shock and clinical decompensation significantly sooner when using AR. These findings suggest the potential of AR to improve clinical care at the bedside [17].

Simulation has been shown to enhance retention of resuscitation skills [20]; pediatric care providers particularly benefit from simulation-based resuscitation exercises, as real-life resuscitation events are rare in children [21,22]. However, even high-fidelity simulations are limited in their capacity to replicate real-life scenarios. These challenges are highlighted in the case of sepsis, a potentially life-threatening response to infection. In children with potential sepsis, clinicians need to make rapid clinical decisions [23], and these decisions are often based on physical examination findings that are difficult to simulate on a mannequin. Time to recognize septic shock and administrate antibiotics and intravenous fluids are all linked to improved outcomes in pediatric patients with septic shock [24]. For this reason, many hospitals have implemented recognition systems and care pathways to ensure rapid, standardized, and high-quality care for children in septic shock; our institution's sepsis pathway is one example. By providing a means of visualizing perfusion during simulation, AR can potentially enhance simulation participants' abilities to make timely and realistic management decisions about patients in septic shock.

Objective

In this study, we aimed to create an AR representation of impaired perfusion (PediSepsisAR) and incorporate this app into a pediatric septic shock simulation. Our primary aim was to determine the feasibility of collecting data on the timing and volume of fluid administrated during septic shock simulation with and without the use of PediSepsisAR. We hypothesized that we would be able to measure the timing and volume of fluid administration in 90% of the participants. A second exploratory aim was to describe PediSepsisAR as an educational tool in septic shock simulation. Specifically, we aimed to compare control and PediSepsisAR participants' timing of stated recognition of shock and desired management steps and elicit participant attitudes toward the experience of using PediSepsisAR during septic shock simulation. We hypothesized that PediSepsisAR participants would sooner state shock recognition and express desired management steps—administering antibiotics and initiating the sepsis pathway. In addition, we hypothesized that participants would report that PediSepsisAR enhanced their awareness of the simulated patient's perfusion; therefore, the use of the app would have made them want to administer fluids more quickly.

Methods

Theoretical Framework

In designing and studying PediSepsisAR, we considered two main underlying principles: real-time feedback and gamification. Studies have demonstrated improved CPR performance in both simulated and real-life resuscitations using CPR feedback devices [25,26]. By adding PediSepsisAR to a traditional septic shock simulation, we hoped to convey a visual representation of poor perfusion that participants could monitor for improvements as they administered fluids. Real-time feedback is closely tied to the gamification of simulation exercises. Specifically, Rutledge et al [27] define gamification as the addition of a design element to an existing learning activity to facilitate achieving the activity's goals. In this manner, PediSepsisAR can be viewed as an element applied to septic shock simulation that provides a dynamic visual representation of the simulated patient's circulation. PediSepsisAR provides ongoing real-time feedback on the participants' progress toward the goal of fluid resuscitating the simulated patient; thus, it facilitates the achievement of the goal and gamifies the simulation.

Study Setting

This study was conducted in the pediatric emergency department of a large tertiary care academic children's hospital from October 10 to November 12, 2020.

Study Participants

We enrolled a convenience sample of 50 participants, including pediatric residents, pediatric emergency medicine (PEM) fellows, PEM attending physicians, nurse practitioners, and pediatric nurses, who regularly practice at the pediatric emergency department in the study hospital. Participants were recruited via a combination of email and in-person communication. Written informed consent was obtained from all participants.

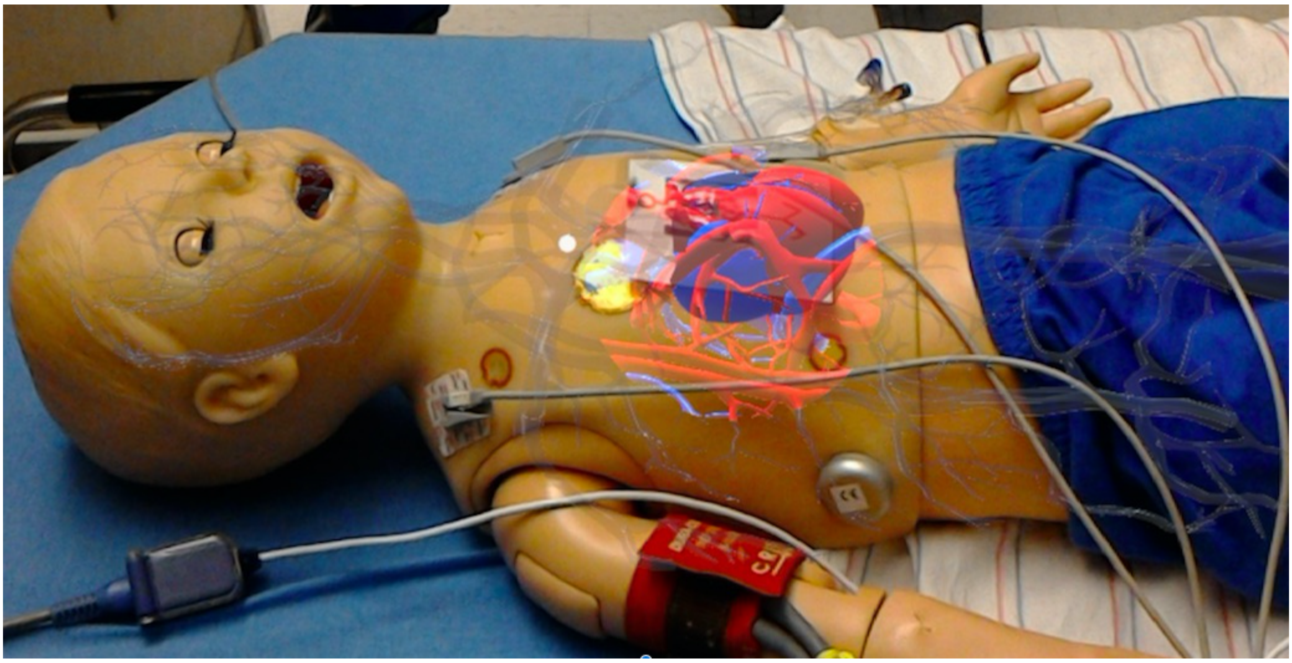
Study Design

This study consisted of a nonblinded, randomized, controlled trial design.

Prototype Design

Through a partnership with BrickSimple, LLC, a Philadelphia-based software company, we adapted an existing prototype, CPReality [28,29], to create PediSepsisAR. CPReality integrates with the first-generation Microsoft HoloLens headset and allows for the depiction of a digital model of the circulatory system that can be overlaid on a simulation mannequin. CPReality integrates data from actual CPR performance on a mannequin to create a digital image of the *patient's* circulation, which allows participants to visualize the effect of their chest compressions on perfusion during CPR. Our aim in adapting this prototype was to enable our participants to visualize a model of impaired perfusion during fluid resuscitation in a simulated patient with septic shock. Initially, the vessels most proximal to the heart are illuminated, demonstrating that peripheral perfusion is limited (Figure 1); after 20, 40, and 60 cc/kg of fluid boluses are administered, perfusion spreads distally until it ultimately reaches the brain and most peripheral tissues. A demonstration of the circulation expansion is shown in Multimedia Appendix 1.

Figure 1. PediSepsisAR overlaid on the simulation mannequin, as visualized through the HoloLens.



We worked with BrickSimple to enable PediSepsisAR to interact with a potentiometer embedded in an intravenous fluid syringe. A potentiometer is a variable resistor that linearly restricts low amounts of electricity that can then be translated into an electrical signal. A linear slide potentiometer was chosen specifically because the sliding effect fits well with the mechanical action of pushing a plunger. Team members fit the potentiometer into a 60-cc syringe and then attached the moving part of the device (Wiper) to the syringe plunger so that it would move in a relative fashion depending on how far the plunger was depressed. The position of the plunger could be measured against time to measure the rate of fluid bolus administration.

Once the potentiometer was developed, it was necessary to ensure its ability to communicate with the HoloLens. This was achieved via a wireless connection. More specifically, the potentiometer is connected via USB to a computer running a custom app called Syringe Relay. The HoloLens app that provides the visuals also spins up a transmission control protocol or IP server. The Syringe Relay then connects to the transmission control protocol or IP server and uses it to send data to the HoloLens. The communication sequence is as follows: the potentiometer sends data to the Syringe Relay via the USB; the Syringe Relay app then processes and forwards the data to the HoloLens via a wireless connection. This sequence is shown in Figure 2.

Figure 2. The sequence of communication between the potentiometer and HoloLens. Note that the potentiometer is embedded within the syringe displayed at the left. TCP: transmission control protocol.

For the flow of communication to work properly, both the HoloLens and computer must be on the same wireless internet network. When launched, the PediSepsisAR app on the HoloLens continually scans for new connections. The Syringe Relay app is then configured with the current IP address of the HoloLens and can thereby connect to it and send data to it.

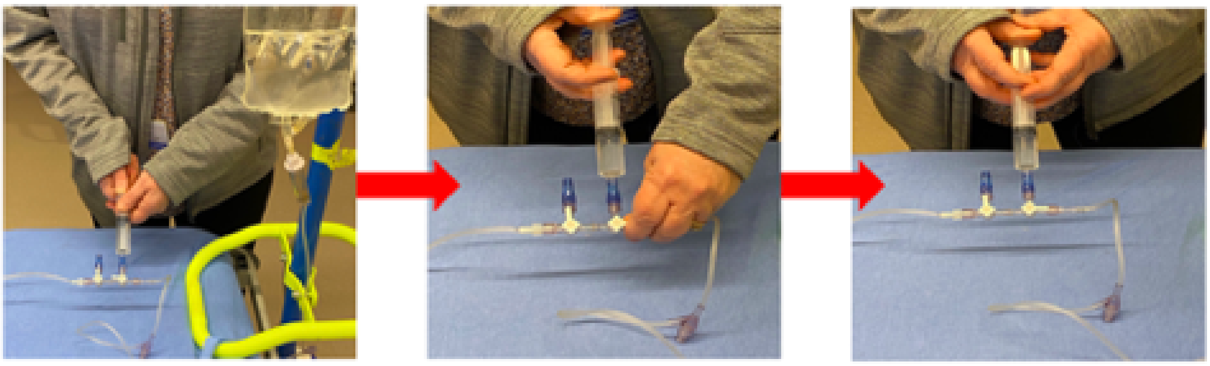
All data processing occurred within the Syringe Relay app. First, the app maps the raw potentiometer values to the current milliliter value on the syringe. When the plunger is depressed, it adds the delta to a running total of how many milliliters are infused. The app then converts the total milliliters infused to total mL/kg and sends that value to the HoloLens. The HoloLens then updates the visual display of the perfusion accordingly.

To our knowledge, this is the first study using a potentiometer to measure real-time intravenous fluid administration during simulation.

Study Procedures

All enrolled participants (n=50) completed an electronic prestudy questionnaire. All questionnaire data were collected and managed using REDCap (Research Electronic Data Capture) tools hosted at our institution [30,31]. The prestudy questionnaire was created de novo in conjunction with a coauthor AKW who has expertise in survey question development and is included as a reference in Multimedia Appendix 2. This questionnaire elicited participants' demographic data and their report of previous experience with push-pull fluid administration, simulated resuscitations in general, and simulated septic shock. After completing the prestudy questionnaire, each participant opened an envelope containing a number; those participants whose envelope contained even numbers were randomized to the PediSepsisAR group, and those whose envelopes contained odd numbers were randomized to the control group. All participants had the opportunity to practice administering fluids using the push-pull technique (Figure 3) before the simulation exercise. Those randomized to PediSepsisAR then received a short orientation on the HoloLens, which reviewed the proper fit of the HoloLens and provided an example of the visual representation of circulation they would see through the HoloLens.

Figure 3. Push-pull technique for fluid administration. Fluid is manually pulled from the bag reservoir and then pushed into the patient.



During the consent procedure, participants were informed that the investigators would evaluate their administration of fluids to a simulated patient with septic shock. They were invited to verbalize their assessment of the patient and the management steps they might take in addition to intravenous fluid administration. Before beginning the exercise, all participants received a standardized, short description of the clinical scenario: a previously healthy male aged 15 months presenting with 2 days of fever and 1 day of decreased oral intake and decreased responsiveness. Facilitators gave no further prompts during the simulation. Those randomized to the PediSepsisAR group wore the HoloLens during the simulation; those randomized to the control group completed the simulation without the use of AR. We used the Pediatric HAL (Gaumard) mannequin for all simulations. We measured all participants' fluid administration using the potentiometer embedded in the 60-cc syringe used to push-pull fluids and recorded the time to administer 20, 40, and 60 cc/kg total administered fluids for the patient's stated weight. Participants were not directed to administer a specific amount of fluids, and those who chose to stop administering fluids at any point in the simulation were allowed to do so. In addition, the facilitator marked the time that the participant verbalized the following elements of sepsis recognition and treatment: tachycardia or hypotension, sepsis, shock, septic shock, initiation of the sepsis pathway, and intent to administer antibiotics.

Following the simulation exercise, those in the PediSepsisAR group completed an electronic poststudy questionnaire through REDCap asking their opinions about how PediSepsisAR did or did not affect their simulation experience. The poststudy questionnaire was created de novo. Participants had the opportunity to elaborate in a free-text form regarding their answers to the survey questions. The poststudy questionnaire is included in Multimedia Appendix 3. All participants received a US $5 coffee shop gift card following their participation.

This study was approved by the institutional review board of the Children's Hospital of Philadelphia. We used Stata 16.0 (StataCorp) for statistical analysis. We assessed the study population using descriptive statistics and compared the median time with the administration of 20, 40, and 60 cc/kg of fluids between each group using the Wilcoxon rank-sum test.

Feasibility Endpoints

We defined the following endpoints a priori as reaching our feasibility goal: (1) We hypothesized that we could feasibly create PediSepsisAR and enable it to interact with a fluid administration system and (2) we hypothesized that we could measure the timing and volume of fluid administration using the potentiometer in at least 90% of the participants. In addition, we hypothesized that for the PediSepsisAR participants, the potentiometer and AR interactivity would function as intended at least 90% of the time.

Results

Overview

We enrolled a total of 50 interprofessional participants, including 6 nurses, 11 nurse practitioners, and 33 physicians at different levels of training: 10 pediatric residents, 13 PEM attendings, and 10 PEM fellows. In total, 25 participants were randomized to the control group, and 25 participants were randomized to the PediSepsisAR group; all disciplines were represented in both the PediSepsisAR and control groups. The demographic characteristics of the study population are shown in Table 1. In the presimulation questionnaire, most participants reported that they had given push-pull intravenous fluids before (21/25, 84% in both groups). Similarly, most participants reported previous experience with septic shock simulation (23/25, 92% in the PediSepsisAR group and 19/25, 76% in the control group). A small minority of participants in either group had previous experience with AR (0/25, 0% in the PediSepsisAR group and 2/25, 8% in the control group).

Table 1. Demographic data for study participants (N=50).

Participants enrolled	PediSepsisAR (n=25), n (%)	Control (n=25), n (%)
Study population		
Nurse	4 (16)	2 (8)
Advanced practice provider	5 (20)	6 (24)
Fellow	6 (24)	5 (20)
Resident	5 (20)	6 (24)
Attending	5 (20)	6 (24)
Clinical experience (years)		
1-5	6 (24)	3 (12)
6-10	8 (32)	8 (32)
>10	11 (44)	14 (56)
Ever administered push-pull IVF[a]		
Yes	21 (84)	21 (84)
No	4 (16)	4 (16)
Times administered push-pull IVF in the past year		
None	12 (48)	10 (40)
1-5	13 (52)	13 (52)
>5	0 (0)	2 (8)
Previous simulation experience		
Yes	23 (92)	25 (100)
No	2 (8)	0 (0)
Septic shock simulation experience		
Yes	23 (92)	19 (76)
No	2 (8)	6 (24)
Augmented reality experience		
Yes	0 (0)	2 (8)
No	25 (100)	23 (92)

[a]IVF: intravenous fluid.

Fluid Administration and Verbalization

We measured and recorded the timing of completed administration of 20, 40, and 60 cc/kg of fluids in all participants. In total, 16% (4/25) participants in the PediSepsisAR group experienced the inability to visualize PediSepsisAR initially through the HoloLens; in each instance, the study staff closed and reopened PediSepsisAR on the device, and participants were able to visualize PediSepsisAR after that. All 4 participants subsequently completed the simulation exercise uninterrupted. Participants in the PediSepsisAR group were slightly more likely than those in the traditional group to administer 60 cc/kg of fluid (relative risk 1.2, 95% CI 1.03-1.41). For participants who elected not to give the third bolus, the 60 cc/kg time point was not included. The median time to administration of 20 cc/kg was 117 seconds (IQR 93-154) for the PediSepsisAR group and 134 seconds (IQR 98-161) for the control group (*P*=.68). For 40 cc/kg, the median time to administration was 265 seconds (IQR 229-363) for the PediSepsisAR group and 284 seconds (IQR 250-350) for the control group (*P*=.51). Finally, the median time to administration of 60 cc/kg was 419 seconds (IQR 377-536) for the PediSepsisAR group and 468 seconds (IQR 392-524) for the control group (*P*=.47). These data are presented in Table 2.

Table 2. Time to fluid bolus in seconds displayed as median (IQR), PediSepsisAR versus control groups.

Fluid bolus	PediSepsisAR (n=25)		Control (n=25)		*P* value
	Time (seconds), median (IQR)	Participants, n (%)	Time (seconds), median (IQR)	Participants, n (%)	
20 cc/kg	117 (93-154)	25 (100)	134 (98-161)	25 (100)	.68
40 cc/kg	265 (229-363)	25 (100)	284 (250-350)	25 (100)	.51
60 cc/kg	419 (377-536)	25 (100)	468 (392-524)	21 (84)	.47

In addition to recording the volume and timing of fluid administration, we recorded the points at which participants verbalized recognizing the patient's condition and expressed the desire to take certain management steps; 92% (23/25) of participants in the PediSepsisAR group and 100% (25/25) of those in the control group verbalized recognizing tachycardia or hypotension. The median time to verbalized recognition was 26 seconds (IQR 6-43) for the PediSepsisAR group and 39 seconds (IQR 10-95) for the control group (*P*=.20). Regarding the desire to initiate the sepsis pathway, 32% (16/50) of participants verbalized that they would like to start the pathway; this included 20% (5/25) of participants in the PediSepsisAR group and 44% (11/25) of participants in the control group. The median time to verbalize the desire to initiate the sepsis pathway was 96 seconds (IQR 90-133) for the PediSepsisAR group and 136 seconds (IQR 40.5-421) for the control group (*P*=.67). The data for *stated shock*, *septic shock*, or *sepsis* are as follows: 56% (14/25) of participants in the PediSepsisAR group verbalized one or more of these terms versus 68% (17/25) in the control group. The median time to verbalized recognition of *shock*, *septic shock*, or *sepsis* was 66 seconds (IQR 34-94) for the PediSepsisAR group and 87 seconds (IQR 23.5-192) for the control group (*P*=.84). In both, the PediSepsisAR and control groups, 84% (21/25) of participants requested antibiotics. Of those who requested antibiotics, the median time to request was 81 seconds (IQR 53-167) for the PediSepsisAR group and 165 seconds (IQR 28-198) for the control group (*P*=.96). These data are presented in Table 3.

Table 3. Time to verbalize specific patient status items and management steps in seconds displayed as median (IQR), PediSepsisAR group versus control group.

Verbalization	PediSepsisAR (n=25)		Control (n=25)		*P* value
	Time (seconds) taken to verbalize, median (IQR)	Participants who verbalized, n (%)	Time (seconds) taken to verbalize, median (IQR)	Participants who verbalized, n (%)	
Tachycardia ± hypotension	26 (6-143)	23 (92)	39 (10-95)	25 (100)	.20
Sepsis pathway	96 (90-133)	5 (20)	136 (40.5-421)	11 (44)	.67
Shock, septic shock, or sepsis	66 (34-94)	14 (66)	87 (23.5-192)	17 (68)	.84
Antibiotics	81 (53-167)	21 (84)	165 (28-198)	21 (84)	.96

In the poststudy questionnaire, most participants in the PediSepsisAR group (23/25, 92%) reported that the addition of AR enhanced their awareness of the patient's blood flow. When asked whether PediSepsisAR made them want to push fluids faster, 56% (14/25) of the PediSepsisAR participants answered that it did. Many participants remarked that PediSepsisAR was distracting (8/25, 32%). In free-text comments, some participants reported that the digital visualization of circulation allowed them to appreciate the patient's fluid responsiveness in a new way. Some participants commented on the limited field of vision through HoloLens.

Discussion

Principal Findings

In this study, we aimed to design an AR app that could be integrated into a pediatric septic shock simulation and demonstrate the feasibility of its use. Our results demonstrate that it is feasible to record the timing and volume of fluid administration during septic shock simulation both with and without the addition of AR. We hypothesized that we would be able to capture such data in at least 90% of participants in each group and ultimately captured the desired data in all participants.

Our study was not powered to detect significant differences in times of fluid administration between the control and PediSepsisAR groups. We observed that the PediSepsisAR group had a shorter time to fluid bolus administration than the control group. More than half of the participants in the PediSepsisAR group reported that PediSepsisAR made them want to push fluids faster, suggesting that perhaps the components of simulation (provided history, vital signs, and reported delayed capillary refill) alone may encourage rapid fluid administration even without an AR component. Of note, participants in the control group were slightly less likely to administer 60 cc/kg than participants in the PediSepsisAR group. The underlying reason for this observation remains unclear. The changes in simulated patient vital signs with each fluid bolus (20, 40, and 60 cc/kg) were the same for both groups; PediSepsisAR participants showed incompletely improved circulation at 40 cc/kg, whereas the control group participants did not. This suggests that perhaps the additional visualization of perfusion provided through PediSepsisAR informed participants' awareness of the patient's status in a way that vital signs alone could not. The question of whether visualizing a digital model of perfusion has an impact on the administration of intravenous fluids during simulation remains and can be explored in future studies.

Our secondary exploratory aim was to describe PediSepsisAR as an educational tool. We explored the educational value of PediSepsisAR in two ways: through comparison of verbalized recognition of patient status and desired management steps in both groups during the simulation exercise and poststudy questionnaires completed by the PediSepsisAR group. We did not find any significant differences in median times to verbalizations of key patient status recognition or management steps, as our study was not powered to detect such a difference. We observed that the time to verbalization of both patient status (abnormal vital signs and shock or septic shock) and requested sepsis pathway initiation and antibiotics were shorter in the PediSepsisAR group than in the control group. This finding suggests that PediSepsisAR may aid the recognition of abnormal fluid status and, in doing so, allow participants to plan management steps more efficiently. Future studies are needed to explore whether the addition of AR impacts the assessment or delivery of care to simulated patients.

The poststudy questionnaire results revealed that most participants perceived that PediSepsisAR enhanced their awareness of the simulated patient's perfusion. Traditional high-fidelity simulation enables participants to palpate pulses and visualize capillary refill [32], allowing them to assess the simulated patient's perfusion. Nevertheless, capillary refill serves as a surrogate marker of perfusion in both simulated and human patients and interprovider assessment of capillary refill lacks reliability [33]. The novel representation of perfusion provided through PediSepsisAR provides visual information of the simulated patient's condition that participants would otherwise not receive. We connect this to our observation that PediSepsisAR participants had overall shorter times to fluid bolus administration, suggesting that AR representation of simulated patient perfusion may have affected the speed of fluid administration.

A key balancing metric from our poststudy questionnaire is that more than 32% (8/25) of the participants in the PediSepsisAR group found the app distracting. Some participants reported in free-text comments that they had difficulty toggling between viewing digital media through the HoloLens and the physical monitor displaying vital signs, which was positioned beside the mannequin. Most of our participants had engaged in simulated septic shock scenarios before but had no previous experience with AR. It is possible that their lack of familiarity with the experience of visualizing digital media in the physical world contributed to their assessment of PediSepsisAR as distracting. Yet, it is important to consider not only the potential benefits but also the disadvantages of incorporating additional technology into an already effective educational practice such as high-fidelity simulation. It is also possible that certain learners would benefit more from AR-based educational strategies than others, which could be explored in future studies.

Limitations

This study has several important limitations. First, we address the limitations of assessing the feasibility of collecting data on the timing and volume of fluid administration with and without PediSepsisAR. Our fluid measurement system, though novel, also has limitations. In this feasibility study, we measured the timing and volume of fluid administration using a potentiometer embedded in a syringe. Because these measurements are based on the movement of the potentiometer and not on the actual volume of fluid administered, the air within the syringe could affect the measurements. It is possible that the fluid administration times for some participants were falsely shortened as a result.

Regarding generalizability, the cost of AR app development and head-mounted displays such as the HoloLens may hinder replicating the design of an AR model of circulation and its integration into a simulation. The potentiometer that we used to measure the timing and volume of fluid administration required engineering expertise. In addition, learning how to use and troubleshoot PediSepsisAR required time investment and technological support from our colleagues at BrickSimple. Therefore, lack of protected time for educational innovation, staffing constraints, and lack of funding for adequate support can all be potential roadblocks to replicate our study in other environments.

Second, we address the limitations of evaluating PediSepsisAR as an educational tool. The limited field of view provided by the first-generation HoloLens used in this study could have negatively affected participants' experiences during the simulation. In particular, suspension of disbelief becomes more challenging as participants experience technology glitches during simulated exercise. Future studies displaying AR app through the HoloLens may benefit from using the second-generation HoloLens or the HP Mixed Reality headset, which have larger fields of view.

PediSepsisAR provides a simple representation of the complex pathophysiology of septic shock. With our available funding, we could integrate the CPReality prototype with the fluid administration system, but we were unable to make the perfusion model more realistic. There are many potential opportunities to make PediSepsisAR a more accurate representation of septic shock. These include, but are not limited to, adding a digital model of impaired capillary refill or skin findings such as mottling or petechiae. A more nuanced model could be configured to reflect improved or worsened perfusion depending on the type of shock (septic vs cardiogenic) and the participants' chosen interventions. Specifically, an AR model of cardiogenic shock could depict impaired distal perfusion with a weakly pumping heart that pumps blood less effectively after the administration of fluids. Visualizing interactive AR models of both cardiogenic and septic shock alongside one another may allow participants to better recognize their differences and distinguish between the two during a simulated case of undifferentiated shock. Future studies should investigate AR models of septic and cardiogenic shock as educational tools to enhance simulation-based recognition of these pathologic states.

Conclusions

In conclusion, this randomized study demonstrated that it is feasible to measure the time to fluid bolus administration during pediatric septic shock simulation. Preliminary findings from our exploratory aims suggest that incorporating PediSepsisAR into septic shock simulation may enhance participants' awareness of the simulated patient's perfusion. Future studies can explore whether the addition of AR affects participant performance, including fluid administration, in septic shock simulation.

Acknowledgments

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Conflicts of Interest

BrickSimple, LLC, which employs JMB and AP, received compensation from the project funding described above for creating the augmented reality app described in this manuscript. ML has licensed intellectual property for virtual reality cardiopulmonary resuscitation applications. TPC has grant funding for research and development from Oculus/Facebook and is a medical advisor to A.i.Solv/i3 Simulations, which is not affiliated with this product or company in this manuscript.

Multimedia Appendix 1
Video 1 demonstrates the incremental expansion of digital circulation as participants administer fluid boluses during the simulation. The first expansion occurred after the administration of 20 cc/kg, the second at 40 cc/kg, and the final expansion at 60 cc/kg.
[MOV File , 2096 KB - mededu_v7i4e29899_app1.mov]

Multimedia Appendix 2
Prestudy questionnaire administered to all participants.
[DOCX File , 15 KB - mededu_v7i4e29899_app2.docx]

Multimedia Appendix 3
Poststudy questionnaire administered to participants in the PediSepsisAR group.
[DOCX File , 14 KB - mededu_v7i4e29899_app3.docx]

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Abbreviations

AR: augmented reality
CPR: cardiopulmonary resuscitation
PEM: pediatric emergency medicine
REDCap: Research Electronic Data Capture
VR: virtual reality

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Viewpoint

Adjusting to the Reign of Webinars: Viewpoint

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Abstract

Background: With the integration of COVID-19 into our lives, the way events are organized has changed. The Cerrahpaşa Neuroscience Days held on May 8-9, 2021, was one of the conferences that was affected. The annual conference of the student-based Cerrahpaşa Neuroscience Society transitioned to the internet for the first time and had the premise of going international.

Objective: With this study, we aim to both discuss how a virtual conference is organized and perceived, and where our conference stands within the literature as a completely student-organized event.

Methods: The conference was planned in accordance with virtual standards and promoted to primarily medical schools. During the execution, there were no major issues. The feedback was collected via a form developed with Google Forms.

Results: Out of 2195 registrations, 299 qualified to receive a certificate. The feedback forms revealed a general satisfaction; the overall quality of the event was rated an average of 4.6 out of 5, and the ratings of various Likert scale–based questions were statistically analyzed. Open-ended questions provided improvement suggestions for future events.

Conclusions: The virtual Cerrahpaşa Neuroscience Days was a success in organization and received positive feedback from the participants. We aim to ground future events on this experience.

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KEYWORDS

virtual conference; student-based organization; neuroscience conference; COVID-19; medical education; webinars; web-based education

Introduction

The integration of COVID-19 into our lives brought along significant changes in the way events are organized. Even though the format of web-based conferences has always been an option, there has never been a time when it was the only one. Therefore, not many were focused on how to optimize virtual conferences. As of August 2021, however, there are plenty of articles based on the experiences of converting a face-to-face conference to a web-based conference [1-4], as well as reviews [5-7] with suggestions to improve the virtual experience. Cerrahpaşa Neuroscience Days was faced with similar challenges to the conferences discussed in the literature with one major difference: it was a student-organized conference.

Cerrahpaşa Neuroscience Society is a student-based organization that was founded in 2018 within Istanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, and has held several seminars with distinguished professors. Cerrahpaşa Neuroscience Days is the annual conference of the society where several speakers are invited for lectures and social activities are organized for the participants, who are mostly medical students. The first Cerrahpaşa Neuroscience Days was organized in 2019 and it was quite successful in terms of organization and feedback. The conference had a completely national identity with both its speakers and participants. In 2020, the second conference was planned to be executed on April 4-5. On March 11, the novel coronavirus outbreak was declared a global pandemic, and on the next day, the second Cerrahpaşa

Neuroscience Days was cancelled with an announcement made over social media platforms. With the uncertainty of the pandemic, the conference had not transitioned to the internet at that time. After 1 year, the conference could still not be held face to face. Therefore, Cerrahpaşa Neuroscience Days was decided to be held on the internet. The society decided to benefit from this change; thus, the 2021 conference had an entirely different premise: going international.

Our conference analysis, as described above, differs from the majority of literature in that it is completely student-organized. There are, however, examples of student-run organizations in the literature [8].

With the acceleration of innovation and renewal in scientific knowledge, undergraduate students want to get involved in academia as early as possible, so as not to lose track of modern science. Not many organizations are easily accessible, especially to undergraduates. Therefore, they organize their own events where they can meet experts on their fields of interest and possibly obtain insight into how to shape their future. Nevertheless, few studies have focused on the process of organizing a conference for students, by students. In this paper, we cover both the student aspect of organizing a conference and how the virtual experience differs from its face-to-face counterpart by reviewing the literature.

Planning

The critical aspect of the conference was choosing and inviting professors who would present topics that are intriguing for students. In addition, the topics and institutions needed to be diverse. With this in mind, the society's organization team contacted several professors via email, some of whom the students had not personally known prior to planning and some of whom had personal connections with the students; out of the 6 professors who agreed to participate in the conference, 5 were the latter.

Even though the logistic requirements were much less for a web-based conference than for face-to-face conferences, our conference required financial support. To meet expenses such as conference website hosting and domains and the premium Zoom membership fee, we applied for sponsorships. Several companies were emailed with a digital booklet containing information on the society, the events, and possible sponsorship types. In the end, the event had 1 sponsor.

The event was announced through social media platforms, such as Instagram, Twitter, Facebook, LinkedIn, and WhatsApp. Those registered to our organization's newsletter also received an email announcing the conference. Medical students were the target audience; thus, contact with medical faculties was prioritized. Our team looked into social media platforms such as Facebook to find foreign organizations to contact. A list of all Turkish medical schools was used to contact the scientific societies of these institutions. The contacted medical schools were asked to announce the event in their local chat groups and on their social media platforms. In addition to this, we used our personal connections to facilitate the promotion of our conference. We began to promote our conference within our own faculty on April 1, 2021, and ended registration on May 7, 2021, with a total of 2195 registrations for passive participation from several countries.

To register participants, an entirely English website of the Cerrahpaşa Neuroscience Society was built as the conference was international. The participants who wanted to register as listeners were instructed to register for the "passive participation" section. The website also included the program arranged for 3 different time zones and information about the speakers.

To ensure participation for certificates, an attendance form was prepared using Google Forms. This form would be sent during each of the lectures with different links. To obtain a certificate, a participant would be required to fill out at least 4 of the 6 forms. Including verification codes for the forms and sending the aforementioned links at randomly chosen points during the lectures increased the reliability of participation from those who filled out the forms.

We wanted this event to present an opportunity to students who are involved in research and want to gain experience in academic presentations. Therefore, we opened registrations for an oral presentation contest and a poster presentation contest. These registrations were named as "active participation." Participants with a completed research study were asked to send abstracts of their studies to be evaluated by our scientific jury. The jury consisted of 4th- and 5th-year medical students, who were also board members of the society. Out of 20 abstract submissions for oral presentations, 8 were chosen to participate in the contest. Along with these submissions, 9 submissions were made for poster presentations, of which 6 were chosen. Both oral and poster presentations were judged on the basis of the criteria of the jury: meeting the application standards and relevancy to the conference content. The oral presentations were set to take place during the meeting while the posters were presented in a web-based exhibition on MedAll with prerecorded voice overs.

For participants who did not participate in the presentation contests, we still wanted to provide a platform to challenge their medical knowledge. Thus, we decided to hold a case contest where those who sign up would be assigned medical cases in the form of free-text questions. This contest was prepared using the platform HyperSay. The top 3 contestants would win the prizes announced on the website. We made this contest exclusive to medical students and decided on a participation fee of 5 Euros (US $5.79).

Execution

On Saturday May 8, 2021, at 11 AM, the Zoom meeting was started by the president of Cerrahpaşa Neuroscience Society (MK) and the conference's main moderator (ZO). The livestreams over YouTube and Twitch platforms started simultaneously, which caused the first technical issue of the conference as the streams were set to start later. The announced schedule had indicated 11:30 AM as the starting time; however, the mail sent to the participants stated that the Zoom meeting would be started at 11 AM, for the attendees who would like to use the Zoom platform. However, the Zoom membership only allowed 100 people for the meeting, and the waiting room was already full as our speaker was ready to enter. This resulted in the removal of many participants from the waiting room, and they were directed to the livestreams. At 11:50 AM, our team, our speaker, and the participants were ready to start as the livestream and the meeting problems were solved. Following opening speeches and brief remarks about attendance forms, the lectures were started.

During the first oral presentation session, minor technical difficulties were faced owing to a contestant not being familiar with the platform. However, this did not interfere with the flow of the program. No contestant used the given time slot completely; hence, an additional break was provided. The program then continued as planned.

On May 9, 2021, there was an update from the final speaker of the day: his session was to be interactive; therefore, our team needed to share a medical case with the participants and collect the answers to the related questions. For this purpose, a section on the organization website was designed with the aforementioned case and 3 related questions, and the answers were organized on a Google Sheets document. The moderator announced the questionnaire before the program for the day began. No other changes were made to the program and with the announcement of the contest winners, the 2021 Cerrahpaşa Neuroscience Days was over.

Participants and Attendance

A total of 2195 people registered for the conference, 477 filled out at least 1 attendance form and were therefore considered participants, and 44 had not registered. The registered participants were from 115 different institutions in 27 different countries, with 18 people having registered as “independent,” not having provided the aforementioned information (Figure 1). The number of national and international registered participants was 365 and 50, respectively (Figure 2). Of the 477 participants, 373 filled out at least 4 out of 6 attendance forms and therefore received a feedback form link. In total, 299 of 373 filled out the feedback form and qualified for a certificate (Figure 3).

Figure 1. Participants' institutions.

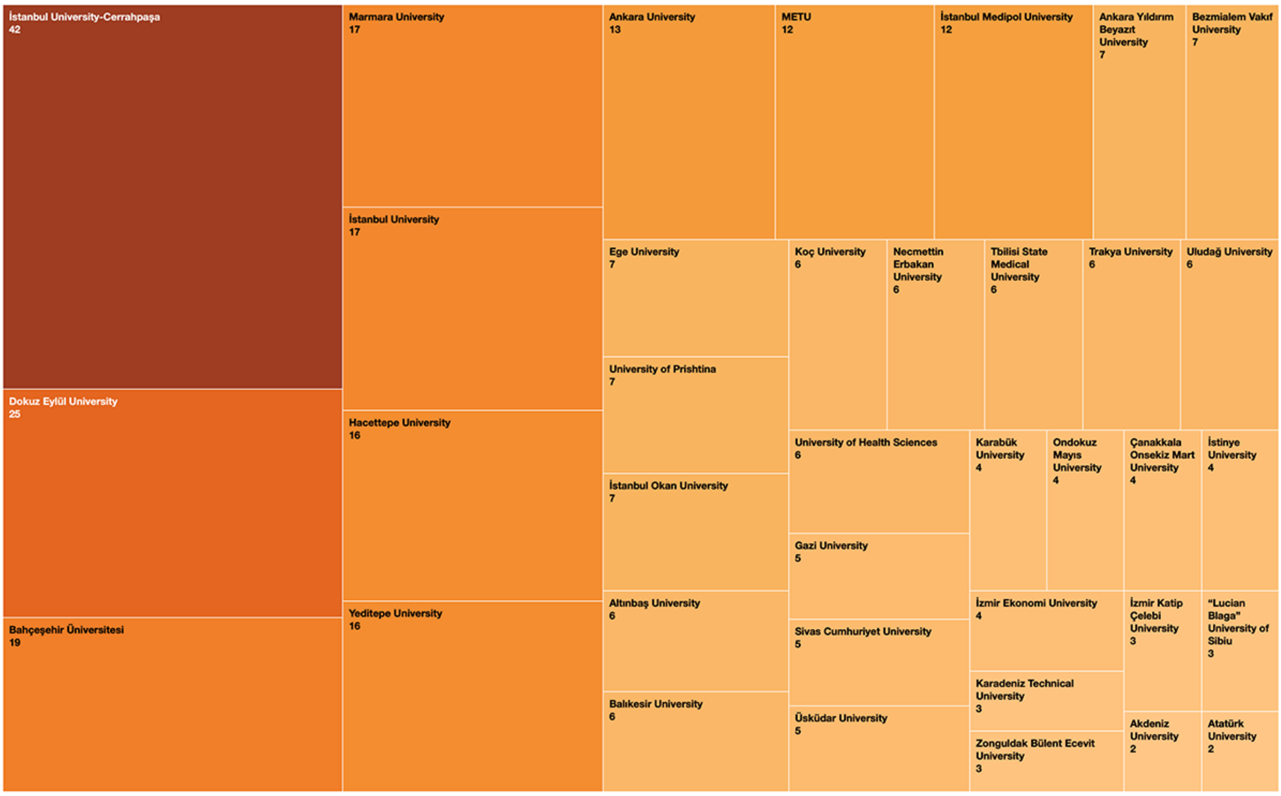


Figure 2. Participants' countries.

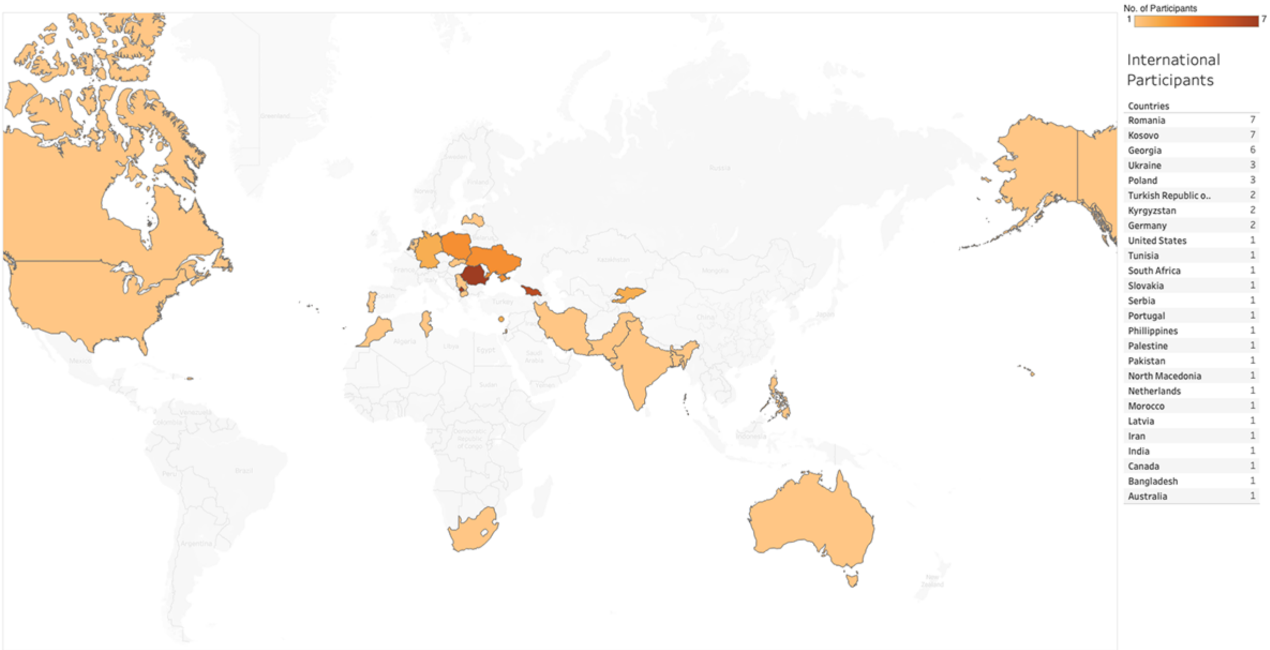
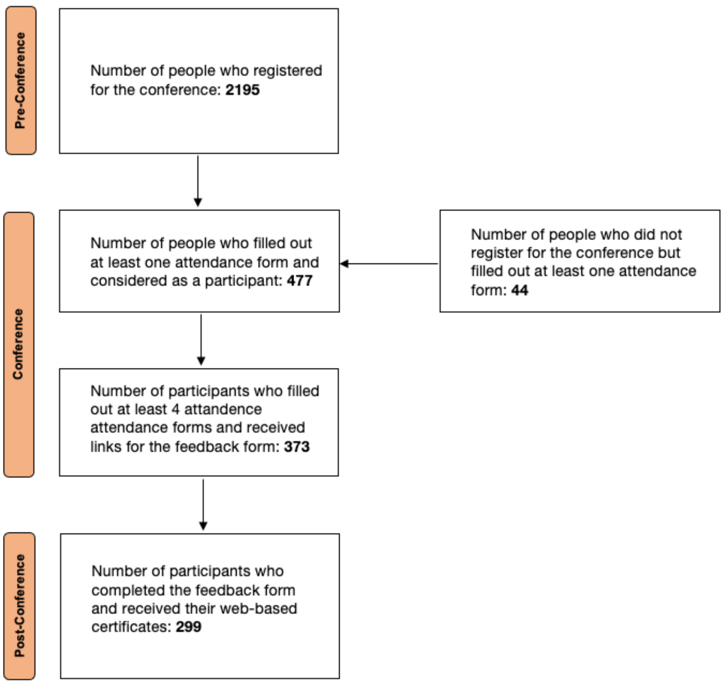


Figure 3. Registration and participation to the conference.



The views from the start to the end of the conference, for 2 days, were analyzed. The peak view number was 460, reached during the first lecture. The second day of the conference had a peak view number of 340. The lowest view number on May 8 was 108 and 117 on May 9, both seen during break times (Figures 4 and 5).

Figure 4. View counts on May 8 2021, Saturday.

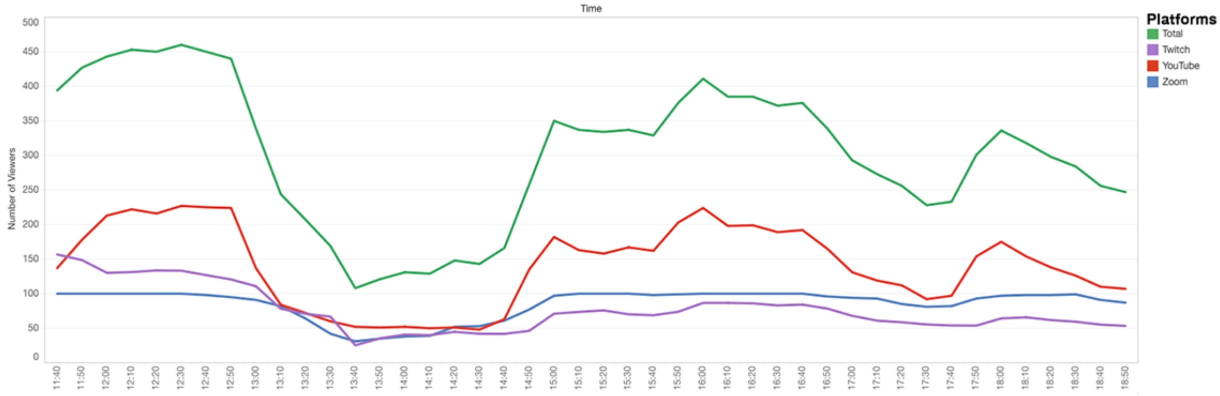
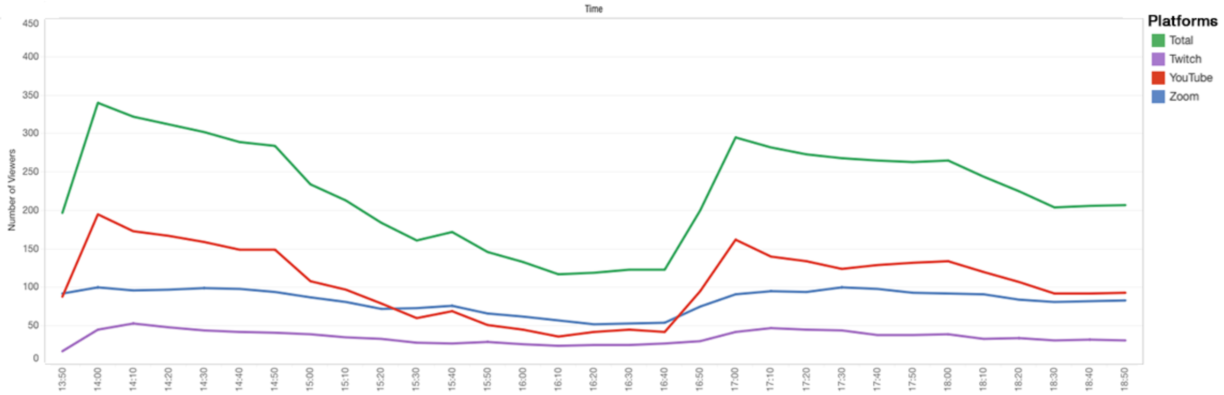


Figure 5. View counts on May 9 2021, Sunday.



Feedback

A feedback questionnaire was prepared, and the e-portfolio platform MedAll was used to collect and categorize feedback. The questionnaire consisted of a total of 19 questions. In total, 14 of these questions were general evaluations regarding the event, based on a 5-point Likert scale with 1="poor" and 5="outstanding." Through 3 open-ended questions, the participants were asked to list the strengths and weaknesses of the event, along with providing suggestions for future organizations. One question was designed to determine how the participants had learned about the event, and one question was regarding obtaining the medical or nonmedical background of the participants. To obtain a certificate, the participants who had filled at least 4 out of 6 participation forms were sent the feedback form and asked to fill it out. Names of the participants were not asked on the form. The responses of the participants were categorized to obtain an overview of how the event was perceived.

In total, 373 participants matched the criteria to fill out the feedback form. Out of these participants, 299 participants filled out the questionnaire and received their certificates on the internet. Lectures of the speakers were evaluated separately. Owing to all of the professors being renowned in their areas of expertise and because a student-based assessment is not adequate to reflect the proficiency of the speakers, we have decided not to disclose the individual feedback ratings of the lecturers in this paper. The contests were evaluated separately as well as overall aspects of the conference, such as the educational content and the selection of topics. These rating averages along with the scoring distribution are visualized in Figure 6.

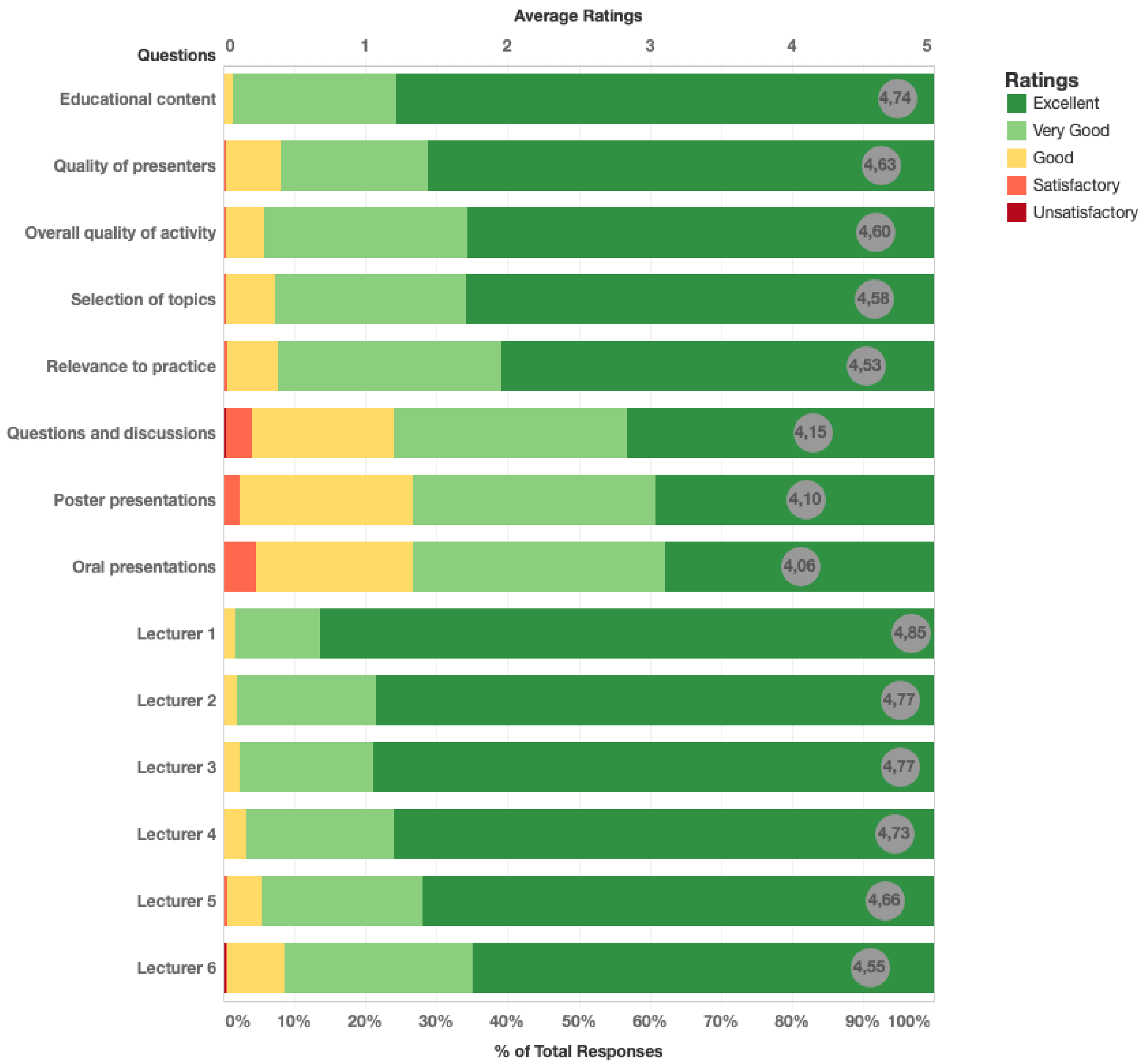
Through open-ended questions, the organizers learned about the perceived strengths and weaknesses of the event, along with receiving suggestions on how to improve the conference in the future. Speaker choices were appreciated while the short duration of the question and answer sessions was pointed out as a weakness. For improvement, it was mostly asked that oral presentation sessions have a different approach.

In total, 143 participants had learned about the conference through social media. Twenty participants learned about the event over their email subscription, and 136 participants learned about the conference from their "friends/colleagues."

Of the 299 participants, 221 had a medical education background, whereas 78 were considered as having a nonmedical background.

Statistical analysis was performed with SPSS Statistics (version 28). Cronbach α and corrected item-total correlations (CITCs) were used to assess the internal consistency of the scales in terms of reliability. Cronbach α was calculated and reached 0.883 (target value>0.7). CITCs ranged from 0.402 to 0.688 (target value>0.3).

Figure 6. Results of feedback forms.



Discussion

Cerrahpaşa Neuroscience Days reached several students from many countries in many continents owing to various factors. With the internet-based format, any logistic issues were prevented, and students who would not be able to join a face-to-face conference could attend the event. We wanted as many students as possible to benefit from the lecturers of our conference; therefore, our conference was open-access. Moreover, with almost no financial requirements, we also decided to not set a registration fee. These served as encouraging factors for students who are eager to learn.

Despite the conference receiving over 2100 passive participation registrations, only 299 (~13%) participants complied with the certification criteria. The number of people who filled at least 1 participation form and were therefore considered participants was 477, with 44 not having registered previously. The numbers indicate crucial lessons about both a virtual format and the organization. The number of virtual events—in other words, easily accessible conferences—has skyrocketed during the pandemic. Even though this accessibility was and is still quite exciting, especially for students, it has also been overwhelming. It is quite easy to decide not to join the event as it is just one click away, and does not require planning ahead. Thus, the registrations and actual participation do not quite overlap. In addition to this factor, our conference was free of charge. This might have contributed to the excessive amount of registration, which was not realized.

When the feedback results were analyzed, an overall satisfaction among participants was observed**.** This is supported by the literature on web-based conferences: in the virtual German Rheumatology Congress, 80% of participants were either “satisfied” or “very satisfied” with the conference [1]. Similarly, II Dermachat Congress survey results showed that 61.6% of the attendees who had also attended the previous face-to-face format found the web-based version of the conference “superior” to its face-to-face counterpart [2]. The lectures of the speakers had the highest ratings. Similarly, feedback on the strengths of the conference mostly focused on how inspiring it was to listen to the professors. Along with the lectures being captivating, the speakers were from the most internationally acknowledged prestigious universities, and this reinforced the positive feedback in this aspect. The only common negative feedback on the lecture sessions was that the duration of the question-and-answer session was not long enough. Every speaker was given a total of 1 hour, including both the lecture and discussion. Our team did not have much control over how long the speeches would last; therefore, some speakers had more time left to answer questions, while some barely had time for one. A solution would be for the host to remind the professors of the duration limit before yielding the floor, so they can arrange their lectures.

The oral presentation sessions, in contrast, had the lowest rating. This was followed by the poster presentations. This correlates with the answers to the open-ended questions where the participants asked the presentation sessions to be handled differently. The majority of the problems regarding the presentations were in the oral presentation sessions and they were due to the lack of experience of the presenters with the platform. However, even when the presentation sessions proceeded as planned, there was a drastic decrease in the view numbers. This was expected, as the oral and poster presentations of the students were not the focus of the conference but rather a platform for students who wanted to gain experience in presenting in front of a large and diverse audience, as well as sharing their research with the attendees. The feedback reinforced this idea. Nonetheless, it would be inspiring to the participants and encouraging for the presenting students to have a larger active audience.

In terms of organization, as shown above, time management of our team was appreciated, except for the misunderstanding at the very beginning of the conference. Technical difficulties have been reported in the literature as in the 2020 Cochrane Skin Conference, sound transmission was not an uncommon issue with several reasons [9]. Nonetheless, these problems can be minimized, and the most important step in this process is to have a technical team working together and informing the participants about any encountered issue. The 2020 midterm conference of the Karnaka State Chapter of the Association of Surgeons in India reported having a technical team with members in different places with the prerecorded lectures in case of a network connectivity problem [10]. Such solutions could help resolve the issues that a web-based format could cause.

Conclusions

As medical students, the increasing prevalence of web-based conferences has helped us introduce our society and events to an international audience. The virtual format also allowed our conference to be open-access and free of charge, which were encouraging factors for our audience. Students from various countries both presented and viewed the event, and the event received excellent feedback. As an undergraduate organization, these were pivotal for our society's representation among the international community. Our team gained a great amount of experience from this organization with it being both virtual and completely student-based, and we hope that this paper helps as a guide for other organizations as they plan their conferences.

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Conflicts of Interest

None declared.

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Abbreviations

CITC: corrected item-total correlations

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Original Paper

Effects of a 2-Week Remote Learning Program on Empathy and Clinical and Communication Skills in Premedical Students: Mixed Methods Evaluation Study

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Abstract

Background: Expressing empathy builds trust with patients, increases patient satisfaction, and is associated with better health outcomes. Research shows that expressing empathy to patients improves patient adherence to medications and decreases patient anxiety and the number of malpractice lawsuits. However, there is a dearth of research on teaching empathy to premedical students. The Clinical Science, Technology, and Medicine Summer Internship of Stanford Medicine (also called the Stanford Anesthesia Summer Institute) is a 2-week collaborative medical internship for high school and undergraduate students to inspire learners to be compassionate health care providers. The summer 2020 program was adapted to accomplish these objectives in a fully remote environment because of the COVID-19 global pandemic.

Objective: This study aims to measure the change in empathy and competencies of participants in clinical and communication skills before and after program participation.

Methods: A total of 41 participants completed only the core track of this program, and 39 participants completed the core + research track of this program. Participants in both tracks received instructions in selected clinical skills and interacted directly with patients to improve their interviewing skills. Research track participants received additional instructions in research methodology. All participants completed web-based pre- and postsurveys containing Knowledge and Skills Assessment (KSA) questions. Participant empathy was assessed using the validated Consultation and Relational Empathy measure. A subset of participants completed optional focus groups to discuss empathy. The pre- and post-KSA and Consultation and Relational Empathy measure scores were compared using paired 2-tailed *t* tests and a linear regression model. Open-ended focus group answers were then analyzed thematically.

Results: Participants in both tracks demonstrated significant improvement in empathy after the 2-week remote learning course (*P*=.007 in core track; *P*<.001 in research track). These results remained significant when controlling for gender and age. A lower pretest score was associated with a greater change in empathy. Participants in both tracks demonstrated significant improvement in KSA questions related to surgical skills (*P*<.001 in core track; *P*<.001 in research track), epinephrine pen use (*P*<.001 in core track; *P*<.001 in research track), x-ray image interpretation (*P*<.001 in core track; *P*<.001 in research track), and synthesizing information to solve problems (*P*<.001 in core track; *P*=.05 in research track). The core track participants also showed significant improvements in health communication skills (*P*=.001). Qualitative analysis yielded 3 themes: empathy as action, empathy as a mindset, and empathy in designing health care systems.

Conclusions: Summer internships that introduce high school and undergraduate students to the field of health care through hands-on interaction and patient involvement may be an effective way to develop measurable empathy skills when combined with clinical skills training and mentorship. Notably, increases in empathy were observed in a program administered via a remote learning environment.

(JMIR Med Educ 2021;7(4):e33090) doi:10.2196/33090

KEYWORDS

empathy; clinical skills; communication skills; high school; undergraduate; summer program; premedical program; remote learning

Introduction

Benefits of Empathy for Patients and Physicians

Increased physician empathy leads to better patient outcomes [1,2]. In studies of patients with diabetes and the common cold, patients of physicians with high levels of empathy had better clinical outcomes and quicker recovery [3,4]. Higher levels of patient-perceived empathy in physicians have been correlated with improved patient adherence to medication regimens [1,5], which remains a pressing issue in reducing complications and promoting health outcomes [6]. It is suggested that these benefits stem from strong communication and mutual trust and understanding in the patient-physician relationship, all of which can be promoted by physicians expressing empathy [1,7]. Crucially, having greater physician empathy has been linked with higher patient satisfaction and trust [5,8], which can lead to patients disclosing more detailed information, more accurate diagnoses, and shared decision-making [9]. Empathy in physicians also decreases patient anxiety [10] and increases patient enablement [11]. Furthermore, quality of care improves because more empathic physicians have fewer malpractice claims [12] and are less likely to commit medical errors [13].

Empathy can also impact caregivers. Those found to have higher empathy for patients also have higher job satisfaction and well-being [14]. High empathy might be a protective factor against the growing and worrying trend of physician burnout. More than half of the physicians now report symptoms of burnout, including emotional exhaustion, depersonalization, and lack of accomplishment [15]. The consequences of burnout include higher rates of medical errors and lower patient satisfaction. A systematic review of the relationship between empathy and burnout found a negative correlation in 8 out of 10 studies [16].

Empathy in Medical Education

Despite these studies on the positive impact of empathy in medicine, there is a dearth of research on how to cultivate empathy in medical education. Our scope of research is motivated by this overarching hypothesis: increases in empathy during early medical education could be crucial in preventing burnout in medical school later [17]. If increases in empathy persist past medical training, they could lead to improved clinical outcomes. Our review of the literature found some studies on empathy in the medical student population; however, the research findings are mixed. Although many studies found that female medical students have significantly higher empathy scores than male students [18-21], some studies did not find such associations [22,23]. Studies examining changes in empathy across the course of medical school have concluded that empathy scores tend to decline across the years of medical school, with younger medical students in preclinical years exhibiting significantly higher empathy scores [17,19-22]; however, there is no systemic evidence for this decline [9]. Recent research also indicates that students who enter medical school at an older age are significantly more likely to demonstrate higher empathy than students entering at a younger age [21]. These findings regarding factors that influence empathy need to be further corroborated.

In the premedical student population, several summer premedical programs for high school and undergraduate students exist, but no studies have focused on empathy in this population. Common outcomes for evaluating these programs include tracking how many students pursue degrees and careers in medicine [24,25], assessing students’ attitudes toward science and students’ mastery in various program goals such as scientific literacy and laboratory skills [26-28]. Tools for program evaluation include self-assessment Likert surveys and open-ended questionnaires. Prior programs do not report cultivating a mindset of compassion or the use of empathy as a primary outcome measure of program efficacy. Therefore, we decided to conduct this mixed-methods study of a 2-week remote learning premedical program and its effects on empathy and clinical and communication skills. This study evaluates the stated program to determine whether there were changes in empathy and competencies in selected clinical skills among program participants.

Methods

Curriculum Development

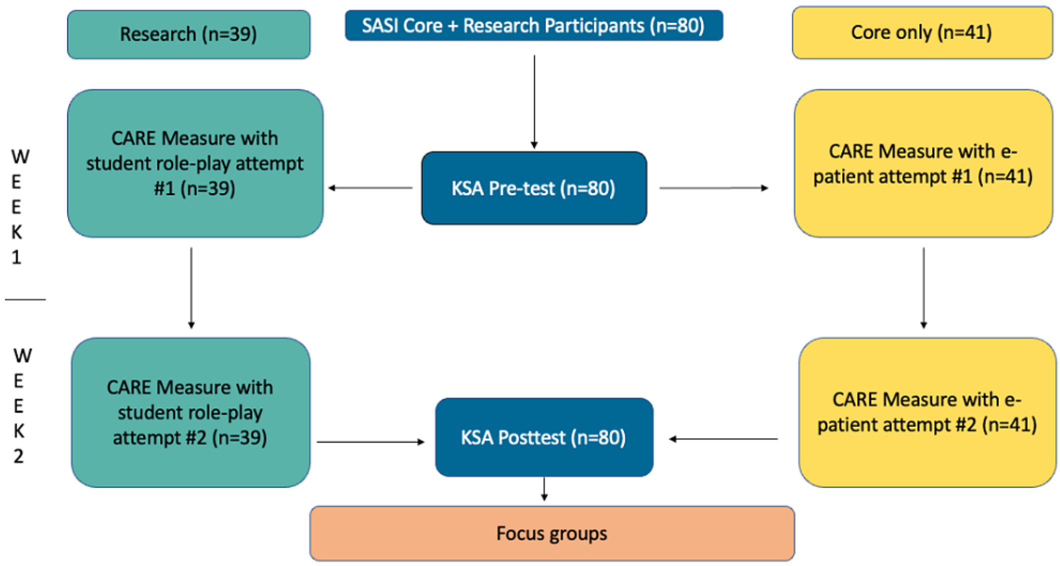
The Clinical Science, Technology, and Medicine Summer Internship (also called the Stanford Anesthesia Summer Institute [SASI]) is a 2-week program for high school and undergraduate students run by the Anesthesia, Informatics, and Media laboratory at the Stanford School of Medicine. The program began in June 2017 and has run every year since, with 435 program participant graduates. Program instruction is typically held in person on the Stanford School of Medicine campus, but the summer 2020 curriculum was adapted to be fully remote because of the COVID-19 pandemic.

The SASI Core curriculum was co-designed with input from patients, high school science teachers, anesthesiology professors, and researchers. Key features of the curriculum include opportunities for SASI participants to interact directly with patients; improve clinical skills through hands-on training; and receive mentorship from clinicians, patients, and near peers. Students take part in lectures and workshops hosted by patients, medical students, and faculty on topics such as empathic listening, emergency medicine, and careers in medicine. They also learned the principles of Everyone Included [29] and worked on a capstone project to coproduce a health care solution with their e-patient [30]—a term used to describe engaged patients who play an active role in their health care decision-making process. Core track participants only attend the morning session, which covers the core curriculum. Research track participants attend the morning session and additional afternoon sessions that focus on research methodology.

Study Design

Although SASI has run before, we developed a novel pilot study to assess empathy in participants (Figure 1). Patients were involved in the coproduction of the study design methodology, with special consideration to patient inclusion, participatory methods, and the inclusion of Everyone Included principles [31].

Figure 1. Study design. Data are collected using a pre-post format for the 2 tracks separately. CARE: Consultation and Relational Empathy; KSA: Knowledge and Skills Assessment; SASI: Stanford Anesthesia Summer Institute.



"Everyone Included™ creates a culture of health in which everyone is trusted and respected for the expertise they bring, where openness and experimentation is the norm, people have personal ownership of health, individual stories have global impact, and the patient voice and choice is a part of all stakeholder decisions" [29].

All SASI participants completed pre- and postsurveys that included Knowledge and Skills Assessment (KSA) questions and questions about attitudes toward empathy. Participant empathy was assessed using the validated Consultation and Relational Empathy (CARE) measure. Core track participants were evaluated by e-patients, and research track participants were evaluated by peers during role-play. Participants were invited to complete an optional focus group at the end of the program to discuss empathy. The purpose of this study design was to evaluate the program by comparing each participant with themselves before and after program completion; thus, they acted as their own control.

Our study protocol was evaluated by the Stanford Institutional Review Board, and it was determined that it does not meet the definition of research, as defined in 45 CFR 46.102(d).

Classroom interactions were conducted in accordance with the Stanford policies outlined in the Guidelines for Online Minors Programs developed by the Office for Protection of Minors. This includes appropriate staff training.

Participants

High school and undergraduate students were selected to participate in SASI through an application process. Accepted program participants were invited to participate voluntarily in our evaluation study. A total of 41 participants were in core track only, and 39 participants were in research track.

Materials

CARE Measure

The CARE measure is regarded as one of the best-validated patient rating scales of practitioner empathy [32]. The survey consists of 10 Likert scale items that aim to evaluate the human aspects of medical care, with a focus on the process rather than the outcome [33]. It has specifically been cited as a potential tool for assessing empathy in undergraduate medical education [33]. All reviewers filled out an electronic version of the survey (Multimedia Appendix 1 [33,34]). The CARE measure was scored by the authors using an official scoring system [33].

Standardized Role-play

Participants took turns role-playing as physicians and patients during a mock medical history–taking session. Those playing the patient were given a specific patient profile card, and those playing the physician were given a medical history–taking form. All scenarios and materials were adapted from the Association of American Medical Colleges premed lesson plans [35]. After the mock consultation, empathy of the participant who played the physician was assessed using the CARE measure.

SASI Survey

The SASI survey was developed by the authors to be electronically completed before and after program participation. Specifically, the survey included demographic information (gender, grade, race, and program track), questions about attitudes toward empathy, the Likert-scale KSA questions (1: strongly disagree; 2: disagree; 3: neither agree nor disagree; 4: agree; and 5: strongly agree), and program reflection questions (in the postsurvey only; Multimedia Appendices 2 and 3).

Qualitative Feedback

SASI participants had the option of completing focus groups to explore empathy. Open-ended questions presented various scenarios regarding empathy (Multimedia Appendix 4).

Zoom Platform

The SASI curriculum instruction was imparted synchronously over the Zoom videoconferencing platform (Zoom Video Communications). Efforts to maintain an engaging sense of community included encouraging participants to keep cameras on, frequent use of breakout rooms, and icebreakers and breaks to prevent Zoom fatigue.

Data Collection and Analysis

Overview

Data were collected according to the following timeline. Day 1 refers to the first day of SASI. All program participants and e-patients were given deidentified program IDs so that they could fill out all surveys anonymously. All quantitative data analyses were performed using RStudio (version 4.0.3).

Empathy Scores (Quantitative)

Day 1

Core track participants met with their assigned e-patient for the first time to complete a pseudohistory–taking session. e-Patients filled out core track CARE Measure Attempt #1 based on their interactions.

Research track participants met in groups of 6 to 8 to complete the role-play activity. In pairs, the participants took turns playing both the physician and patient, according to the character card they were given. For each participant who played the physician, the other participants in the group filled out research track CARE Measure Attempt #1 to assess the physician's empathy based on the mock consultation. Each physician's CARE measure scores were averaged to increase validity and consistency and produce a single empathy prescore.

Day 6

Core track participants met with the same assigned e-patient again and worked on coproducing their health solutions. e-Patients filled out core track CARE Measure Attempt #2 based on their interactions.

Day 9

Research track participants met in the same groups to complete the role-play activity. In pairs, participants repeated the role-play activity, but they were assigned different case scenarios. For each participant who played the physician, the other participants in the group filled out research track CARE Measure Attempt #2 to assess the physician's empathy based on the mock consultation. Each physician's CARE measure scores were averaged to increase validity and consistency and produce a single empathy prescore.

For hypothesis testing of CARE measure scores, normality of change in scores was assessed using a quintile plot, and boxplots were generated to find outliers. Initial testing was performed using paired 2-tailed *t* tests by track. Follow-up analysis was performed using multivariate linear regression to control for the effects of gender, grade, and pretest empathy score on changes in empathy. We met the guidelines for minimum sample size [36].

KSA Scores (Quantitative)

Day 1

SASI participants filled out the SASI presurvey to self-assess their knowledge and skills.

Day 9

SASI participants filled out the SASI postsurvey to self-assess their knowledge and skills.

For hypothesis testing of KSA questions, normality of change in scores was assessed using a quintile plot and boxplots were generated to find any outliers. Paired *t* tests were performed for each question by track.

Focus Groups (Qualitative)

Subset of SASI participants completed focus groups on Day 10.

Qualitative methods were guided by the Grounded Theory of Strauss and Corbin [37]. Focus group responses were transcribed using Descript software. Transcripts were read over for accuracy and data familiarization. We used open and axial coding to conduct qualitative analysis of the focus group responses. A researcher (US) read the responses and identified major themes and subthemes based on the frequency of repetition of keywords. Quotes that supported the generated themes were selected to highlight the anecdotes. Final themes were reviewed by an independent researcher (LFC) to ensure accuracy and consistency.

Overall Program Feedback (Qualitative)

SASI participants filled out the SASI postsurvey to provide overall program feedback on Day 9.

Responses were read and analyzed by the authors, and quotes were selected to highlight the anecdotes.

Results

Descriptive Statistics

A total of 90 participants completed the SASI program, of which 80 participants completed the SASI pre- and postsurveys that matched (core track, n=41 and research track, n=39). Of these 80 participants, 55 participants had complete CARE measure data for both attempts that matched (core track, n=20 and research track, n=35). Table 1 presents demographic data of all the participants who participated in the study. There were no significant differences in age, gender, and race in the subgroup that completed the CARE measure data surveys (chi-square test: *P*=.94 in core track and *P*=.99 in research track).

Table 1. Participant demographic data (n=80).

Characteristic	Participants in core track (n=41), n (%)	Participants in research track (n=39), n (%)
Gender		
Male	15 (37)	16 (41)
Female	26 (63)	21 (54)
Prefer not to say	0 (0)	2 (5)
Grade		
High school student	36 (88)	34 (87)
College student	5 (12)	5 (13)
Race		
African American	2 (5)	1 (3)
Asian	27 (66)	29 (74)
White	3 (7)	5 (13)
More than one race	5 (12)	0 (0)
Other	3 (7)	2 (5)
Prefer not to say	1 (2)	2 (5)

Empathy Scores (Quantitative)

Participants in both tracks demonstrated significant improvement in empathy after the 2-week remote learning course, as assessed by paired *t* tests. In the core track (n=20), the mean CARE score increased from 31.31 (SD 10.81) before SASI to 40.75 (SD 12.57) after SASI (*P*=.007). In the research track (n=35), the mean CARE score increased from 40.42 (SD 6.24) before SASI to 43.50 (SD 3.76) after SASI (*P*<.001). The CARE score ranges from 10-50. Each Likert-scale question is scored 1 (poor) to 5 (excellent), and there are a total of 10 questions.

Effect of Gender, Grade, and Pretest Score on Change in Empathy

To further study changes in empathy scores, we used multivariate linear regression analysis to model differences in pre- and posttest empathy scores as the dependent variable, adjusting for gender, grade, and empathy pretest score.

For the research track, improvement in empathy scores remained statistically significant after controlling for gender and grade. Participants with lower CARE measure pretest scores were significantly more likely to improve their empathy scores (Table 2). For core track, improvement in empathy scores remained statistically significant after controlling for gender, grade, and empathy pretest scores (Table 3).

Table 2. Multivariate linear regression model for factors influencing change in the Consultation and Relational Empathy (CARE) measure pre- and posttest scores in Stanford Anesthesia Summer Institute research track participants.[a]

Factors	β coefficient (SE)	*P* value
Intercept	24.337 (2.741)	<.001
CARE measure pretest score	−0.534 (.068)	<.001
Gender (female)	0.891 (.842)	.30
Gender (prefer not to say)	2.524 (1.833)	.18
College student	−1.822 (1.191)	.14

[a]Adjusted R^2=0.668.

Table 3. Multivariate linear regression model for factors influencing change in the Consultation and Relational Empathy (CARE) measure pre- and posttest scores in Stanford Anesthesia Summer Institute core track participants.[a]

Factors	β coefficient (SE)	*P* value
Intercept	27.167 (8.803)	.007
CARE measure pretest score	−0.587 (0.283)	.05
Gender (female)	−1.612 (6.478)	.81
College student	11.963 (7.656)	.14

[a]Adjusted R^2=0.236.

KSA Scores (Quantitative)

Participants in both tracks demonstrated significant improvement in the total KSA score after program completion. In core track, the mean score increased from 27.93 (SD 4.06) before SASI to 34.51 (SD 3.04) after SASI—a 24% improvement (*P*<.001). Significant increases were specifically observed in KSA questions 1-5. In research track, the mean score increased from 29.28 (SD 2.96) before SASI to 35.33 (SD 3.26) after SASI—a 21% improvement (*P*<.001). Significant increases were specifically observed in KSA questions 1-4. Table 4 summarizes the KSA score changes before and after program completion by track for each KSA question.

Table 4. Paired *t* test for Knowledge and Skills Assessment (KSA) scores by question before and after the completion of the Stanford Anesthesia Summer Institute internship (n=80).

Health outcome	Participants in core track (n=41)				Participants in research track (n=39)			
	Pretest, mean (SD)	Posttest, mean (SD)	Change (%)	*P* value	Pretest, mean (SD)	Posttest, mean (SD)	Change (%)	*P* value
KSA question 1[a]	2.05 (1.28)	3.95 (0.77)	92.7	<.001	2.62 (1.35)	4.21 (0.52)	60.7	<.001
KSA question 2[b]	2.34 (1.54)	4.51(0.55)	92.7	<.001	1.95 (1.05)	4.51 (0.51)	131.3	<.001
KSA question 3[c]	2.07 (1.14)	3.37 (1.04)	62.8	<.001	2.05 (0.92)	3.56 (0.88)	73.7	<.001
KSA question 4[d]	3.83 (0.59)	4.49 (0.51)	17.2	<.001	4.33 (0.62)	4.51 (0.60)	4.2	.05
KSA question 5[e]	3.93 (0.87)	4.41 (0.55)	12.2	.001	4.33 (0.70)	4.56 (0.60)	5.3	.08
KSA question 6[f]	4.32 (0.69)	4.46 (0.60)	3.2	.18	4.54 (0.60)	4.62 (0.49)	1.8	.50
KSA question 7[g]	4.63 (0.58)	4.61(0.44)	−0.4	.80	4.64 (0.49)	4.67 (0.48)	0.6	.71
KSA question 8[h]	4.76 (0.43)	4.71 (0.46)	−1.0	.57	4.82 (0.39)	4.69 (0.47)	−2.7	.10

[a]Apply the basic surgical suture knot (1 [strongly disagree] to 5 [strongly agree]).
[b]Apply an epinephrine pen to a person with anaphylaxis (1 [strongly disagree] to 5 [strongly agree]).
[c]Interpret the basic chest x-ray for signs of pneumothorax, hemothorax, or major trauma (1 [strongly disagree] to 5 [strongly agree]).
[d]Analyze relevant information and arrive at a solution to a new challenge (1 [strongly disagree] to 5 [strongly agree]).
[e]Demonstrate effective communication skills to promote health (1 [strongly disagree] to 5 [strongly agree]).
[f]Connect and expand on ideas when collaborating with peers (1 [strongly disagree] to 5 [strongly agree]).
[g]Listen to a friend sharing their problem (1 [strongly disagree] to 5 [strongly agree]).
[h]Role of technology in solving health care challenges (1 [strongly disagree] to 5 [strongly agree]).

Focus Groups (Qualitative)

Overview

A total of 32 participants consented to be recorded in the focus groups. Three main themes were constructed from transcript data. These themes are elaborated here using brief explanations and verbatim quotations. The major themes established after reading all transcripts are presented as follows:

1. Empathy as action.
2. Empathy as a mindset.
3. Empathy in designing health care systems.

Theme 1: Empathy as Action

This theme includes responses that characterize empathy as a set of specific actionable items that a physician can implement, such as listening to their patient; appropriate use of voice, tone, and body language when conversing; and fine-tuning treatment plans according to patient needs to yield better adherence and outcomes:

> *Empathy is being a good listener, not portraying judgement, and being open to change in terms of what you might not know and expanding your knowledge set.*

> *Letting [patients] tell their side of the story and believing that there's something there and not dismissing their concerns...the body language of the doctor and things like not commanding [patients] shows if they're engaged with the patient or not.*

Theme 2: Empathy as a Mindset

This theme includes responses that characterize empathy as a mindset that physicians can adopt to be more empathetic toward patients. These responses focused on ways to undo biases physicians may have, with potential solutions such as metaphorically putting oneself in the patient's shoes and treating them as a whole person:

> *In the doctor-patient context, empathy is what makes the patient feel they are considered as human beings instead of being analyzed by their diseases.*

> *A lot of patients were saying that they like to be looked at as more than their disease or their diagnosis, and to be looked at as a whole person by their doctor.*

Theme 3: Empathy in Designing Health Care Systems

Although previous responses centered on the individual responsibilities of the physician, responses in this theme were related to empathy in the context of the health care system as a whole. The predominant suggestion was to encourage empathy via shared decision-making, including giving the patient an equal voice and not being ignorant of or condescending toward the patient:

> *Without empathy, I feel like we might easily fall into a philosophy of considering efficiency when designing healthcare, and not actually consider the patients as humans.*

> *The clinician should be in the driver's seat and the patient should be in the passenger seat, not in the back. Empathy is about making sure that everyone has a say. Traditional medicine focuses on this idea that the patient just listens to a doctor and does they say, but patients have their own experiences.*

Program Feedback (Qualitative)

In the postsurvey, participants were asked to rate their overall program experience (1: poor; 2: fair; 3: good; 4: very good; and 5: excellent). SASI was well-received and earned an average score of 4.04 (SD 0.87).

Participants were also asked to respond to open-ended, written questions about the overall program. Common themes were identified and are presented later with verbatim quotations.

Three major themes were coded in response to the question *What was the most important thing you learned as a SASI student?* The 3 themes are as follows: 41% (33/80) of the participants referenced empathy in their answers, 31% (25/80) referenced patients and health care systems, and 24% (19/80) referenced specific clinical skills such as suturing and basic life support:

> *The most important lesson I learned is to have empathy for patients. Before SASI, I knew that physicians should treat patients with empathy, but I did not know how to apply the practice of empathy or about the perspective of patients. However, through this program, I had the opportunity to hear from patients about their stories, which gave me a better understanding of how to treat people with empathy.*

When asked to identify their favorite lecture or activity, 64% (51/80) of participants selected the "10 Ways to Die" lecture—a crash course on the leading causes of mortality in the United States—or the suturing activity—one of the few hands-on activities made possible during the remote learning program by mailing a suturing kit to all participants. Participants described these activities as "engaging," "practical," and "fun."

Most participants shared that the SASI had increased their motivation and interest in pursuing a career in health care. In terms of criticism, the most common feedback was difficulties associated with remote learning.

Discussion

Principal Findings

This study evaluated a 2-week remote learning premedical program and found that it was successful in achieving its course objectives. Quantitative analysis of pre- and posttest scores indicated that participant empathy and clinical and communication skills increased after program completion. Qualitative analysis of open-ended responses suggested that SASI developed a participant's understanding of empathy at the individual and systemic level. Overall, the program was well-received, although remote learning posed some challenges.

The CARE measure score data support that clinically relevant empathy can be taught in a remote learning environment. SASI participants had measurable improvements after program completion: the mean CARE measure score increased by 9 points in core track and by 3 points in research track. The CARE measure is composed of 10 questions (scored 1-5), each assessing a unique subskill that builds toward physician empathy. Thus, a 3-point improvement can roughly be equated to a 1 Likert-level improvement in 3 of the 10 empathy skills assessed in the CARE measure. Similarly, a 9-point increase represents a holistic improvement in multiple facets of the CARE measure. In terms of absolute scores, a few studies have published benchmark means that provide a reference comparison. While developing and testing the CARE measure, the designers concluded an average score of 40.8 [34]. By this standard, research track went from below average (40.42) to above average (43.50) during the program and core track progressed from severely below average (31.31) to average (40.75). One possible explanation for the low core track CARE measure prescore could be the initial hesitation to talk to an unknown adult patient. A meta-analysis of 64 studies involving the CARE measure found a mean score of 40.42 [32]. By this metric, both tracks finished with above-average CARE measure scores. The CARE measure has been credited for its robustness and relevancy by both patients and physicians and has demonstrated strong validity across multiple patient populations and settings [34].

The CARE measure provides an external rating for patient-assessed empathy, and the thematic analysis of the focus groups corroborates these findings from the participant's perspective. Participant responses demonstrate that they have inculcated a mindset of empathy (theme 2) and have the requisite tools to execute their empathy meaningfully (theme 1). They also have a broader view of the importance of empathy (theme 3), which will hopefully sustain empathy.

The KSA data reveal measurable gains in self-assessed clinical and communication skills. Participants in both tracks demonstrated significant improvement in KSA questions related to surgical skills, epinephrine pen use, x-ray image interpretation, and synthesizing information to solve problems (questions 1-4). The core track participants also showed a significant improvement in health communication skills (question 5). The high baseline health communication score could be a reason why the improvement was not significant in the research track participants. Questions 6 and 7 reference domains of broad, transferable skills that, although related to the field of medicine, are not necessarily specific to that domain. Therefore, premedical students were likely to have had prior knowledge or skill development in these domains. This could explain the high baseline scores observed for questions 6 and 7 in our student cohort. High baseline scores could be a reason why there was no significant improvement in either track in questions relating to collaborating and listening to peers. Despite the SASI curriculum advocating for technology to promote health care, it is interesting to note that support for technology had a slight decrease in both tracks. Given that participants had an increase in empathy, this supports previous research that found a negative correlation between empathy and medical students who preferred technology-oriented specialties [18].

There are a few key SASI program features that facilitate teaching empathy. Most notably, SASI creates opportunities for early patient interactions. SASI students participate in e-patient–led lectures and workshops such as *Empathic Communication and Leadership in Healthcare*, co-design health solutions with e-patients, and practice interviewing skills with them via standardized consultations. In previous research, early patient contact has repeatedly been cited as a motivator for empathy in medical students [38-41]. SASI is taking a novel approach to extend this a step further by introducing patient contact as early as in high school and undergraduate years of college. The role-play activity is crucial in improving health communication and allowing students to perceive both patient and physician perspectives, and this tool has been found to boost empathy in medical students [42]. In addition, the SASI curriculum emphasizes empathy as a priority; allows for self-reflection through guided activities such as focus groups; facilitates clinical and communication skills training; and provides positive role models and mentorship from physicians, teaching staff, and near peers. All of these factors have been found to promote empathy [38].

It is worth noting that the most popular activities, as rated by SASI participants, were hands-on clinical skills training and a Socratic-style discussion. This can be attributed to the remote environment, in which opportunities for engagement lead to higher ratings. The charisma of the speaker or the chance to get a feeling of a clinical experience can excite students, but it is equally important to include the empathy-enhancing activities described earlier in the curriculum.

This is one of the several issues with the remote learning environment that participants mentioned in the postsurvey. They also noted a lack of engagement with peers and speakers (both socially and professionally), difficulties staying energized for extended hours on Zoom, occasional troubles with time zones and logistics, and fewer hands-on opportunities. Despite these criticisms, significant improvements in empathy were observed in the remote setting.

Comparison With Prior Work

In our study, the increase in empathy was not affected by gender, as has been the case in previous studies [18-21]. Initial age did not affect the ability to improve empathy, as previously proposed [21]. The regression analysis that measured the effect of gender and age had differing R^2 values for the 2 tracks. A low R^2 value in core track suggests that the independent variables might be less predictive of change in the outcome, and there could be other independent variables that could be studied further. However, this does not weaken support for the findings that female and male participants benefited equally from SASI, although it is possible that there were baseline empathy differences that persisted even though there was a change in empathy because SASI was the same. Owing to the short nature of the program, we were not able to measure empathy across multiple years of education.

One study found an increase in cultural empathy in college and master's students after a virtual simulation [43], and another study found videoconference communication training to help build patient trust [44]. Our study evaluated a niche program that uses remote learning to build clinically relevant empathy in high school participants. At the high school level, premedical programs report increased scientific skills and desire to pursue careers in medicine [24-28], both of which were found in SASI participants. Some programs track success through the number of participants who complete degrees in medicine, but we do not have access to such data for SASI currently.

Limitations

One of the main limitations of this study is that the generalizability of the findings may be limited because of (1) the small sample size of participants, (2) a self-selecting group who voluntarily attended SASI, and (3) lack of a true control group. The main purpose of this study is to report on early work at SASI and assess the program for quality improvement, which is why only SASI participants were included. Another potential limitation is that empathy increases with the familiarity of meeting the same patient over time. This could be addressed by future work that provides a control group who does not participate in the SASI curriculum but meets the same patient multiple times. In addition, the KSA scores were self-assessed, which could introduce potential bias. In addition, there was only one coder for the interview data. To reduce the effect of this potential bias, the themes and quotes were discussed among the authors.

Future Work

The results of this study are promising and indicate that the effects of SASI should be studied further. Future work should focus on the next in-person iteration of the program to see how empathy and clinical and communication skills change during an in-person SASI session. Future work should also target longitudinal analysis to see how SASI participants fare over time. Initially, we could measure how many participants went into medical careers, track these participants, and correlate findings with clinical outcomes. The CARE measures could also be examined. We hypothesize that the increase in empathy demonstrated in the CARE measure scores of SASI participants could translate to meaningful impacts in actual clinical outcomes, as premedical students progress to clinical practice. It remains to be seen whether the empathy gains of SASI translate to meaningful clinical metrics such as better patient satisfaction, less burnout, and fewer medical mistakes. This analysis could also assess whether the SASI empathy effect persists through medical school or whether the benefits are only of short term. If this is the case, follow-up SASI workshops to boost empathy during medical school could be explored.

Conclusions

The findings of this study indicate that summer premedical internships for high school and undergraduate students are well-received and can inspire participants to pursue careers in health care. Program participation can lead to increased patient-assessed empathy and significant improvement in self-assessed clinical skills, even in a web-based, remote learning environment. Key program features that enable these benefits include early patient contact, role-play activities, and hands-on clinical and communication skills training and mentorship.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Consultation and Relational Empathy measure.
[PDF File (Adobe PDF File), 138 KB - mededu_v7i4e33090_app1.pdf]

Multimedia Appendix 2
The Stanford Anesthesia Summer Institute presurvey (including Knowledge and Skills Assessment questions).
[PDF File (Adobe PDF File), 53 KB - mededu_v7i4e33090_app2.pdf]

Multimedia Appendix 3
The Stanford Anesthesia Summer Institute postsurvey (including Knowledge and Skills Assessment questions).
[PDF File (Adobe PDF File), 62 KB - mededu_v7i4e33090_app3.pdf]

Multimedia Appendix 4
Focus group questions.
[PDF File (Adobe PDF File), 69 KB - mededu_v7i4e33090_app4.pdf]

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Abbreviations

CARE: Consultation and Relational Empathy
KSA: Knowledge and Skills Assessment
SASI: Stanford Anesthesia Summer Institute

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Letter to the Editor

Innovation and Inequality: A Medical Student Perspective. Comment on "The Present and Future Applications of Technology in Adapting Medical Education Amidst the COVID-19 Pandemic"

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KEYWORDS

medical education; technology; coronavirus; medical students; COVID-19; pandemic; online lecture; virtual reality; education

We read with great interest a *JMIR Medical Education* article from Remtulla [1] on the merits of using technology in medical education amidst the COVID-19 pandemic. The article resonated greatly with our experiences as fifth-year medical students during the pandemic, which has created an opportunity to innovate and redefine medical education in an age of technology.

First, the author suggests online lectures may become a permanent alteration. We find Zoom or Microsoft Teams convenient and practical to use for clinical teaching, while our colleagues agree that concentration is better in our own rooms than in lecture theaters. Moreover, it is easier to see and annotate clinical pictures on laptop screens. Thus, we support virtual clinical teaching, particularly in specialties such as radiology and dermatology where it has been the most useful. However, online lectures may risk losing rapport between educators and students [2]. This is especially true for prerecorded lectures, which may reduce engagement if students cannot ask questions for clarification or prompt discussions. There may also be health consequences from increased screen time [2]. Therefore, we recommend synchronous online learning, where students engage in virtual classes and live webinars in real time with their lecturers and peers, which can complement face-to-face teaching once the pandemic resolves.

Secondly, we commend the author for highlighting the importance of incorporating telemedicine into medical education. On placement, we witnessed the benefits of virtual clinics for frail patients such as in old-age psychiatry or movement disorder clinics where consultations can be done from their own homes. Doctors can also accommodate more students to observe and learn within a conference call, whereas space is a limiting factor with physical consultations. The pandemic demonstrated our unpreparedness, as students, for history-taking and examination in video calls, despite the difficulty of them for even experienced professionals. Undoubtedly, the use of telemedicine will increase post–COVID-19, which makes it an urgent case for telemedicine to be taught early on in medical school. Studies from the United States show high student satisfaction and engagement where telemedicine is a component of the medical curriculum [3]. Therefore, we would appreciate more virtual history-taking and examination skills teaching at medical school. This can perhaps take place during community placements as general practitioners already utilize telemedicine day to day in their practice. Medical schools can also offer student-selected modules within telemedicine in preclinical years for early exposure.

Finally, while we value the author's suggestions for medical education going forward, we are concerned about the limits of technology in widening participation [4]. We want to ask the author's and readership's opinions on widening access for students who may not benefit from a digitalized education such as those from socially disadvantaged backgrounds or people with disabilities. However, we acknowledge that online teaching holds the potential to even increase equity for students by enabling flexible working patterns and participation from different geographical locations. In our experience, the pandemic has shown many merits in utilizing technological advances for medical education, but much work is still yet to be achieved to provide an equitable one.

Editorial Notice

The corresponding author of *"The Present and Future Applications of Technology in Adapting Medical Education Amidst the COVID-19 Pandemic"* did not respond to our request to comment on this letter.

Conflicts of Interest

No conflicts declared.

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Original Paper

Medical Data Mining Course Development in Postgraduate Medical Education: Web-Based Survey and Case Study

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Abstract

Background: Medical postgraduates' demand for data capabilities is growing, as biomedical research becomes more data driven, integrative, and computational. In the context of the application of big data in health and medicine, the integration of data mining skills into postgraduate medical education becomes important.

Objective: This study aimed to demonstrate the design and implementation of a medical data mining course for medical postgraduates with diverse backgrounds in a medical school.

Methods: We developed a medical data mining course called "Practical Techniques of Medical Data Mining" for postgraduate medical education and taught the course online at Peking Union Medical College (PUMC). To identify the background knowledge, programming skills, and expectations of targeted learners, we conducted a web-based questionnaire survey. After determining the instructional methods to be used in the course, three technical platforms—Rain Classroom, Tencent Meeting, and WeChat—were chosen for online teaching. A medical data mining platform called Medical Data Mining - R Programming Hub (MedHub) was developed for self-learning, which could support the development and comprehensive testing of data mining algorithms. Finally, we carried out a postcourse survey and a case study to demonstrate that our online course could accommodate a diverse group of medical students with a wide range of academic backgrounds and programming experience.

Results: In total, 200 postgraduates from 30 disciplines participated in the precourse survey. Based on the analysis of students' characteristics and expectations, we designed an optimized course structured into nine logical teaching units (one 4-hour unit per week for 9 weeks). The course covered basic knowledge of R programming, machine learning models, clinical data mining, and omics data mining, among other topics, as well as diversified health care analysis scenarios. Finally, this 9-week course was successfully implemented in an online format from May to July in the spring semester of 2020 at PUMC. A total of 6 faculty members and 317 students participated in the course. Postcourse survey data showed that our course was considered to be very practical (83/83, 100% indicated "very positive" or "positive"), and MedHub received the best feedback, both in function (80/83, 96% chose "satisfied") and teaching effect (80/83, 96% chose "satisfied"). The case study showed that our course was able to fill the gap between student expectations and learning outcomes.

Conclusions: We developed content for a data mining course, with online instructional methods to accommodate the diversified characteristics of students. Our optimized course could improve the data mining skills of medical students with a wide range of academic backgrounds and programming experience.

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KEYWORDS

medical data mining; course development; online teaching; postgraduate medical education

Introduction

Big data holds promise for achieving a new understanding of the mechanisms of health and disease and of making biomedical research more data driven, integrative, and computational. In a survey of 704 National Science Foundation investigators from the Directorate for Biological Sciences [1], 90% reported that they were, or would soon be, analyzing large data sets. Meanwhile, future physicians are actively preparing for this new era of data and digital health. A national survey conducted by Stanford Medicine [2] showed that medical students now pursue supplemental education in data-oriented subjects, such as advanced statistics, coding, and artificial intelligence.

With the aim of training students in data operation and advanced algorithm application via computer programming, data mining courses are designed to develop students' practical skills in general data structure and program coding [3-6]. For example, "Introduction to Data Mining" at Ohio State University [3] is a project-based course that provides an in-depth understanding of data mining methodology. However, these courses are not specific to health care scenarios. Developing data mining courses that focus on the characteristics of medical data and associated data mining techniques in the context of concrete health care analytic applications is essential for medical postgraduates.

For medical schools, achieving this is more difficult than expected. Firstly, medical data mining courses may attract medical students with diverse academic backgrounds, including public health, oncology, cardiology, neurology, pharmacy, and nursing. Since the role of domain knowledge may be dominant when analyzing data and interpreting results [7], instructors need to be equipped with necessary domain knowledge and programming skills. However, instructors generally lack training or expertise, just as a nationwide survey of US life sciences faculty showed [8]. Secondly, health care analytic applications are diverse, including planning or implementing interventions, disease detection, therapeutic decision support, outcome prediction, and personalized medicine [9]. Different applications vary in scientific problems, data type, analysis paradigms, and techniques. Meanwhile, the medical data are from different sources, involving insurance claims, clinical registries, electronic health records (EHRs), biometric data, patient-reported data, medical imaging, biomarker data, prospective cohort studies, large clinical trials, the internet, and mobile apps [10]. It is still inconclusive as to which type of the above applications should be involved in a practical medical data mining course targeting medical students. Thirdly, learn-to-code courses are largely absent from medical school curricula [11]. Some medical students may have received supplemental education, while others may not have. The diversity of their background knowledge and programming skill level makes course development more difficult, although previous studies showed that medical students who were complete novices at coding were able to create simple, usable clinical programs with 2 days of intensive teaching [12].

To address these problems, some medical schools collaborated with other departments to develop courses, such as the University of Toronto Faculty of Medicine [11]. They developed a 14-month certificate course, "Computing for Medicine," in collaboration with the Department of Computer Science. Some medical schools developed medical data mining courses focusing on specific data types or specific health care analytic applications. For example, "Collaborative Data Science in Medicine" at the Massachusetts Institute of Technology [13] focused on performing retrospective research using data from EHRs. "Data, Models, and Applications to Healthcare Analytics" at Stanford University delved into applications to medical product safety evaluation and health risk models [14]. Columbia University provides an overview of research methods relevant to biomedical informatics for students in clinical, public health, or translational research programs [15]. Incorporating diversity in a medical data mining course is still a challenging problem.

We aimed to develop an online medical data mining course to accommodate a diverse group of medical students with a wide range of academic backgrounds, programming experience, and motivations. We have an offline course called "Practical Techniques of Medical Data Mining" (No. INSC11011) at Peking Union Medical College (PUMC) [16]. This course started in 2016 and initially targeted medical informatics students with prerequisite course training for computer science. Recently, more and more clinical students have enrolled in our course. Their diversity in programming skills, background knowledge, and needs has brought challenges to our course, which motivates us to incorporate knowledge diversity into our course. To achieve this, previous studies have shown that uncovering potential participants' needs may be helpful [17-19]. Since medical data mining courses are developed to prepare medical students for data-driven research and the new era of data and digital health, we believe that it is necessary to survey medical postgraduates to identify their perceptions. Accordingly, diversified course content and teaching methods could be designed. For teaching methods, online learning environments offer an opportunity for self-learning and collaborative learning [20,21]. Different web-based platforms have been successfully applied to support different learning processes [22], such as Rain Classroom [23], WeChat [24], DingTalk [25], Zoom [26], Skype, and FaceTime. Compared with traditional face-to-face classes, learning online has advantages in flexibility and virtual communication, and has the potential to deal with the diverse needs of students. Meanwhile, due to the threat of COVID-19, colleges and universities have mandated that faculty move their courses online to help prevent the spread of the virus [27]. In this study, we developed a medical data mining course using internet education technology, aiming to improve the data mining skills of medical students with a wide range of academic backgrounds and programming experience.

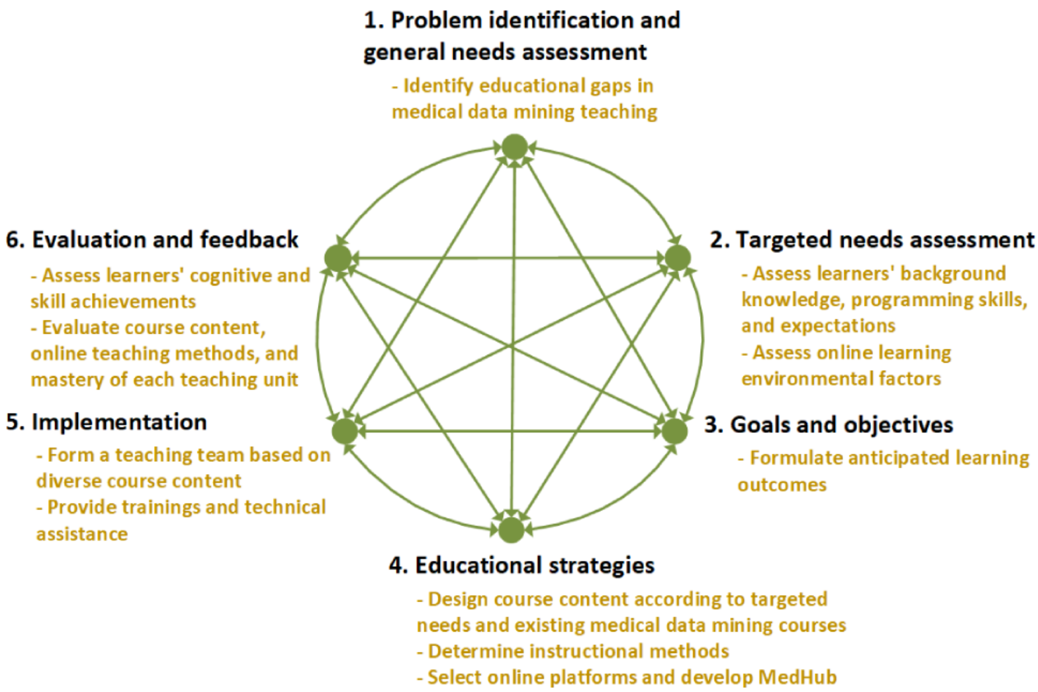
Methods

Medical Data Mining Course Development Process

Overview

The course "Practical Techniques of Medical Data Mining" (No. INSC11011) is offered at PUMC in the spring semester of each academic year, with a cap of 48 students. To optimize both the content and educational format of our online medical data mining course, we utilized a six-step approach [28] to guide its development, as this approach has led to the successful implementation of a variety of traditional and online courses in medicine [29-31]. The step-by-step process is discussed in the following sections (Figure 1).

Figure 1. Development process for the medical data mining course. MedHub: Medical Data Mining - R Programming Hub.



Step 1: Problem Identification and General Needs Assessment

We reviewed published literature, state-of-art medical data mining courses in leading international medical schools, and existing courses at PUMC to identify educational gaps in medical data mining teaching. After evaluating the advantages and disadvantages of traditional face-to-face teaching and online teaching, we clarified how to move the course online.

Step 2: Targeted Needs Assessment

To make the course content suitable for targeted learners, we conducted a web-based questionnaire survey among postgraduates of PUMC to understand their diversified characteristics (detailed in the Precourse Survey section), which should be fully considered in the course design. For online learning environments, factors that affected the selection of online teaching platforms, such as local technical support, were evaluated.

Step 3: Goals and Objectives

Based on the needs assessment, anticipated learning outcomes were formulated, including the following: (1) mastering medical data mining research design, (2) learning to use data mining tools (ie, R software environment), and (3) mastering skills of medical data processing, analysis, and interpretation.

Step 4: Educational Strategies

To facilitate achievement of educational goals and objectives, this step focused on course content design and determination of online instructional methods. For course content design, we first analyzed the demographics of targeted students, evaluated their background knowledge of data science (statistics, R programming, etc), and picked out some expected subtopics for the medical data mining course from the web-based questionnaire. This process allowed us to get some clarity regarding their diversity. Meanwhile, we investigated medical data mining–related courses that are offered in the leading colleges and universities, such as Stanford University, Harvard University, and Columbia University, so that we could note the differences between segments currently taught by these courses and what the students wanted to learn. Based on our abundant investigation and detailed analysis of the requirements, the overall scheme, as well as the targeted content of the course, was then established. We structured the course into eight sessions, with the first three sessions covering the general introduction of medical data mining and R programming, while the following five sessions introduced different medical data mining scenarios that delivered a transformative learning experience that would bring the students to their desired future state.

To meet content objectives and address the diversity of potential target learners, we intended to use a variety of instructional methods. We compared 41 teaching methods [32] to identify the appropriate ones for this course and discussed how to convert them into an online format. After summarizing the advantages and disadvantages of commonly used online teaching technologies and social media platforms (Multimedia Appendix 1), we chose Rain Classroom [33], Tencent Meeting [34], and WeChat [35] for their different instructional methods. Meanwhile, a specific medical data mining platform, named Medical Data Mining - R Programming Hub (MedHub) [36], was developed for self-learning (detailed in the Development of the Medical Data Mining Platform: MedHub section).

Step 5: Implementation

The course was open for registration in January 2020 and was online from May to July in the spring semester of 2020. To be qualified for diverse teaching units, our teaching team consisted of 6 investigators from different disciplines, including bioinformatics, medical informatics, statistics, and computer science. To familiarize both learners and participating faculties with online instruction, we, as well as the Graduate School, organized various trainings and provided technical assistance to troubleshoot issues during the course. With the online course, we could track all our students' progress, figure out how to design our course better, and tweak our teaching style. For example, if we saw that most students performed poorly on a certain chapter quiz, we would review the key points of that chapter and interpret the quiz questions in future iterations of the course.

Step 6: Evaluation and Feedback

According to anticipated learning outcomes, we clarified a specific measurable method for learners' cognitive and skill achievements. Meanwhile, we conducted a postcourse survey (detailed in the Postcourse Survey section) and a case study to validate the effectiveness of our online medical data mining course in benefitting a diverse group of medical postgraduates.

Web-Based Survey

Overview

We conducted pre- and postcourse surveys to understand students' views on the course. An online survey platform, WJX, was employed to collect survey data, and R (version 4.0.0; The R Foundation) was used for statistical analysis. Survey data were only available to teaching team members for the purpose of course development and assessment. All participants were informed that their responses would be used to inform public-facing research. The ethics committee of the Institute of Medical Information, Chinese Academy of Medical Sciences and PUMC, approved this study (IMICAMS/01/20/HREC).

Precourse Survey

The precourse questionnaire consisted of two main parts. The first part comprised a set of demographic questions to capture each participant's name, student ID, department or faculty, discipline, grade, and email address. The second part consisted of questions to acquire information about the students' mathematical foundation, programming experience (ie, R and other programming languages), and expectations about the course; expectations were collected in free-text format. Participants were recruited via a WeChat group, which consisted of postgraduates of PUMC who were interested in medical data mining. We collected data at the beginning of the spring semester in 2020 and exported them from the online survey platform to Microsoft Excel 2010. Standard descriptive statistics were used to summarize the data. Qualitative data were analyzed based on human-annotated results.

Postcourse Survey

The postcourse questionnaire contained 20 items grouped into three topics: course content assessment, online teaching methods assessment, and mastery of each teaching unit. Items that assessed attitudes toward course content included reasonable knowledge structure, front-edged teaching content, the content's integration with clinical practice and research, and practicality. The evaluation of online teaching methods mainly focused on the functions and teaching effects of four platforms: Rain Classroom, Tencent Meeting, WeChat, and MedHub. Responses to items under the topics "course content assessment" and "mastery of each teaching unit" were recorded on a scale that ranged from 1 ("very negative") to 5 ("very positive"). For the topic "online teaching methods assessment," we chose a 3-point scale with the options "dissatisfied" (score=1), "neutral" (score=2), and "satisfied" (score=3). Enrolled students and auditors were invited to participate in the survey. Data collection took place in July 2020.

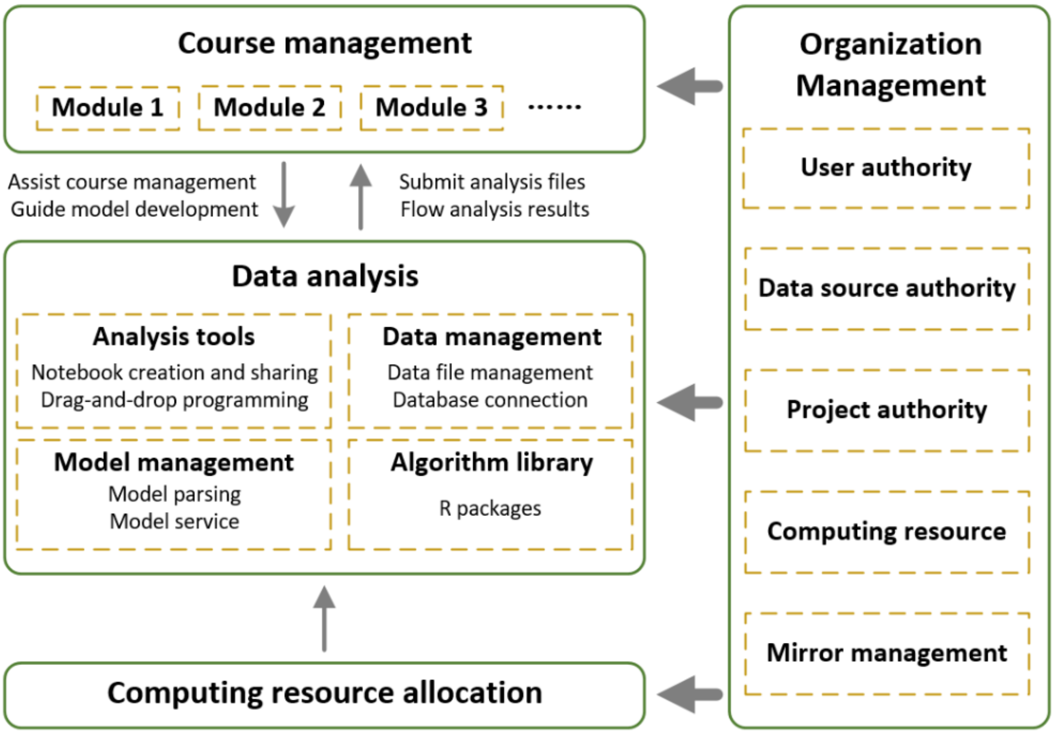
Development of the Medical Data Mining Platform: MedHub

We designed and developed MedHub [36] based on the Jupyter Notebook [37], aiming to help students build their computational thinking and avoid engineering troubles in the process of coding and environment configuration. Considering their limited available time [38]—especially under the influence of COVID-19 [39]—and diverse expectations, it was necessary to integrate multimedia learning materials into the platform to facilitate on-demand self-learning. As a result, MedHub consisted of four modules (Figure 2), as follows:

1. Computing resource allocation module. A Kubernetes-based [40] computing resource allocation module was used for automating deployment, scaling, and management of containerized applications. It could provide an online R programming workspace for authorized users. Once medical data mining tasks were performed, the customized workspace could allocate computing resources and produce the results.
2. Data analysis module. This module contained core functions required for medical data mining, including analysis tools, data management, model management, and algorithm library. It allowed authorized users to upload data sets, import R packages, and execute medical data mining tasks.
3. Course management module. This module was used to create courses, add course content (ie, multimedia files, data sets, projects, and homework), create and edit notebook courseware (eg, R markdown files), and manage homework.
4. Organization management module. This module was employed to help system administrators manage students, instructors, and groups; clarify access rights; assign different computing resources to different groups; and manage the mirror environment.

Website security was guaranteed through an authentication mechanism with usernames and passwords.

Figure 2. MedHub (Medical Data Mining - R Programming Hub) system architecture.



Results

Diversified Characteristics of Target Learners

A total of 200 medical postgraduates from 30 disciplines at PUMC participated in the precourse survey (Table 1). Most of them (n=137, 68.5%) were clinical students, majoring in internal medicine (n=57, 28.5%) and surgery (n=28, 14.0%), among other fields. The survey results showed that future physicians were indeed preparing for the era of data and digital health. Although 73.7% of clinical students (101/137) had no programming experience, the majority (108/137, 78.8%) had background knowledge of statistics, which could help them to understand data mining methods. Since 75.5% (151/200) of potential target learners had knowledge of statistics, we could pay less attention to mathematical fundamentals in the course. Compared with other disciplines, public health and preventive medicine students had a good foundation in statistics (17/17, 100%) and programming (12/17, 71%). For biology students, half of them had basic programming skills in R, while over half had knowledge of statistics (12/22, 55%). Meanwhile, survey data showed that students with programming experience were distributed across different disciplines. A total of 63% (45/72) had the ability to code in R, and 31% (22/72) knew at least two programming languages (eg, R and Python). Such distribution drove us to comprehensively consider the explanation of basic programming and the theoretical basis of data mining when designing course content. Meanwhile, the diversity of programming skills and data science background knowledge indicated the feasibility of collaborative learning.

We further analyzed the survey data available in textual format and summarized the participants' expectations for the medical data mining course (Table 2). It was worth noting that each participant might propose various concerns about the course. Survey data showed that the majority of respondents (68/109, 62.4%) were taking the course for research purposes. They expected to make use of omics data (33/109, 30.3%) and EHRs (20/109, 18.3%). Numerous open data sets were mentioned, including the Medical Information Mart for Intensive Care III [41], the Gene Expression Omnibus [42], and The Cancer Genome Atlas (TCGA) [43]. For clinical data, they realized the importance of information extraction and data cleaning and expected to master relevant skills. For omics data, they mainly wanted to learn how to analyze an open data set from start to finish. As 64.0% of participants (128/200) had no programming experience, 51 (25.5%) expressed their desire to develop practical skills in program coding. Their main concern was learning to use R programming languages to complete specific analysis tasks (33/109, 30.3%) and visualize results (11/109, 10.1%). Moreover, 35.8% of respondents (39/109) expected to understand the data mining methodology, especially machine learning (16/109, 14.7%). A total of 11.9% (13/109) of participants needed to build computational thinking, which would help them design data mining studies.

Table 1. Demographics of participants.

Demographics	Participants (N=200), n (%)
Academic discipline	
Clinical medicine	
Total	137 (68.5)
Internal medicine	57 (28.5)
Surgery	28 (14.0)
Oncology	13 (6.5)
Obstetrics and gynecology	10 (5.0)
Imaging medicine and nuclear medicine	7 (3.5)
Others	22 (11.0)
Biology	
Total	22 (11.0)
Biochemistry and molecular biology	17 (8.5)
Others	5 (2.5)
Public health and preventive medicine	
Total	17 (8.5)
Epidemiology and health statistics	15 (7.5)
Others	2 (1.0)
Basic medicine	
Total	9 (4.5)
Medical informatics	3 (1.5)
Stem cells and regenerative medicine	2 (1.0)
Others	4 (2.0)
Pharmaceutical science	
Total	7 (3.5)
Pharmacology	3 (1.5)
Others	4 (2.0)
Library, information, and archival sciences	6 (3.0)
Public management science	2 (1.0)
Training program	
Doctor of Medicine or Doctor of Philosophy	98 (49.0)
Master’s program	102 (51.0)
Background knowledge of statistics	
Yes	151 (75.5)
No	49 (24.5)
Programming experience	
No programming experience	128 (64.0)
Only R	23 (11.5)
Only other programming languages	27 (13.5)
R and other programming languages	22 (11)

Table 2. Participants' expectations about the course.

Expectations of the course	Participants (N=200), n (%)	Examples of typical statements[a]
Research		
Total participants taking the course for research purposes	68 (34.0)	N/A[b]
Expectations[c]		
Omics data analysis	33 (16.5)	我想学习基因的差异性表达分析. (I want to learn differential gene expression analysis.)
Clinical data analysis	20 (10.0)	希望学习如何从病历中提取数据进行研究. (I want to know how to extract and mine electronic medical record data.)
Text mining	2 (1.0)	对文本挖掘比较感兴趣. (I am interested in text processing.)
Others	18 (9.0)	希望能讲一下图像的影像组学，特别是神经影像. (I expect the course will include radiomics, especially neuroimaging.)
Programming		
Total participants taking the course to learn about programming	51 (25.5)	N/A
Expectations[c]		
R	33 (16.5)	期待应用R语言实现聚类分析等生信分析. (I look forward to using R to perform bioinformatics analysis such as cluster analysis.)
Draw function	11 (5.5)	希望会做火山图、热图、气泡图等. (I want to know how to generate volcano maps, heat maps, bubble maps, etc.)
General	11 (5.5)	希望代码示例能够有详细讲解或注释. (I would like the codes to be explained or commented on in detail.)
Others	2 (1.0)	熟悉常用医学统计软件使用. (I expect the course will help me get familiar with statistical software.)
Data analysis and mining methods		
Total participants taking the course to learn about data analysis and mining methods	39 (19.5)	N/A
Expectations[c]		
Machine learning	16 (8.0)	学习用临床数据制作手术前危险因素对术后预后的预测的临床预测模型. (I expect to learn how to use clinical data to establish a predictive model of preoperative risk factors for postoperative prognosis.)
Computational thinking	13 (6.5)	希望能够掌握数据挖掘的基本思路和方法. (I expect to master the basic ideas and methods of data mining.)
General	10 (5.0)	希望学会文献里常用的一些数据分析方法. (I expect to learn data analysis methods commonly used in scientific literature.)
Statistical analysis	7 (3.5)	学习不同的统计建模方法的原理和应用场景. (I expect to learn the principles and application scenarios of different statistical modeling methods.)
Deep learning	3 (1.5)	对深度学习有一定理解，初步进行分析. (I want to learn deep learning and be able to perform preliminary data analysis.)
Other expectations	11 (5.5)	希望能跟着老师做几个实际的案例. (I want to follow the teacher to do some cases.)
No expectations	91 (45.5)	N/A

[a]Example statements are reported in Chinese, followed by their English translations.

[b]N/A: not applicable; statements were provided only for specific expectations.

[c]Participants could have multiple expectations about the course.

Course Content Design Toward Improving Data Mining Practical Skills of Medical Postgraduates

According to the surveyed programming skills, experiences, background knowledge, and learning expectations of targeted students, we designed the course so that it focused on the combination of theory and practices to achieve good teaching outcomes. The designed content covered the theoretical introduction of expected subtopics as well as the relevant medical data mining cases and practical analyzing strategies. In this way, students could be highly engaged and could practice throughout the class. Generally, according to the curriculum arrangement, we structured the course into eight logical teaching units or sessions, each comprised of four theoretical lessons and two practical lessons. Considering that 64.0% (128/200) of learners had no programming experience, the first three sessions covered the general introduction of medical data mining and R programming. This would lay a foundation for the study and practice topics that would follow. Summarization of the participants' expectations for the medical data mining course showed that omics and clinical data analysis were hot domains in research, and the literature supports this [44-47]. In addition, many students were interested in the methods used for data analysis and data mining. Therefore, we designed five different medical data mining subtopics to be included in Sessions 4 to 8, to introduce commonly used data cleaning strategies, machine learning models, clinical text mining, gene expression analysis, and the transformation of medical data mining into online application tools (Table 3). Each session would summarize the basic research methods and the recent progress in the theoretical portion, while the practice lesson would demonstrate how to complete a specific health care analytic application from start to finish using R. To accommodate diverse medical students, we included diversified health care analysis scenarios (eg, gene expression analysis and clinical named entity recognition [CNER]), diversified data types (eg, omics data and EHRs), and associated data mining techniques (eg, using R packages to perform CNER based on conditional random fields [CRFs]).

The last session would be the final exam. Based on anticipated learning outcomes and student perceptions, we designed a three-step method to assess student achievement:

1. Problem-solving case study (30% of their final mark). Students needed to apply R to solve practical problems, such as handling outliers in a specified data set.
2. Reading report (30% of their final mark). Students needed to write reading reports to show how much information they understood and grasped from a medical data mining paper.
3. Group project (40% of their final mark). Students were divided into groups. Each group collaborated to complete a complex data mining project and gave an oral presentation.

Faculty members involved in the course would give a comprehensive score based on students' performance in these three aspects.

Table 3. Optimized course content.

Week and module	Teaching content
Week 1. Introduction to medical data mining	1. Conceptual introduction to medical data mining, as well as the ideas behind turning data into actionable knowledge. 2. Practical introduction to tools (R and RStudio) that will be used in the program.
Week 2. R programming (1)	1. Install and configure software necessary for programming environment. 2. Introduction to R basic programming, including accessing R packages, import data with R, R functions, and data visualization. 3. Examples for profiling R code.
Week 3. R programming (2)	1. Descriptive and exploratory data analysis with R (t test, regression models, generalized linear models, etc) and R markdown. 2. Examples for profiling R code.
Week 4. Data acquisition and cleaning	1. Data interface with R, which will cover the basic ways that data can be obtained. 2. Data cleaning with R (missing values, outliers, error data, and inconsistent data). 3. Examples for profiling R code.
Week 5. Machine learning models for medical data	1. Introduction to a range of machine learning models, as well as the process of building and applying prediction functions with emphasis on practical applications with R programming. 2. Examples for profiling R code.
Week 6. Clinical text mining	1. Conceptual introduction to text mining. 2. Summarization of methods and workflow for medical text mining. 3. Case study: clinical named entity recognition for electronic health records.
Week 7. Data mining for biomarker discovery	1. Introduction to computer-aided biomarker discovery. 2. Regular pipeline for gene expression analysis with R. 3. Case study: differential gene expression analysis.
Week 8. Development of medical data mining tools	1. Introduction to interactive web application construction, including the basics of creating data products using Shiny, R packages, and interactive graphics. 2. Case study: development of medical data mining tools.
Week 9. Exam and final presentation	1. Assessment method: oral presentation of group projects; the primary measure is the understanding and knowledge of tools and ideas for medical data mining.

Teaching Strategies Using Internet Technology

Instructional Methods for Online Teaching

To meet content objectives and various expectations, we adopted eight instructional methods for our online course (Table 4). Demonstration, problem solving, and a group project were core methods of skill education [48], while self-learning was a modern method emerging with the rise of the internet. Note that students in collaborative learning groups should be as diverse or heterogeneous as possible. In this way, students with different background knowledge or skills could strengthen their existing skills by teaching others and, in turn, learn new skills from other group members.

Accordingly, we selected three online platforms and developed MedHub to convert instructional methods into an online format (Table 4). Roughly, Rain Classroom, Tencent Meeting, and WeChat were used for theoretical lectures, live demonstrations, and discussion, respectively, while MedHub was used for self-learning (detailed in MedHub for Self-learning section) and homework submission. For the case study, the instructor would use Rain Classroom to present case content and establish a framework for analysis and would then use Tencent Meeting to lead students to solve the case in real time.

Since each module consisted of independent activities, discussions, required reading, individual or group tasks, and flexible use of various platforms, students could learn on demand or by preference.

Table 4. Online platforms corresponding to instructional methods.

Instructional method	Online platform			
	Rain Classroom	Tencent Meeting	WeChat	MedHub[a]
Lecture	✓[b]			
Demonstration		✓		
Discussion			✓	
Case study	✓	✓		✓
Problem solving				✓
Self-learning	✓			✓
Reading report				✓
Group project		✓	✓	

[a]MedHub: Medical Data Mining - R Programming Hub.

[b]Check marks signify that the indicated platforms were used for the indicated methods.

MedHub for Self-learning

MedHub, a web-based application, allowed students to learn by themselves on demand. To achieve this, instructors needed to organize multimedia learning materials for each teaching unit (PowerPoint courseware, data sets, codes, videos, papers, websites, etc) in a structured manner. For case studies, they could share R markdown files containing live code, equations, graphics, visualizations, and narrative text. Experimental data might be provided in a separate file (eg, a comma-separated values file) or be imported programmatically; for instance, by including code in the notebook to download the data from a public internet repository. For the computing environment, system administrators configured the platform with the R environment (version 3.6.0; The R Foundation) as well as packages commonly used in biomedical data mining. Meanwhile, they grouped students according to their characteristics and clarified their access rights to different resources. Authorized students could access various learning materials. Since MedHub provided an online programming workspace with a customized environment, students could create a copy of the R markdown file and run code segments via a web browser (Figure 3). They could also write code based on their own data. Once the code was executed, the platform would allocate computing resources and produce the results so that students could learn how the code worked line by line, with live feedback along the way.

Figure 3. Example of case study in MedHub (Medical Data Mining - R Programming Hub).

Practicable Implementation and Demonstration

In 2020, the outbreak of COVID-19 disrupted normal teaching and studying in the field of medical education. To ensure the orderly progress of teaching work, online teaching was put forward by the Graduate School of PUMC. This 9-week course was online from May to July in the spring semester of 2020, with one module per week (roughly 4 hours of student engagement time per week). A total of 6 faculty members and

317 students participated in the course, of which 48 were enrolled students and 269 were auditors.

The practicable implementation of the medical data mining course contained the following aspects. For the theoretical teaching portion, educational resources (PowerPoint courseware, data sets, codes, videos, etc) were provided to students in advance for prelearning through Rain Classroom, the WeChat group, and MedHub. During the class, the instructor conducted theoretical lectures by entering Rain Classroom from the PowerPoint slideshow. Once students used WeChat to scan a QR (Quick Response) code to enter the Rain Classroom, the PowerPoint courseware was synchronized with their mobile phones (Figure 4). Students internalized knowledge under the guidance of the instructor, and they gave feedback using multiple interactive methods, such as bullet-point screen comments and the “do not understand” button.

For the practical teaching portion, instructors used Tencent Meeting to demonstrate how to perform data analysis operations in RStudio (Figure 5). After joining the video conference via their mobile phones, students followed the instructor to complete relevant operations synchronously on their own computers. To practice complex cases such as CNER, which comprised data preparation, dictionary-based CNER, CRF-based CNER, and evaluation, MedHub was used instead of RStudio. When programming errors occurred, students preferred to send instant messages or upload screenshots in the WeChat group for help. Other faculty members and students would give solutions based on their experience.

Figure 4. Screenshot of a theoretical lecture in Rain Classroom.

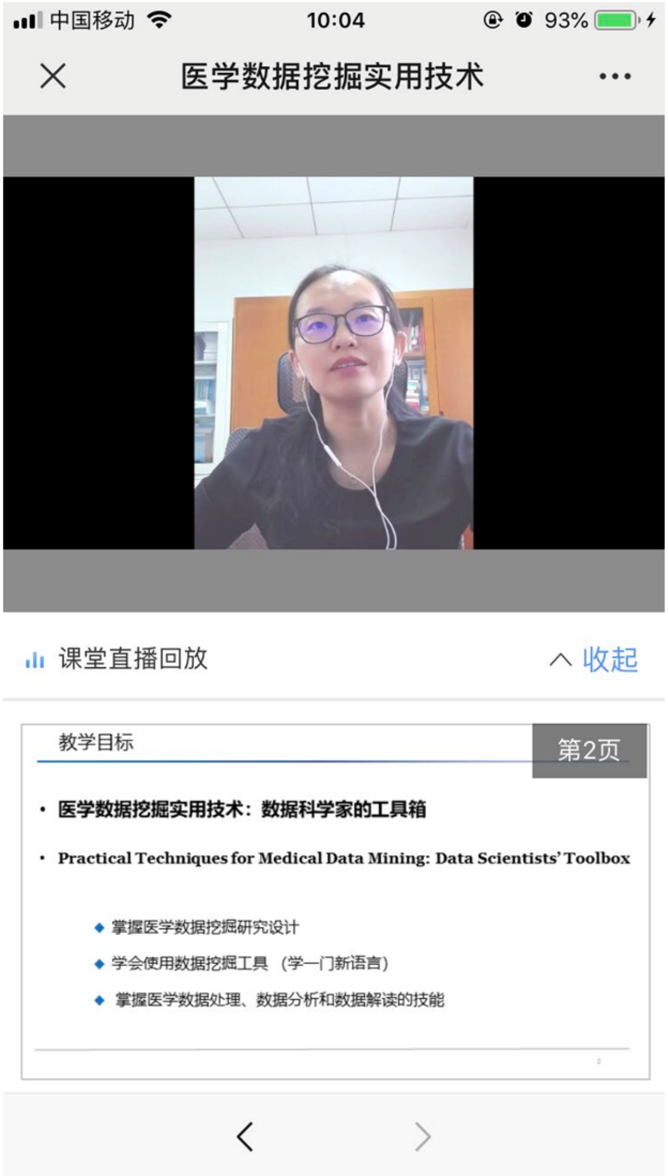
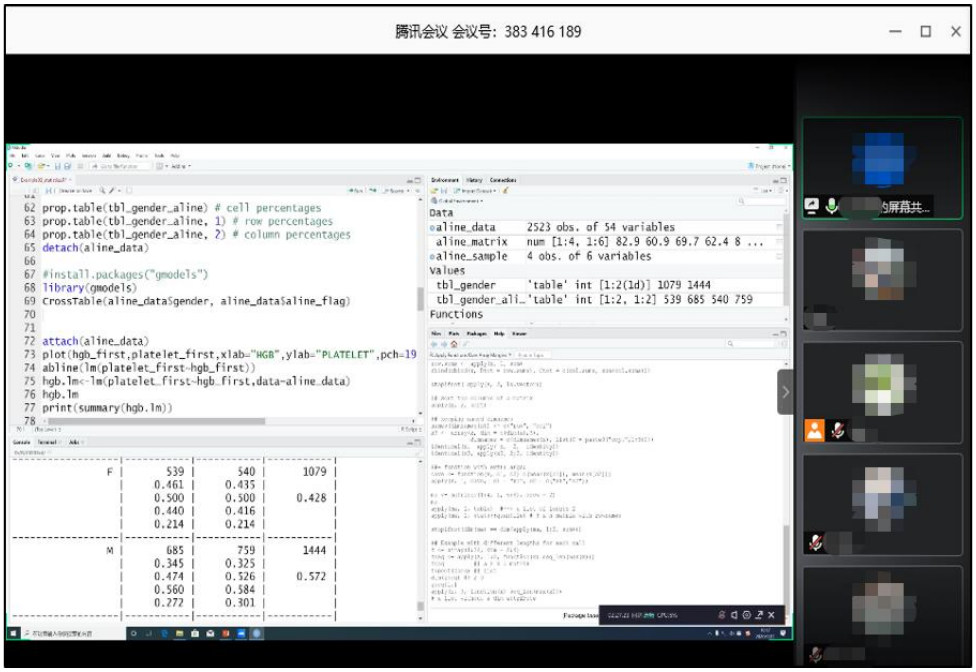


Figure 5. Screenshot of a live demonstration using RStudio in Tencent Meeting.



After the class, students could review what they had learned, and they completed individual and group tasks (ie, problem-solving case studies, reading reports, and group projects) that were released by the instructor to reinforce their skills. For the final group project after 1 month, 48 enrolled students were divided into eight groups. Each group had a leader who was responsible for organizing group members to discuss and complete the group project, as well as a tutor who aimed to give guidance. Group members selected a project from a given list, designed their research, and used R to perform data cleaning, modeling, and visualization, among other tasks. Finally, an oral presentation was given to show the whole process (Figure 6). All of the faculty members assessed each group member according to their performance in the project as well as in the question-and-answer session.

Figure 6. Screenshot of a group presentation in Tencent Meeting.

Course Assessment

To validate the effectiveness of our online medical data mining course in benefitting medical postgraduates with diverse backgrounds, we conducted a postcourse survey with a total of 83 participating students (Table 5). Survey data showed that they found our course to be very practical (n=83, 100% indicated "very positive" or "positive"). A total of 82% (n=68) of the students stated that the content integrated highly with their clinical or scientific problems. For online learning methods, MedHub received the best feedback, both in function (n=80, 96% chose "satisfied") and teaching effect (n=80, 96% chose "satisfied"), while Rain Classroom performed poorly in function (n=63, 76% chose "satisfied"). In addition, participants' mastery of the content gradually decreased with the progress of the course: average self-rating scores ranged from 4.78 (SD 0.44) to 4.00 (SD 1.02). Starting from Module 5, several students were unable to keep up with the course at all (n=2, 2% chose "very negative"). Even so, the majority of respondents could master relevant knowledge and skills for each module: responses of "very positive" or "positive" were given by 82 (99%) respondents for Module 1; 78 (94%) respondents for Module 2; 75 (90%) respondents for Module 3; 70 (84%) respondents for Module 4; 64 (77%) respondents for Module 5; 61 (73%) respondents for Module 6; 65 (78%) respondents for Module 7; and 57 (69%) respondents for Module 8.

Table 5. Participants' feedback regarding the course (n=83).

Feedback item	Score, mean (SD)
Course content[a]	
Reasonable knowledge structure	4.86 (0.39)
Front-edged teaching content	4.82 (0.39)
Good integration with clinical practice and research	4.81 (0.43)
Practicality	4.89 (0.31)
Online teaching methods[b]	
Rain Classroom	
Platform function	2.73 (0.50)
Teaching effect	2.89 (0.35)
Tencent Meeting	
Platform function	2.86 (0.35)
Teaching effect	2.90 (0.30)
MedHub[c]	
Platform function	2.96 (0.19)
Teaching effect	2.96 (0.19)
WeChat	
Platform function	2.94 (0.24)
Teaching effect	2.93 (0.26)
Mastery of each module[a]	
Module 1. Introduction to medical data mining	4.78 (0.44)
Module 2. R programming (1)	4.60 (0.68)
Module 3. R programming (2)	4.46 (0.80)
Module 4. Data acquisition and cleaning	4.37 (0.81)
Module 5. Machine learning models for medical data	4.16 (0.96)
Module 6. Clinical text mining	4.10 (0.97)
Module 7. Data mining for biomarker discovery	4.14 (0.96)
Module 8. Development of medical data mining tools	4.00 (1.02)

[a]Responses to items under this topic were recorded on a scale ranging from 1 ("very negative") to 5 ("very positive").

[b]Responses to items under this topic were recorded on a scale ranging from 1 ("dissatisfied") to 3 ("satisfied").

[c]MedHub: Medical Data Mining - R Programming Hub.

Discussion

Principal Findings

The growing demand for data mining skills among medical postgraduates prompted us to develop an online medical data mining course at PUMC, exploring how to improve the data mining skills of medical students with a wide range of academic backgrounds and programming experience. According to a six-step approach for course development, combining student expectations and new internet technologies, the course was successfully launched in the spring semester of 2020. Once online, it attracted wide attention, and a total of 317 students participated in the course. Postcourse survey data showed that our course was very practical (n=83, 100% indicated "very positive" or "positive"), and MedHub received the best feedback, both in function (n=80, 96% chose "satisfied") and teaching effect (n=80, 96% chose "satisfied").

Our course design was learner centered. To understand who our students were, we used a precourse questionnaire survey to get some clarity regarding their academic backgrounds and programming experience (Table 1). Survey data showed that 68.5% (137/200) of respondents were clinical students, which was consistent with the findings from Stanford Medicine [2]. However, 73.7% (101/137) of students had no programming experience, even though the majority (108/137, 78.8%) had background knowledge of statistics. The data revealed that the lack of necessary background knowledge and skills was the main obstacle to medical data mining education, which has also been verified in bioinformatics education [8]. To minimize the prerequisites, we introduced the basic knowledge and skills of R programming at the beginning of the course, aiming to lay a foundation for the study and practice topics that would follow. According to the responses, 94% (78/83) and 90% (75/83) of the participants were able to master relevant knowledge and skills in Modules 2 and 3, respectively.

The precourse survey was also used to collect, analyze, and interpret the diverse concerns and expectations of our potential learners (Table 2). The survey results showed that the majority of students (68/109, 62.4%) took the course for research purposes and many expected to make use of omics data (33/109, 30.3%) and EHRs (20/109, 18.3%). Thereby, the optimized course covered data acquisition and cleaning, machine learning modeling, clinical data mining, omics data mining, and other content that the students cared about. Simultaneously, a team of teachers with multidisciplinary backgrounds were equipped to teach the course content. To help students translate theoretical knowledge into necessary data mining skills, we developed some representative and typical programming examples or case studies—including "predicting mortality of ICU (intensive care unit) patients," "differential gene expression analysis," and "CNER"—for each module, which could assist the students in gaining a rapid understanding of the problem-solving process. These case studies were also chosen to ensure that a variety of techniques were available as useful tools to help students answer the questions. Data mining tasks based on open accessible data sets were introduced in our course as data mining case studies. Strictly following the data access permission, we used the demo codes in the textbook [49] and task publications [50-53] and required the students to apply for data use permissions according to their corresponding licenses. Responses from students indicated that the content integrated highly with their clinical or scientific problems (68/83, 82% chose "very positive") and that the knowledge structure was highly reasonable (72/83, 87% chose "very positive"). Meanwhile, 77% (64/83) of the students pointed out that the case studies were very helpful for understanding medical data mining knowledge and skills. This indicated that our learner-centered approach was effective for skill-based education, which has been validated by existing research on competency-based education [54,55]. Nevertheless, some content might be difficult for students with weak foundations (2/83, 2% chose "very negative"). In the future, we will design the complex sessions (ie, Sessions 4 to 8) with scenarios, which will be divided into step-by-step and operable units from medical data processing to machine learning model installation. Thus, it will help the students understand the content.

To convert the offline course to an online format, various kinds of online platforms, such as Rain Classroom, Tencent Meeting, WeChat, and MedHub, were used for different instructional methods (Table 4). Relationships between classroom teaching, online teaching, and students' self-learning are established through mobile phones to achieve long-term efficiency in teaching. Through course implementation, we found that the online format attracted more students to participate in the course. We started by creating a WeChat group that involved 48 enrolled students in order to facilitate communication. Later, more students joined the group via invitations from their classmates. The number of group members exceeded 300 within a few days, which increased the diversity of the students. According to our observations, students with a good foundation in programming and background knowledge were active in the online environment. They were willing to share learning materials and help others, which enabled us to achieve good results in group projects. Eight groups were able to flexibly use knowledge and skills learned to solve various clinical and scientific research problems based on diverse data sets. Some even used algorithms, models, and R packages that were not included in the course.

MedHub, a medical data mining platform, performed impressively as part of our online course. It received the best feedback, both in function (80/83, 96% chose "satisfied") and teaching effect (80/83, 96% chose "satisfied"). Among all its functions, shared R markdown files containing live code, visualizations, and narrative text were considered the most helpful for authorized students (67/83, 81%), followed by one-stop navigation and downloading of learning materials (61/83, 73%). Students with a poor foundation in programming reported that it was difficult to keep up with instructors to complete operations synchronously on their own computers. The abundant learning resources and demonstration of case studies on MedHub enabled students to review what they had learned and to avoid omissions after class, especially for content that was hard to understand and master. For those with a good foundation in programming and background knowledge, providing more advanced knowledge and skills was important. The online programming workspace with customized environment on MedHub helped them to explore their own data sets, and the extended reading materials allowed them to expand their knowledge. Compared with other biomedical data mining platforms (eg, DrBioRight [56]), our web-based application had an educational purpose, aiming to accommodate a diverse group of medical students.

To validate the effectiveness of our online medical data mining course in helping to improve the data mining skills of medical students with diversified academic backgrounds and programming experience, we randomly selected one group to conduct a case study. Out of 6 group members, 4 (67%) participated in the pre- and postcourse survey; they were majoring in internal medicine, surgery, oncology, and information science. The group leader had no programming experience. From this course, he expected to learn R and analytic applications related to clinical and basic medicine. Through our 9-week course, he was able to lead the group to complete a project—“基于数据挖掘的胃癌微环境及单基因分析” (“Microenvironment and Single Gene Analysis of Gastric Cancer Based on Data Mining”)—by applying the data mining workflow he designed. In addition, he was able to use R to perform microenvironment analysis and visualize the results. The group member who was majoring in oncology had neither programming experience nor statistical knowledge. The precourse survey results showed that she expected the course to teach her how to mine TCGA data. After the course, she was able to use R and Perl to integrate the clinical and transcriptome data of gastric cancer patients from TCGA into a matrix, so that other group members could perform microenvironment analysis and single gene analysis. The group member who was majoring in internal medicine had basic programming skills in R and wanted to learn more advanced data mining techniques. His feedback showed that vivid health care analysis cases in the course made obscure machine learning algorithms easy to understand. He had been able to apply the knowledge and techniques learned to solve his own data mining tasks and had obtained extended learning materials for further study. The group member who had the ability to code in other programming languages expressed his desire to master R. According to his postcourse self-evaluation, he was able to master relevant knowledge and skills from each module (five modules were rated as “very positive,” while others were rated as “positive”). In addition, he was able to collaborate with other group members to complete the analysis of a data set from start to finish using R. This case study showed that our course was able to fill the gap between students’ expectations and learning outcomes, regardless of their academic backgrounds, programming experience, and motivations.

To prepare medical students for data-driven research and the new era of data and digital health, it would be ideal for medical schools to provide a series of medical data mining courses for diverse medical students. Considering that achieving this is currently difficult for most medical schools, incorporating diversity into course content and teaching methods in a medical data mining course has become important. Previous studies have demonstrated diversified course content and teaching methods in neuroscience and nursing [57,58]. However, medical data mining courses still lack exploration. Thereby, we demonstrated how to incorporate diversity into a medical data mining course in a medical school. Our experience showed that designing course content and online instructional methods that accommodated the diversified characteristics of medical students was an effective method of course development. The results showed that our course was able to fill the gap between student expectations and learning outcomes. This process could be helpful to course designers in similar situations.

Limitations

Our study has two limitations. First, we did not compare learners’ data mining skill levels before and after the class to validate the effectiveness of our online course in improving data mining skills. Instead, we used the self-evaluation of learners in a postcourse survey and a case study, which might make the results somewhat subjective. We will conduct more rigorous validation in the future.

Second, our online course has not yet been accredited by an external organization. After this pilot study has demonstrated the feasibility of the medical data mining course at PUMC, we will apply for a training program from the Chinese Medical Association [59] and the Chinese Society of Academic Degrees and Graduate Education [60].

Conclusions

In this study, we integrated student expectations and new internet technologies to develop an online medical data mining course, titled “Practical Techniques of Medical Data Mining” (No. INSC11011), for medical students with a wide range of academic backgrounds and programming experience. Its successful application in postgraduate medical education at PUMC indicates that designing course content and online instructional methods that accommodate diversified characteristics of medical students is effective for the development of a data mining course in medical school. The diverse course content, along with representative programming examples and case studies, could meet the different expectations of targeted learners and minimize the prerequisites. In addition, the use of different instructional methods and online platforms had advantages in flexibility, which could accommodate a diverse group of medical students. The results showed that our course was able to fill the gap between student expectations and learning outcomes. In the future, we will further optimize our online course, complete the comparison of learners’ data mining skill levels before and after the class, and complete external validation.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Advantages and disadvantages of online platforms.
[DOCX File , 16 KB - mededu_v7i4e24027_app1.docx]

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Abbreviations

CNER: clinical named entity recognition
CRF: conditional random field
EHR: electronic health record
ICU: intensive care unit
MedHub: Medical Data Mining - R Programming Hub
PUMC: Peking Union Medical College
QR: Quick Response
TCGA: The Cancer Genome Atlas

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Original Paper

e-Learning and Web-Based Tools for Psychosocial Interventions Addressing Neuropsychiatric Symptoms of Dementia During the COVID-19 Pandemic in Tokyo, Japan: Quasi-Experimental Study

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Abstract

Background: Concern has been raised that the COVID-19 pandemic and consequent social distancing measures may increase neuropsychiatric symptoms in people with dementia. Thus, we developed and delivered an e-learning training course to professional caregivers on using a web-based tool for psychosocial interventions for people with dementia.

Objective: The aim of our study was to evaluate the feasibility and efficacy of an e-learning course in combination with a web-based tool in addressing neuropsychiatric symptoms of dementia.

Methods: A quasi-experimental design was used in Tokyo, Japan. The e-learning course was delivered three times to professional caregivers between July and December 2020. Caregivers who completed the course assessed the level of neuropsychiatric symptoms in people with dementia using the total score from the Neuropsychiatric Inventory (NPI) via a web-based tool. The primary outcome measures were the number of caregivers who implemented follow-up NPI evaluations by March 2021 and the change in NPI scores from baseline to their most recent follow-up evaluations. As a control group, information was also obtained from professional caregivers who completed a face-to-face training course using the same web-based tool between July 2019 and March 2020.

Results: A total of 268 caregivers completed the e-learning course in 2020. Of the 268 caregivers, 56 (20.9%) underwent follow-up evaluations with 63 persons with dementia. The average NPI score was significantly reduced from baseline (mean 20.4, SD 16.2) to the most recent follow-up evaluations (mean 14.3, SD 13.4). The effect size was assumed to be medium (Cohen $d_{\text{rm [repeated measures]}}$=0.40). The control group consisted of 252 caregivers who completed a face-to-face training course. Of the 252 caregivers, 114 (45.2%) underwent follow-up evaluations. Compared to the control group, caregivers who completed the e-learning course were significantly less likely to implement follow-up evaluations (χ^2_1=52.0, P<.001). The change in NPI scores did not differ according to the type of training course (baseline-adjusted difference=–0.61, P=.69).

Conclusions: The replacement of face-to-face training with e-learning may have provided professionals with an opportunity to participate in the dementia behavior analysis and support enhancement (DEMBASE) program who may not have participated in the program otherwise. Although the program showed equal efficacy in terms of the two training courses, the feasibility was suboptimal with lower implementation levels for those receiving e-learning training. Thus, further strategies should be developed to improve feasibility by providing motivational triggers for implementation and technical support for care professionals. Using online communities in the program should also be investigated.

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KEYWORDS

dementia; home care services; implementation science; nursing homes; web-based tool

Introduction

Dementia is a public health concern since people are living longer and age increases the risk of dementia. Globally, the total number of people with dementia was estimated to be 46.8 million in 2015 and is projected to rise to 131.5 million by 2050 [1]. Dementia is chronic and progressive in nature, caused by a variety of brain illnesses that affect memory, thinking, behavior, and ability to perform everyday activities. It is estimated that 5% to 8% of the general population aged 60 years and over, at any given time, have dementia. Dementia affects individuals, their families, and the economy, with global costs estimated at approximately US $1 trillion annually [2]. Japan also faces an expected increase in the number of people with dementia. This number is estimated to reach 10.2 million by 2050, accounting for 10% of the total population [3].

The COVID-19 pandemic has disproportionately impacted people living with dementia [4]. The severity and mortality of COVID-19 worsens with age [5] and in individuals with pre-existing illnesses, such as hypertension and diabetes [6,7], which are common in people with dementia [8]. Furthermore, people with dementia may not understand or remember the required COVID-19 preventive measures, such as wearing a facial mask, physical distancing, and hygiene, because of their cognitive impairment [9].

Concern has been raised that the COVID-19 pandemic and consequent social distancing measures may increase neuropsychiatric symptoms in people with dementia [10]. Neuropsychiatric symptoms, such as shouting, wandering, agitation, resistance to care, depression, anxiety, apathy, and other behaviors, are considered expressions of distress in people with dementia. Neuropsychiatric symptoms are common in people with dementia both in the community [11] and in nursing homes [12], resulting in higher psychotropic drug use [13] and increased mortality [14]. Women are more likely to exhibit a broader range of symptoms compared to men [15]. Since neuropsychiatric symptoms represent unmet needs and distress, psychosocial interventions are globally recommended as first-line treatments to target the underlying causes [4]. Social distancing measures related to the COVID-19 pandemic, such as home confinement and restrictions on visitors for nursing home residents, imposed a risk for social isolation and/or loneliness and they limited physical activity for people with dementia [16]. This has been shown to negatively impact neuropsychiatric symptoms, such as anxiety and depression [17-19], in people with dementia and to cause further cognitive and functional decline [17,20]. However, some nursing home residents in the Netherlands were reported to have decreased neuropsychiatric symptoms, such as agitation and aggression, due to a reduction in overstimulation [21]. Therefore, monitoring the potential long-lasting effects of COVID-19 on neuropsychiatric symptoms and the effectiveness of interventions delivered remotely through technology is warranted [4,10].

To address neuropsychiatric symptoms, a face-to-face training course was delivered with a web-based tool to professional caregivers who participated in the psychosocial dementia behavior analysis and support enhancement (DEMBASE) program. The results of a cluster-randomized controlled study indicated that DEMBASE is effective in reducing neuropsychiatric symptoms in people with dementia [22]. Based on these results, the Tokyo Metropolitan Government introduced the DEMBASE program into the daily practice of professional caregivers in 2018 [23].

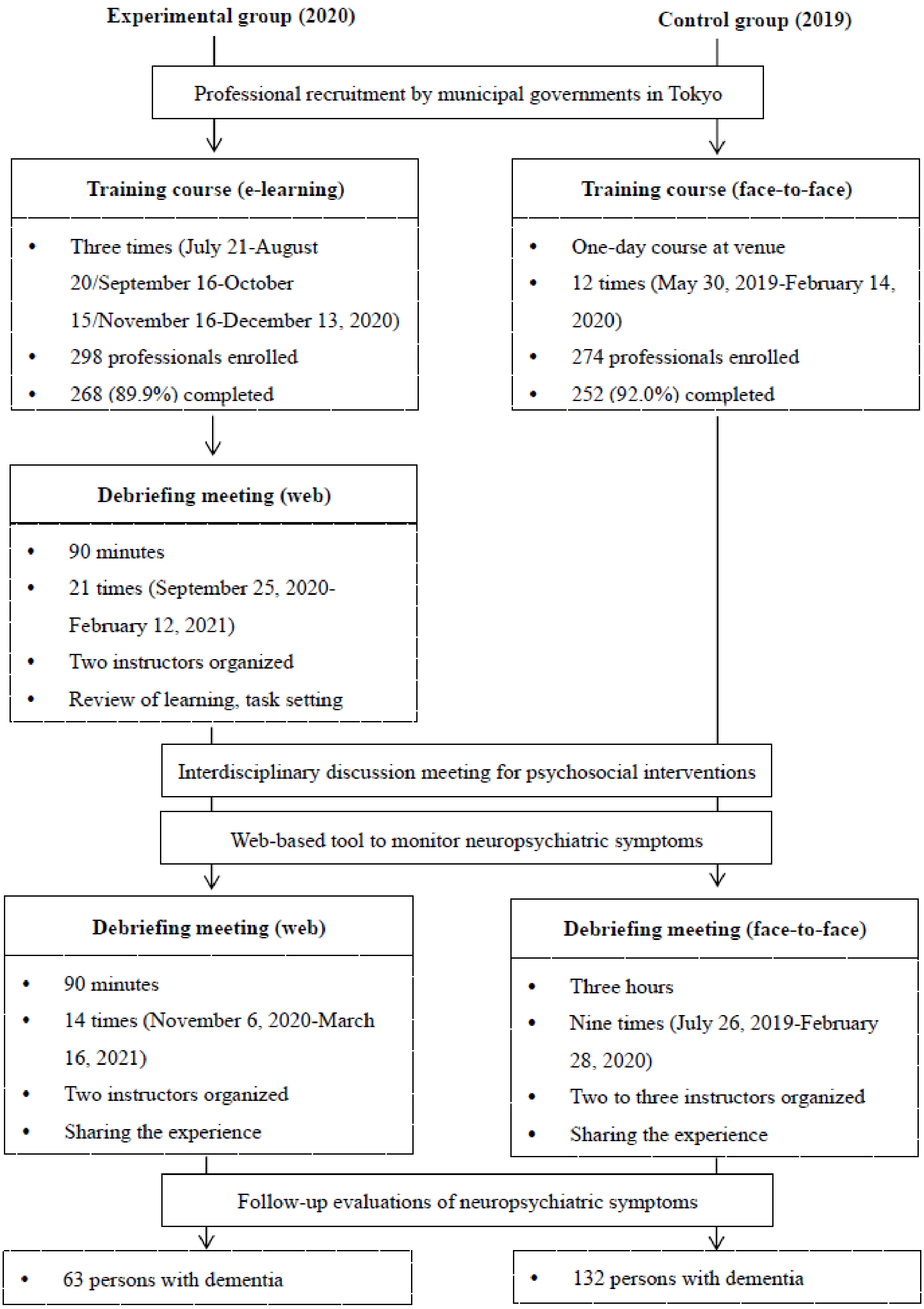
Although the demand for e-learning platforms is emerging among essential care workers, no evaluation exists that tests the feasibility and efficacy of the digital transformation of the psychosocial dementia care program for neuropsychiatric symptoms. Therefore, we developed an e-learning training course for professional caregivers using a web-based tool for psychosocial interventions for people with dementia in Tokyo, Japan. The e-learning course aimed to replace the face-to-face training course to avoid group gatherings during the COVID-19 pandemic in 2020. Furthermore, this study evaluated the feasibility and efficacy of the e-learning course combined with a web-based tool in addressing neuropsychiatric symptoms of dementia. We hypothesized that the e-learning course would sustain the efficacy in reducing neuropsychiatric symptoms because the interventions include discussions with a multidisciplinary discussion team. Feasibility, as measured by the percentage implementation, was anticipated to be lower in the e-learning training course due to reduced availability of human resources during the COVID-19 pandemic.

Methods

Design

A quasi-experimental, longitudinal design was used (Figure 1). The experimental group consisted of 268 professional caregivers who completed the e-learning course and participated in the DEMBASE program between July 2020 and March 2021. The control group consisted of 252 professionals who completed a face-to-face training course and participated in the program between May 2019 and March 2020.

Figure 1. Flow of the psychosocial dementia care program in the experimental (e-learning course) and control (face-to-face training) groups.



Procedure

Data were collected in naturalistic long-term care settings from April 2019 to March 2020 for the control group, and from April 2020 to March 2021 for the experimental group. Each municipal government independently decided whether to apply for the fund, which was approved for use in the recruitment of care providers and other professionals and in conducting a training course among all participating professionals.

All professionals were informed of their voluntary participation during the recruitment process, and their application to participate was regarded as consent. Participating professionals acquired informed consent from persons with dementia and/or their family members prior to providing care.

Since the e-learning training course was introduced by the government in response to the COVID-19 pandemic, we could not determine the sampling process and sample size a priori for this study. We anticipated that the rate of implementation would be 15% lower in the experimental group compared to the control group. The rate of implementation in the control group was expected to be equal to that in our previous study (46.4%) [23]. Therefore, the desired sample size of professionals was 283 per group, which was calculated using G*Power software (version 3.1.9.7; Heinrich-Heine-Universität Düsseldorf) [24,25].

Participants

Care professionals working as long-term service providers were invited to participate in the DEMBASE program. Potential participants included care managers, nurses, and other direct care workers who worked for providers that were accredited by the public long-term care insurance program. We included all the professionals who applied to participate in the program. Participant recruitment was conducted by each municipality that applied to the program. In 2019, 10 municipalities participated in the face-to-face training course. The number of participating municipalities increased to 23 in 2020; this was due to the availability of e-learning.

The approaches for the recruitment process, therefore, varied according to municipality-based choices (eg, an application form on a website, an oral invitation sent to 3-4 providers, and holding a seminar for the directors of the providers). Under the funding rule established by the Tokyo Metropolitan Government, the DEMBASE program was made available for in-home care management agencies, in-home care services, and residential care services. In-home care management agencies handle monthly care plans for in-home care recipients and are independent from the providers of in-home care services. In-home care service providers offer direct care to individuals who live in their houses. Residential care service providers offer a residential care package to individuals who reside in facilities, and they handle the monthly care plans for their care recipients.

Intervention

Overview

The DEMBASE program was comprised of (1) a training course, (2) an interdisciplinary discussion meeting (analysis), (3) a web-based tool for ongoing behavioral assessments (dementia behavior), and (4) a debriefing meeting (support enhancement). The timing of the training course and debriefing meetings varied by municipality (Figure 1). The characteristics of the programs in both groups are summarized in Table 1.

Table 1. Characteristics of the dementia behavior analysis and support enhancement (DEMBASE) program in the experimental group (e-learning) and control group (face-to-face training course).

Program characteristic	Experimental group	Control group
Time period	• July 21, 2020-March 31, 2021	• May 30, 2019-March 31, 2020
Training course details	• e-Learning delivery • 5.5 hours on average	• Face-to-face delivery • 1-day course at venue
Interdisciplinary discussion meeting: action items	• Evaluation of neuropsychiatric symptoms • Specification of unmet needs • Establishment of an interdisciplinary action plan	• Evaluation of neuropsychiatric symptoms • Specification of unmet needs • Establishment of an interdisciplinary action plan
Web-based tool: contents	• Neuropsychiatric Inventory (NPI) • Basic physical needs and environmental sources of discomfort • Prescribed medication for the nervous system	• Neuropsychiatric Inventory (NPI) • Basic physical needs and environmental sources of discomfort • Prescribed medication for the nervous system
Debriefing meeting details	• Zoom meeting • Two meetings, 90 minutes each • First meeting: review of learning and setting a task • Second meeting: sharing the experience of the program	• Face-to-face meeting • 1 day, 3 hours at venue • Sharing the experience of the program

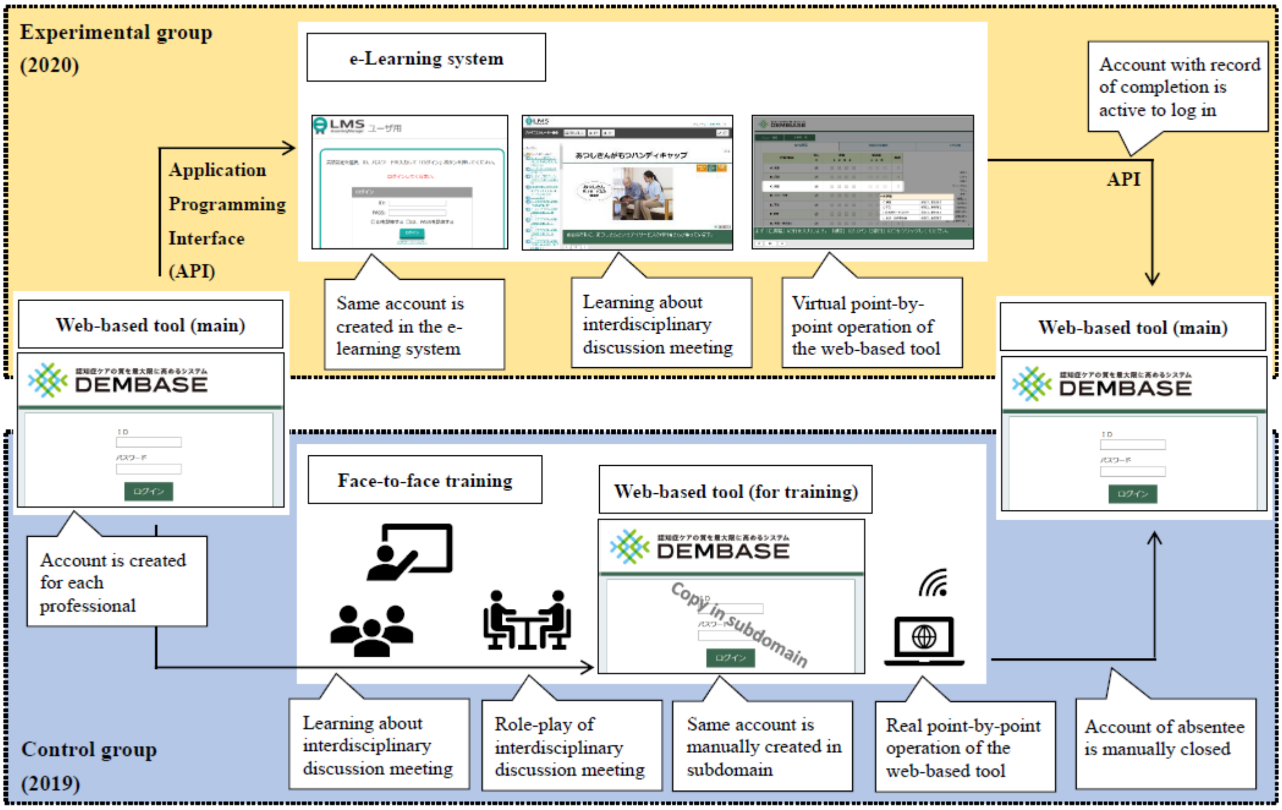
Training Course

Overview

The training course guided (1) the process of an interdisciplinary meeting to evaluate neuropsychiatric symptoms, specify unmet needs using a 23-item checklist, and establish an action plan using an interdisciplinary approach; (2) the implementation of the action plan; and (3) the use of the web-based tool.

The training course was based on the consideration of neuropsychiatric symptoms as communicating unmet needs [26-28]. Based on global evidence, psychosocial interventions including goal setting, such as providing pleasant activities, providing outdoor activities, and removal of environmental triggers, were recommended to address these unmet needs [29]. The web-based tool was explained to each participating professional during the training course (Figure 2). Further details regarding the training components and topics of discussion from debriefing meetings are reported elsewhere [23].

Figure 2. Web-based tool and training course of the program. DEMBASE: dementia behavior analysis and support enhancement.



e-Learning Training Course and Web-Based Debriefing Meeting

The e-learning training course was delivered thrice to 298 professional caregivers between July and December 2020. Of the 298 caregivers, 268 (89.9%) completed the course. On average, professionals spent a total of 331.1 (SD 262.3) minutes to complete the course. The e-learning system was developed based on the framework provided by the Ginger App Company. The course included learning about interdisciplinary discussion meetings and virtual point-by-point operation of the web-based tool (Figure 2). Every text and direction on the screen was followed by voices that were developed using Amazon Polly (Amazon Web Services). The e-learning course was designed and developed by the Tokyo Metropolitan Institute of Medical Science, in collaboration with the face-to-face training course's instructors and the Tokyo Metropolitan Government. A prototype of the course was completed by four professionals who had not participated in the face-to-face training. Based on their feedback, revisions were made to the course, after which it was finalized.

A debriefing meeting was delivered via a Zoom meeting (Zoom Video Communications) and divided into two parts. The first 90-minute debriefing meeting was within 4 weeks after the e-learning course was completed and was aimed at reviewing what participants had learned during the course, motivating use of the DEMBASE program, and setting a task by the next debriefing meeting. Hereafter, a 90-minute debriefing meeting was set 4 weeks later to share participant experiences related to the program. The first debriefing meetings were held 21 times between September 2020 and February 2021. The second debriefing meetings were held 14 times between November 2020 and March 2021. Both debriefing meetings were organized by instructors who had completed the face-to-face training course and the train-the-trainer program offered by the Tokyo Metropolitan Institute of Medical Science.

Face-to-Face Training Course and Debriefing Meeting

A 1-day, face-to-face training course was delivered 12 times to 274 professional caregivers between May 2019 and February 2020. Of the 274 caregivers who intended to participate in the course, 252 (92.0%) attended and completed it. The course included learning about, and role-play of, interdisciplinary discussion meetings and real point-by-point operation of the web-based tool (Figure 2).

Face-to-face, 3-hour debriefing meetings were held nine times, 4 to 6 weeks after the face-to-face training, which was conducted between July 2019 and February 2020. Debriefing meetings were organized by instructors who had completed the face-to-face training course and the train-the-trainer program, offered by the Tokyo Metropolitan Institute of Medical Science.

Interdisciplinary Discussion Meeting

Once the training course was completed, the professionals held an interdisciplinary discussion meeting with other care professionals to evaluate the neuropsychiatric symptoms of each participant with dementia, to specify their unmet needs, and to establish an interdisciplinary action plan to meet those needs. The medications prescribed to each participant with dementia were also assessed.

These components were included to promote a plan-do-study-act (PDSA) cycle, developed according to the team-based dementia case management model. The PDSA cycle is widely used as a quality improvement method in health care settings [30]. If the level of neuropsychiatric symptoms assessed was not reduced during follow-up evaluations, care professionals reviewed unmet needs and revised the action plan during the discussion meeting.

Unmet needs, content of the action plan, and types of caregivers involved in the meeting were categorized and recorded using the web-based tool. The categories of unmet needs were developed by referring to the findings on associations between neuropsychiatric symptoms and basic physical needs [31] as well as environmental sources of discomfort [32,33].

Web-Based Tool

The web-based tool provided a visualization of longitudinal changes in neuropsychiatric symptoms measured by the Neuropsychiatric Inventory (NPI) to inform interdisciplinary decision making. Professionals input the information collected during the discussion meeting into the web-based tool. The individual characteristics of persons with dementia were recorded at registration, including birth year and month, sex, and type of dementia. Participating professionals performed a baseline evaluation and follow-up evaluations to assess neuropsychiatric symptoms at each time point for each person with dementia until the end of the fiscal year.

Debriefing Meeting

The participating professionals attended a debriefing meeting after training where they were divided into groups of 4 to 6 members to share their experiences about the program.

Measurement

The primary outcome measure for feasibility was the percentage of professionals with "full implementation" of the DEMBASE program. Full implementation was defined as the completion of a follow-up evaluation of neuropsychiatric symptoms for at least one person with dementia.

The primary outcome measure for efficacy was the change in the level of neuropsychiatric symptoms in persons with dementia who received full implementation of the program. The secondary outcome measure was the change in the percentage of psychotropic prescriptions. We collected this information on neuropsychiatric symptoms and prescribed medications, which was available via the web-based tool.

The NPI–Nursing Home version (NPI-NH) was used to assess the incidence, frequency, and severity of neuropsychiatric symptoms. The original NPI-NH was comprised of 12 items to rate the frequency and severity of neuropsychiatric symptoms in persons with dementia [34-37]. Scores for each item ranged from 0 to 12, with higher scores indicating more severe symptoms. Frequency and severity scores were multiplied to determine a total score ranging from 0 to 144. The Japanese version of the NPI-NH had good validity and reliability [38].

Drug names and daily dosage were recorded for each prescribed medication. In this study, the presence of prescribed medication for the nervous system was used for analysis based on the Anatomical Therapeutic Chemical classification system: percentages of the prescriptions were calculated for analgesics (N02), antipsychotics (N05A), anxiolytics (N05B), hypnotics and sedatives (N05C), antidepressants (N06A), and antidementia drugs (N06D).

Statistical Analysis

The percentage of professionals who implemented follow-up evaluations was compared between the experimental and control groups using a chi-square test.

The change in the level of neuropsychiatric symptoms in persons with dementia from baseline to the most recent follow-up was compared between the two groups. Multiple linear regression analysis was used, including the NPI score at the most recent follow-up evaluation as a dependent variable and group as an independent variable. The NPI score at baseline was entered as a covariate.

The within-subject effect size was calculated using the Cohen formula for the NPI score. The effect size was assumed to be low if *d* values varied by approximately 0.20, medium if *d* values varied by approximately 0.50, and large if *d* values were greater than 0.80 [39,40].

Between-group differences were also examined for changes in psychotropic prescriptions using binomial logistic regression analysis. The model included the rate of prescription at the most recent follow-up evaluation as a dependent variable, group as an independent variable, and rate of prescription at baseline as a covariate.

Statistical significance was considered at an overall α value of .05. All statistical analyses were conducted using Stata software (version 16.1; StataCorp LLC).

Ethics

This project was approved by the Ethics Review Board of the Tokyo Metropolitan Institute of Medical Science (No. 20-41) and Tohoku University (2021-1-293). This project was completed in accordance with the Helsinki Declaration of 1975 (as revised in 2013).

Results

Characteristics of Care Professionals

The experimental group (ie, e-learning) included professionals from in-home care management (131/268, 48.9%), in-home care services (93/268, 34.7%), and residential care services (44/268, 16.4%) (Table 2). The distribution of types of service did not significantly differ between the experimental group and the control group (ie, face-to-face) (χ^2_2=4.1, *P*=.13).

Table 2. Types of service of professional caregivers who completed the training course to use a web-based tool of psychosocial interventions for neuropsychiatric symptoms of dementia.

Type of service	Professionals in e-learning group, 2020 (n=268), n (%)	Professionals in face-to-face training group, 2019 (n=252), n (%)
In-home care management		
Community general support center	50 (18.7)	8 (3.2)
Initial phase intensive support team	12 (4.5)	1 (0.4)
Care management agency	69 (25.7)	101 (40.1)
In-home care service		
Day care at center	41 (15.3)	52 (20.6)
Rehabilitation at center	3 (1.1)	2 (0.8)
Rehabilitation at home	2 (0.7)	0 (0)
Home-visiting nursing care	32 (11.9)	2 (0.8)
Personal care at home	10 (3.7)	16 (6.3)
In-home multiple service	5 (1.9)	11 (4.4)
Residential care service		
Group home	19 (7.1)	31 (12.3)
Housing with care	3 (1.1)	4 (1.6)
Geriatric intermediate care facility	4 (1.5)	3 (1.2)
Nursing home	17 (6.3)	21 (8.3)
Long-term sanatorium	1 (0.4)	0 (0)

Feasibility: Full Implementation

Of the 268 professionals who completed the e-learning course, 56 (20.9%) implemented follow-up evaluations of neuropsychiatric symptoms by the end of March 2021 (Table 3). The percentage of full implementation in the experimental group was significantly lower than that of professionals who completed the face-to-face training course in 2019.

Table 3. Percentage of professionals who implemented follow-up evaluations of neuropsychiatric symptoms.

Follow-up evaluation	Professionals in the e-learning group, 2020 (n=268), n (%)	Professionals in the face-to-face training group, 2019 (n=252)	Chi-square (*df*)	*P* value
Implemented	56 (20.9)	114 (45.2)	52.0 (1)	<.001
Did not implement	212 (79.1)	138 (54.8)	—[a]	—

[a]Chi-square and *P* values are reported in the top row of compared items.

Characteristics of Persons With Dementia

There were 63 persons with dementia who received follow-up evaluations by professionals who completed the e-learning course (Table 4). The distribution of types of service did not significantly differ between the experimental group and the control group (ie, face-to-face) (χ^2_2=1.4, *P*=.51). There was no significant between-group difference in sex (χ^2_2=0.1, *P*=.81) or age ($t_{145.72}$=0.42, *P*=.68).

Some people in the experimental group (n=63) were identified to have unmet needs at baseline related to the following: social isolation (n=30, 48%), sleepiness or tiredness (n=27, 43%), urination (n=27, 43%), hydration (n=27, 43%), and evacuation (n=24, 38%). Some people in the control group (n=132) presented with needs related to sleepiness or tiredness (n=65, 49.2%), evacuation (n=56, 42.4%), feeling uncomfortable (n=53, 40.2%), and pain (n=52, 39.4%) (Table S1 in Multimedia Appendix 1).

Table 4. Baseline characteristics of persons with full implementation of the psychosocial dementia care program in Tokyo.

Characteristic	Persons with dementia in e-learning group, 2020 (n=63), n (%)	Persons with dementia in face-to-face training group, 2019 (n=132), n (%)
Age in years		
≤64	0 (0)	4 (3.0)
65-74	6 (9.5)	12 (9.1)
75-84	21 (33.3)	38 (28.8)
85-94	32 (50.8)	69 (52.3)
≥95	4 (6.3)	9 (6.8)
Sex		
Male	18 (28.6)	40 (30.3)
Female	45 (71.4)	92 (69.7)
In-home care management		
Community general support center	12 (19.0)	1 (0.8)
Initial phase intensive support team	1 (1.6)	0 (0)
Care management agency	16 (2.5)	49 (37.1)
In-home care		
Day care at center	8 (12.7)	36 (27.3)
Rehabilitation at center	3 (4.8)	0 (0)
Rehabilitation at home	1 (1.6)	0 (0)
Personal care at home	1 (1.6)	5 (3.8)
Home-visiting nursing care	7 (11.1)	2 (1.5)
In-home multiple service	3 (4.8)	9 (6.8)
Residential care		
Group home	3 (4.8)	14 (10.6)
Housing with care	0 (0)	4 (3.0)
Geriatric intermediate care facility	2 (3.2)	3 (2.3)
Nursing home	6 (9.5)	9 (6.8)

Efficacy: Neuropsychiatric Symptoms

The 63 persons with dementia in the experimental group had a mean NPI score of 20.4 (SD 16.2) at baseline. The symptoms that were frequently observed in the experimental group at baseline included agitation or aggression (n=48, 76%), anxiety (n=35, 56%), delusion (n=32, 51%), irritability or lability (n=30, 48%), and depression or dysphoria (n=26, 41%). These symptoms were also observed in the control group at baseline (Table S2 in Multimedia Appendix 1). The mean NPI score was significantly reduced to 14.3 (SD 13.4) at the most recent follow-up (paired t_{62}=4.10, P<.001). The level of reduction was not significantly different from that in the control group (Table 5). The effect size was assumed to be medium for both the experimental group ($d_{rm\ [repeated\ measures]}$=0.40) and the control group (d_{rm}=0.36).

Table 5. Change in level of neuropsychiatric symptoms from baseline to the most recent follow-up evaluation.

Measure	Persons with dementia in e-learning group, 2020 (n=63)	Persons with dementia in face-to-face training group, 2019 (n=132)	Baseline-adjusted difference[a]	*P* value
NPI score[b], mean (SD)				
Baseline	20.4 (16.2)	23.8 (18.1)	N/A[c]	N/A
Follow-up	14.3 (13.4)	17.4 (17.2)	N/A	N/A
Difference	6.1 (11.8)	6.4 (10.6)	–0.61	.69
Effect size: Cohen $d_{rm\ (repeated\ measures)}$	0.40	0.36	N/A	N/A

[a]The baseline-adjusted difference was examined using multiple linear regression analysis with the Neuropsychiatric Inventory (NPI) score at baseline as a covariate.

[b]Levels of neuropsychiatric symptoms were assessed using the total NPI score, which ranged from 0 to 144.

[c]N/A: not applicable; these values were only calculated for the NPI score difference.

Efficacy: Psychotropic Prescriptions

The percentage of psychotropic prescriptions was not significantly different between the experimental and control groups (Table 6).

Table 6. Change in psychotropic prescriptions from baseline to the most recent follow-up evaluation.

Prescription	Persons with dementia in e-learning group, 2020 (n=63), n (%)	Persons with dementia in face-to-face training group, 2019 (n=132), n (%)	Baseline-adjusted difference[a]	*P* value
Analgesics				
Baseline	10 (15.9)	20 (15.2)	—[b]	—
Follow-up	9 (14.3)	19 (14.4)	0.68	.72
Antipsychotics				
Baseline	10 (15.9)	23 (17.4)	—	—
Follow-up	12 (19.0)	27 (20.5)	1.03	.97
Anxiolytics				
Baseline	7 (11.1)	7 (5.3)	—	—
Follow-up	7 (11.1)	7 (5.3)	1.52	.78
Hypnotics and sedatives				
Baseline	7 (11.1)	14 (10.6)	—	—
Follow-up	6 (9.5)	13 (9.8)	0.46	.61
Antidepressants				
Baseline	2 (3.2)	4 (3.0)	—	—
Follow-up	3 (4.8)	6 (4.5)	1.05	.97
Antidementia drugs				
Baseline	21 (33.3)	59 (44.7)	—	—
Follow-up	24 (38.1)	64 (48.5)	0.99	.99

[a]The baseline-adjusted difference was examined using binomial logistic regression analysis with psychotropic prescription at baseline as a covariate.

[b]Baseline-adjusted differences and *P* values are reported in the bottom row of compared items.

Discussion

Overview

With an increasing demand for e-learning platforms for essential workers, it is vital that the feasibility and efficacy of the digitally transformed DEMBASE program be assessed. Thus, this study aimed to test the feasibility and efficacy of the e-learning training course, distributed to 268 professionals between July and December 2020 during the COVID-19 pandemic, by comparing it to the face-to-face training course and assessing which program more effectively addressed neuropsychiatric symptoms of dementia.

Principal Findings

By replacing the face-to-face training course with the e-learning course, professionals who may not have participated in the program otherwise were provided the opportunity to participate in the DEMBASE program. This may explain the reduction in neuropsychiatric symptoms, which was significant with a medium effect size in this study. Similarly, the natural reduction of NPI scores was –0.8 over 6 months in a randomized controlled study [22]; thus, the program with e-learning training in this study appeared to be clinically effective. The efficacy of the program was not significantly different between the two groups. However, the percentage of full implementation was significantly lower among professionals who completed the e-learning course than among those who completed the face-to-face training course. Therefore, replacing face-to-face training courses with e-learning training courses appeared to be less effective in encouraging professionals to implement the program.

Compared to the face-to-face training course, the e-learning course may have lacked motivational triggers for implementation for professionals. Unlike e-learning, face-to-face training courses involved role-play in an interdisciplinary discussion meeting that may have yielded human interactions among participating professionals and between instructors and participants. Although we divided debriefing meetings into two parts and intended for the first meeting to offer interactions between participants, the 90-minute Zoom meeting may have been suboptimal to substitute the motivational triggers that emerged in the face-to-face training course. In addition, facilitating such an interaction can be complemented by using online communities, such as Facebook and LinkedIn; however, these online platforms are not often used by professional caregivers [41]. Therefore, the use of online communities in the DEMBASE program, which has not yet been introduced because of privacy concerns with social networks, is encouraged and should be further investigated.

The reduced implementation could also have been because of the increased workload of professionals due to the COVID-19 pandemic. This pandemic may have had a negative impact on the feasibility of the DEMBASE program among professionals. As preventive measures against COVID-19 were added to their daily practice, professionals had less time to implement the program. Furthermore, face-to-face contact was avoided, even for communication between professionals, under the lockdown and other public health and social measures that were implemented. In this study, we replaced a face-to-face debriefing meeting with a Zoom meeting, thus providing professionals with an opportunity to participant in a web-based meeting. Furthermore, we proposed to the participants that an interdisciplinary discussion meeting also be held via a Zoom meeting. Municipal governments also provided financial support to long-term care providers to refund the costs of purchasing tablet devices for program implementation. However, long-term care service providers generally have several barriers to implementing digital transformation in dementia care, including information technology infrastructure instability and a reluctance to change established practices and routines [42]. Thus, additional technical support is warranted to enable long-term care providers to have essential communication between professionals and with people with dementia amid the COVID-19 pandemic.

The reduced rate of full program implementation in the e-learning course may also be attributed to possible misdirection in the recruitment process phrased as "participation in e-learning course." Some professionals confessed in the debriefing meeting that they recognized the DEMBASE program as an e-learning course rather than the PDSA cycle combining an interdisciplinary discussion meeting with a web-based tool. Therefore, a video message from "peer" professionals who have implemented the program and recognized its effectiveness may improve the readiness of applicants for participation. Such peer messages can also be integrated into the content of the e-learning training course. Additionally, recruiting two or more professionals from the same provider could encourage program implementation, as they may be able to commence the program with a small discussion meeting with those who have completed the course.

Strengths and Limitations

A strength of this study was that the efficacy and feasibility of replacing a face-to-face course with an e-learning training course was tested using a quasi-experimental design, thus addressing a gap in the literature. A limitation was the lack of information on the characteristics of professionals. That is, differences in the gender and age of the professionals in the experimental (ie, e-learning) and control (ie, face-to-face) groups may have influenced the level of resistance to technology usage [43]. Based on the agreement for this study with the Tokyo Metropolitan Government, we were not allowed to access such information. In addition, the small number of persons with follow-up evaluations in the experimental group may have caused insufficient statistical power to examine the differences in changes in neuropsychiatric symptoms.

Conclusions

The e-learning training course provided the opportunity for professionals to participate in the psychosocial dementia care program during the COVID-19 pandemic. Following completion of the e-learning course, the program sustained an equal level of efficacy in reducing neuropsychiatric symptoms compared to the face-to-face training course. However, the feasibility appeared to be suboptimal as the rate of implementation was low among professionals who completed the e-learning course. Further strategies to encourage implementation of the program should, thus, be developed to provide motivational triggers for implementation, such as distribution of a video message from peer professionals in the recruitment process and the e-learning training course as well as technical support for care professionals who work for people with dementia. Additionally, the use of online communities by the professionals in the program should be further investigated.

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Authors' Contributions

MN, SY, KE, JN, and AN collected the data, analyzed and interpreted the data, and prepared the manuscript draft. CZ, TJEMB, EG, and KN were involved in the study design and setup, supervised the data analysis, and contributed to finalizing the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Unmet needs identified and presence of neuropsychiatric symptoms evaluated during the interdisciplinary discussion meeting at baseline.

[DOCX File , 24 KB - mededu_v7i4e30652_app1.docx]

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Abbreviations

DEMBASE: dementia behavior analysis and support enhancement
NPI: Neuropsychiatric Inventory
NPI-NH: Neuropsychiatric Inventory–Nursing Home version
PDSA: plan-do-study-act

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Original Paper

An e-Learning Program for Physiotherapists to Manage Knee Osteoarthritis Via Telehealth During the COVID-19 Pandemic: Real-World Evaluation Study Using Registration and Survey Data

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Abstract

Background: The COVID-19 pandemic necessitated clinicians to transition to telehealth, often with little preparation or training. The Physiotherapy Exercise and Physical Activity for Knee Osteoarthritis (PEAK) e-learning modules were developed to upskill physiotherapists in management of knee osteoarthritis (OA) via telehealth and in-person. In the research setting, the e-learning modules are perceived by physiotherapists as effective when they are part of a comprehensive training program for a clinical trial. However, the effectiveness of the modules on their own in a *real-world* setting is unknown.

Objective: This study aims to evaluate the reach, effectiveness, adoption, and implementation of PEAK e-learning modules.

Methods: This longitudinal study was informed by the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework. Participants were clinicians, researchers, educators, and health care students who registered for access to the modules between April 1 and November 30, 2020. Reach was evaluated by outcomes (countries, referral sources, and attrition) extracted from registration data and embedded within precourse surveys in the Learning Management System (LMS). Effectiveness was evaluated by outcomes (confidence with videoconferencing; likelihood of using education, strengthening exercise, and physical activity in a treatment plan for knee OA; usefulness of modules) measured using a 10-point numeric rating scale (NRS; score range from 1=not confident or likely or useful at all to 10=extremely confident or likely or useful) in pre- and postcourse (on completion) surveys in the LMS. Adoption and implementation were evaluated by demographic and professional characteristics and outcomes related to the use of learning and usefulness of program elements (measured via a 4-point Likert scale, from not at all useful to extremely useful) in a survey administered 4 months after module completion.

Results: Broad reach was achieved, with 6720 people from 97 countries registering for access. Among registrants, there were high levels of attrition, with 36.65% (2463/6720) commencing the program and precourse survey and 19.61% (1318/6720) completing all modules and the postcourse survey. The program was effective. Learners who completed the modules demonstrated increased confidence with videoconferencing (mean change 3.1, 95% CI 3.0-3.3 NRS units) and increased likelihood of using education, strengthening and physical activity in a knee OA treatment plan, compared to precourse. Adoption and implementation of learning (n=149 respondents) occurred at 4 months. More than half of the respondents used their learning to structure in-person consultations with patients (80/142, 56.3%) and patient information booklets in their clinical practice (75/142, 52.8%).

Conclusions: Findings provide evidence of the reach and effectiveness of an asynchronous self-directed e-learning program in a real-world setting among physiotherapists. The e-learning modules offer clinicians an accessible educational course to learn about best-practice knee OA management, including telehealth delivery via videoconferencing. Attrition across the e-learning program highlights the challenges of keeping learners engaged in self-directed web-based learning.

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KEYWORDS

osteoarthritis; knee; physiotherapy; exercise; e-learning; telehealth; pain; education; implementation; evaluation; professional development; rehabilitation

Introduction

Background

The prevalence of knee osteoarthritis (OA) is rapidly increasing as the population ages and the obesity epidemic rises worldwide [1]. As a debilitating chronic musculoskeletal condition, OA is ranked as the 12th leading cause of disability worldwide [2]. Education and exercise are highly recommended as core interventions [3-6], and these are often delivered via in-person consultations by physiotherapists [7,8]. In 2020, the COVID-19 pandemic imposed a substantial change in the delivery of in-person health care services worldwide [9,10]. Social distancing requirements and lockdowns necessitated many physiotherapists to rapidly transition to telehealth service delivery using freely available real-time videoconferencing software (eg, Zoom, Zoom Video Communications; Microsoft Teams, Microsoft; WhatsApp, Facebook Inc; and FaceTime, Apple Inc) [11,12], often with little preparation or training. A global survey of allied health practitioners between April and June 2020 showed that 68% of respondents used telehealth to manage people with OA during the pandemic and that exercise and education were used by 96% of respondents as part of telehealth consultations [11].

Telehealth is a term under the *digital practice* umbrella, which encompasses *health care services, support, and information* provided remotely via telecommunication technology [13]. Telehealth has been shown to be an effective model of physiotherapy service delivery for a range of musculoskeletal conditions [14], including OA [15]. A randomized controlled trial has shown the effectiveness [16] and patient acceptability [17] of the remote delivery of a physiotherapist-prescribed exercise program via video consultations for people with knee OA; however, before the COVID-19 pandemic, a minority of allied health clinicians provided telehealth services [11]. Before the pandemic, barriers to telehealth were multifactorial and included costs associated with implementing telehealth infrastructure, lack of third-party payer funding for telehealth consultations, and clinician resistance to practice change [15,18]. Significantly, many physiotherapists lack specific training in delivery of care via telehealth [13,19], and subsequently may have little knowledge [18], experience [20], and confidence [21] in telehealth delivery. Research shows that clinician education about and exposure to telehealth increases both acceptance of, and confidence with, delivery of care via telehealth [20,21]. Furthermore, physiotherapists and other health care professionals have highlighted limitations in their knowledge, skills, and confidence in managing people with knee OA [22]. Thus, providing education and knowledge resources to clinicians in telehealth skills to deliver evidence-based OA management is paramount.

e-learning is an accessible and scalable method for delivering health professional education and training. e-learning broadly relates to the delivery of educational material through information and communication technology, often using the internet to wholly or partially replace the need for a human instructor [23]. The Physiotherapy Exercise and Physical Activity for Knee Osteoarthritis (PEAK) e-learning modules [24] were developed by researchers, in the context of a clinical trial [25], to upskill physiotherapists in evidence-based management of knee OA through telehealth and in-person consultations. The self-directed modules aim to educate learners on how to implement evidence-based physiotherapy care using a structured program of education, strengthening exercises, and individualized physical activity over 5 individual consultations, delivered via videoconferencing or in-person. In the research setting, the PEAK e-learning modules were perceived by physiotherapists as effective when delivered as part of a comprehensive training program for a clinical trial [20]. However, the effectiveness of the PEAK e-learning modules on their own in a *real-world* setting is unknown.

Objectives

In light of the unfolding COVID-19 pandemic, the PEAK e-learning modules were released globally, free of charge, on April 1, 2020, to assist physiotherapists and other clinicians in providing care to patients with knee OA through telehealth. There is currently limited research evaluating professional development initiatives (ie, beyond entry-to-practice training) for physiotherapists regarding the management of OA. Guided by the Reach, Effectiveness, Adoption, Implementation and Maintenance (RE-AIM) framework [26], this study aims to evaluate the reach, effectiveness, adoption, and implementation of the PEAK e-learning modules during the COVID-19 pandemic. Specifically, we aimed to (1) evaluate the reach of, and attrition across the PEAK e-learning program; (2) evaluate the effectiveness of the PEAK e-learning program in building confidence with telehealth and intention to use core recommended OA treatments among learners who completed the program; and (3) evaluate how learners who completed the PEAK e-learning program implemented what they learned into practice 4 months after completion, including the settings it was adopted into.

Methods

Design

A longitudinal study with pre- and postcourse evaluations was conducted via an electronic survey. The RE-AIM framework [26] has informed the study.

Participants

Participants in this study were those who registered for access to the PEAK e-learning modules between April 1, 2020 (launch date), and November 30, 2020. There were no specific eligibility criteria for registration (learners self-select whether to register based on the English language description of the e-learning modules on the registration page) and no costs were charged for the modules; thus, participants in this study included health care clinicians, researchers, educators, and health care students from anywhere in the world. After activating access to the Learning Management System (LMS), learners provided consent for researchers to use their program data for research purposes. Four months after the completion of the e-learning modules, learners were sent an electronic survey about how they had implemented their learnings into practice. Completion of this survey was voluntary, and implied consent to participate. This study was approved by the University of Melbourne Human Research Ethics Committee (#2056938).

The PEAK e-Learning Modules

The PEAK e-learning modules [24] teach clinicians how to deliver an evidence-based management program (PEAK program) for people with knee OA, either via telehealth (videoconferencing) or in-person. The PEAK program and the e-learning modules were devised by researchers at the University of Melbourne specifically for use in a National Health and Medical Research Council–funded clinical trial [25] comparing videoconferencing with face-to-face care by physiotherapists for people with knee OA (trial ongoing). Thus, the program was designed for delivery by physiotherapists in Australia but is relevant to physiotherapists and other health care clinicians globally. The program focuses on education, strengthening exercise, and physical activity, delivered during 5 consultations over 3 months and can be individualized to patient needs. The e-learning modules were made publicly available across the globe on April 1, 2020, and they were promoted by researchers via social media and directly to physiotherapy professional organizations worldwide.

The asynchronous e-learning modules were delivered on the University of Melbourne LMS (Canvas LMS by Instructure, 2019), covering (1) evidence-based best-practice knee OA management, (2) telehealth (the delivery of care via Zoom videoconferencing), and (3) the PEAK program (a structured physiotherapy treatment protocol). Each module included a quiz at the end to help reinforce learning. The modules were sequentially released in the order listed, with access to subsequent modules unlocked as the preceding module was completed (defined as all pages viewed within the module and quiz questions submitted). Quizzes required >80% correct answers for advancement to the next module, and learners were allowed unlimited, multiple attempts at quiz questions. Learners were instructed to allow approximately 3 to 4 hours to complete all modules. The e-learning modules also provided learners with access to a website of videos of the exercises contained within the PEAK program. For learners who completed all e-learning modules, a suite of resources was unlocked on completion for printing and downloading. This included educational booklets that clinicians can provide to their patients (*Preparing for your Consultations*, *Osteoarthritis Information*, *Exercise Booklet*, and *Knee Plan and Log Book*) as well as clinician resources (*Zoom Troubleshoot Guide, Initiating and using Zoom for video consultations, Accessing the website of exercise videos, Pre-consultation survey, Consultation Outline, and Readiness Checklist*). On completion of the e-learning modules, learners could request a certificate of completion via email.

Users registered for access via a web-based form (Qualtrics International) housed at the University website [24], where they provided their names and email addresses. It took up to 24 to 48 hours after registration for the research staff to create a log-in. External users (non–University staff or students) were required to activate their account before they could log into the LMS to commence learning.

Data Collection

Registration Data

The number of registrants was captured using the Qualtrics registration form. The geographic location of registrants was estimated from the approximate longitude and latitude obtained from their deidentified IP addresses. Researchers used the location data to correlate this with known country and continent information.

LMS Data

The PEAK e-learning modules contained pre- and postcourse survey questions (Multimedia Appendix 1) embedded within the LMS. After activating their LMS account, learners were provided with an introduction to the e-learning modules and completed a mandatory precourse survey before the first module was accessible. Learners who completed all the modules were invited to complete a postcourse survey. As an incentive, the printable and downloadable resources and instructions for obtaining a certificate of completion were made available to those who completed the postcourse survey. No fee was charged to obtain a certificate of completion.

The precourse survey comprised brief descriptive questions regarding learners' professional characteristics and their usual clinical practice. Precourse levels of *confidence* with videoconferencing and *likelihood to use* education and strengthening exercise and physical activity in a treatment plan for patients with knee OA were ascertained by a series of questions each rated via a 10-point numeric rating scale (NRS), ranging from 1=not at all confident or likely to 10=extremely confident or likely. The postcourse survey immediately reassessed these questions, with additional questions about *how long it took to complete the modules* (via dropdown lists for hours and minutes) and *how useful was the course* (NRS 1=not useful at all to 10=extremely useful).

Adoption and Implementation Data

Learners who completed the postcourse survey within the LMS were invited to complete another survey 4 months later to ascertain the adoption and implementation of learnings into practice. This electronic survey (Multimedia Appendix 2) link was sent by email and accessed via a secure web-based survey tool (REDCap, Research Electronic Data Capture, Vanderbilt University). The survey presented slightly different questions depending on whether the learner was a health professional, student, an educator, or a researcher. The first section ascertained demographic information and professional characteristics (data regarding adoption). The second section ascertained what the learner had implemented into practice from the PEAK e-learning modules, including how they used the downloadable resources. Questions evaluated the usefulness of the PEAK e-learning modules and their resources, as well as the extent to which learnings from the modules had changed learners' practice and how. The barriers to implementation were also evaluated. Learners rated their agreement with relevant statements using a 4-point Likert scale ranging from *not at all* to *extremely useful* or *to a large extent*.

Data Analysis

Data were downloaded from the LMS and REDCap software and processed in Excel (Microsoft Corporation). Descriptive analysis of the data was performed using means, SD, and proportions with Excel, where appropriate. For the second aim, only data from individuals who had answered both the precourse and postcourse surveys were analyzed for paired outcomes. For paired outcomes, individual change scores (for each learner and each outcome) were calculated by subtracting precourse scores from postcourse scores. The mean change (95% CI) was then calculated for each outcome.

Results

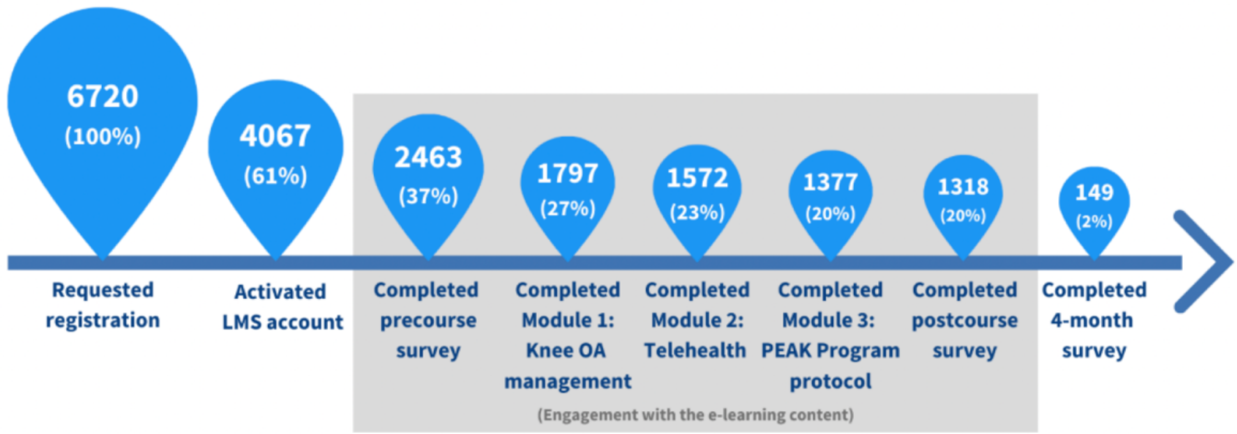
Aim 1: Reach of, and Attrition Across, the PEAK e-Learning Modules

From launch (April 1) to November 30, 2020, 6720 people registered for access to the PEAK e-learning modules. There was a broad international reach. Registrants came from 97 countries, with the top 10 most common countries being Australia (2077/6720, 30.91%), Canada (870/6720, 12.95%), United Kingdom (636/6720, 9.46%), United States (632/6720, 9.40%), South Africa (253/6720, 3.76%), Ireland (251/6720, 3.74%), Romania (152/6720, 2.26%), India (148/6720, 2.20%), Brazil (121/6720, 1.80%), and New Zealand (119/6720, 1.77%). The 5 most common nationalities have English as their native language.

There was attrition of learners across the pipeline from registration to the 4-month survey completion (Figure 1). The greatest attrition occurred between requesting registration and activating the LMS account, with 39.48% (2653/6720) of registrants failing to activate their LMS account. Of the 4067 users who activated their account within the LMS, 60.56% (2463/4067) completed the precourse survey, 44.18% (1797/4067) completed the first module, and 32.41% (1318/4067) completed all modules as well as the postcourse survey. Of the 2463 learners who completed the precourse survey, 53.51% (1318/2463) completed all modules and the postcourse survey, but only 6.05% (149/2463) completed the 4-month survey.

Of the participants who activated their LMS account and completed the precourse survey, most found out about the PEAK e-learning modules through a work colleague (795/2463, 32.28%). Other referral sources included Twitter (450/2463, 18.27%), professional organizations (368/2463, 14.94%), Facebook (281/2463, 11.41%), the internet (132/2463, 5.36%), a physiotherapy course instructor (128/2463, 5.20%), a friend/family (114/2463, 4.63%), other health professional course instructor (31/2463, 1.26%), LinkedIn (23/2463, 0.93%), and other sources (134/2463, 5.44%).

Figure 1. Users since program launch. Pipeline depicting the number of people who registered for access, activated their Learning Management System (LMS) account, and completed the various modules of the e-learning program. Percentages are calculated as a proportion of those who requested registration. OA: osteoarthritis.



The characteristics of learners who completed the e-learning program (ie, those who completed both the pre- and postcourse surveys) and noncompleters (ie, those who completed the precourse survey but not the postcourse survey), along with those who completed the 4-month survey (n=149) are summarized in Tables 1 and 2. The characteristics were generally similar across completers and noncompleters, except that more Australians tended to complete the program, whereas other geographic locations had similar proportions of completers and noncompleters. Similarly, there was a higher proportion of completers than noncompleters among chiropractors compared with other professions. The small sample of respondents to the 4-month survey was largely physiotherapists, predominantly from Australia.

Table 1. Demographic characteristics of learners who completed (completers) and did not complete (noncompleters) the e-learning program.

Variables	Completers (n=1318)[a]	Noncompleters (n=1145)[a]	Completed 4-month survey (n=149)[a]
Gender, n (%)			
Female	—[b]	—	93 (62)
Male	—	—	54 (36)
Do not wish to disclose	—	—	2 (1)
Age (years), mean (SD)			
≤30	—	—	29 (19)
51-60	—	—	41 (28)
≥60	—	—	33 (22)
31-40	—	—	16 (11)
41-50	—	—	4 (3)
Main work role, n (%)[c]			
Physiotherapist delivering clinical care to patients	869 (66)	796 (70)	121 (81)
Physiotherapy student	159 (12)	100 (9)	4 (3)
Other health professional student	118 (9)	43 (4)	3 (2)
Other health professional delivering clinical care to patients	74 (6)	61 (5)	14 (9)
Other	27 (2)	54 (5)	0 (0)
Education of physiotherapy students	23 (2)	51 (4)	2 (1)
Physiotherapy researcher	20 (2)	28 (2)	2 (1)
Education of other health professional students	24 (2)	8 (1)	0 (0)
Other health professional researcher	3 (0)	3 (0)	3 (2)
Location, n (%)[d]			
Africa	33 (3)	45 (4)	7 (5)
Asia	53 (4)	96 (8)	12 (8)
Australia	549 (42)	373 (33)	61 (41)
Europe	261 (20)	265 (23)	27 (18)
North America	372 (28)	302 (26)	30 (20)
Pacific islands	36 (3)	24 (2)	8 (5)
South America	13 (1)	37 (3)	4 (3)

[a]Individual characteristics may not add to totals due to missing data.

[b]—: not recorded.

[c]Percentages calculated for completers and noncompleters based on n=1317 and 1144, respectively.

[d]Percentages calculated for completers and noncompleters based on n=1317 and 1142, respectively.

Table 2. Clinical practice characteristics of learners who completed (completers) and did not complete (noncompleters) the e-learning program.

	Completers (n=1318)[a]	Noncompleters (n=1145)[a]	Completed 4-month survey (n=149)[a]
Profession, n (%)[b]			
Physiotherapist/physical therapist	782 (78)	692 (84)	126 (89)
Chiropractor	147 (15)	54 (7)	5 (3)
Rheumatologist	3 (0)	1 (0)	0 (0)
General practitioner or family physician	0 (0)	2 (0)	0 (0)
Sport and exercise medicine physician	0 (0)	3 (0)	0 (0)
Orthopedic surgeon	0 (0)	2 (0)	1 (1)
Dietitian	1 (0)	0 (0)	0 (0)
Podiatrist	1 (0)	0 (0)	0 (0)
Other	67 (7)	70 (8)	10 (7)
Average patients with knee OA[c] treated per month, mean (SD)	12 (17)	12 (38)	8 (5)
Clinical practice experience (years), mean (SD)	9.4 (10.2)	10.0 (9.9)	—[d]
Strategies usually used to manage people with knee OA, n (%)			
Education	1218 (92)	1051 (92)	—
Exercise	1242 (94)	1092 (95)	—
Physical activity advice	1164 (88)	1003 (88)	—
Weight loss advice	887 (67)	746 (65)	—
Manual therapy	610 (46)	550 (48)	—
Acupuncture	110 (8)	91 (8)	—
Bracing	147 (11)	145 (13)	—
Shoe orthotics	130 (10)	134 (12)	—
Other	174 (13)	137 (12)	—
Currently offer videoconferencing consultations to patients with knee OA, n (%)[e]			
Yes	366 (28)	317 (28)	72 (51)
No	939 (72)	817 (72)	68 (49)
Experience with teleconsultations using videoconferencing[f], mean (SD)	2.4 (1.9)	2.3 (1.9)	—

[a]Individual characteristics may not add to totals due to missing data.
[b]Percentages calculated for completers, noncompleters, and 4-month completion based on n=1001, 824, and 142, respectively.
[c]OA: osteoarthritis.
[d]—: not recorded.
[e]Percentages calculated for completers, noncompleters, and 4-month completion based on n=1305, 1134, and 140, respectively.
[f]Scored on a 10-point numerical rating scale (1=no experience at all to 10=extremely experienced).

Aim 2: Effectiveness of the PEAK e-Learning Modules

On average, learners who completed all modules and the postcourse survey spent a mean of 4.1 (SD 2.7) hours using the e-learning program (n=1318 respondents). Regarding the usefulness of the PEAK e-learning modules (n=1317 respondents), learners scored on average, 8.7 (SD 1.4) on a 10-point NRS, indicating high levels of perceived usefulness. The learners who completed the course reported increased confidence in videoconferencing (Table 3) relative to precourse. This is visualized in Figure 2 and Figure 3, where regarding confidence in using videoconferencing consultations with patients with knee OA, 71.98% (935/1299) of completers scored at least 8 out of 10 on the NRS postcourse compared with just 13.00% (166/1277) before. The likelihood of using education, strengthening exercise, and physical activity in a treatment plan for people with knee OA also increased postcourse (Table 3). Figures 4-6 graphically display the distribution of scores, with the greatest shifts in NRS scores postcourse occurring with the likelihood of using physical activity in a treatment plan. Precourse, 82.99% (1078/1299) of learners were likely to use physical activity in a treatment plan, compared with 96.01% (1252/1304) postcourse.

Table 3. Immediate changes in confidence with videoconferencing and likelihood to use education, strengthening exercise, and physical activity in a treatment plan for patients with knee osteoarthritis in learners (n=1299) who answered both the pre- and postcourse surveys.

	Precourse[a], mean (SD)	Postcourse[a], mean (SD)	Mean change (95% CI)[b]
Confidence with videoconferencing	4.8 (2.4)	7.9 (1.5)	3.1 (3.0-3.3)
Confidence with videoconferencing for people with knee OA[c]	4.7 (2.4)	8.2 (1.4)	3.5 (3.4-3.6)
Likelihood to use education	9.3 (1.5)	9.7 (0.9)	0.4 (0.3-0.5)
Likelihood to use strengthening exercise	9.4 (1.3)	9.8 (0.7)	0.4 (0.3-0.5)
Likelihood to use physical activity	8.9 (1.6)	9.6 (0.9)	0.7 (0.6-0.8)

[a]Scored on a 10-point numeric rating scale (1=not at all confident/likely to 10=extremely confident/likely).

[b]Calculated as postcourse score minus precourse score.

[c]OA: osteoarthritis.

Figure 2. Distribution of confidence scores with videoconferencing consultations for participants (n=1299) who answered this question pre- and postcourse (where scores of 1=not confident at all and 10=extremely confident).

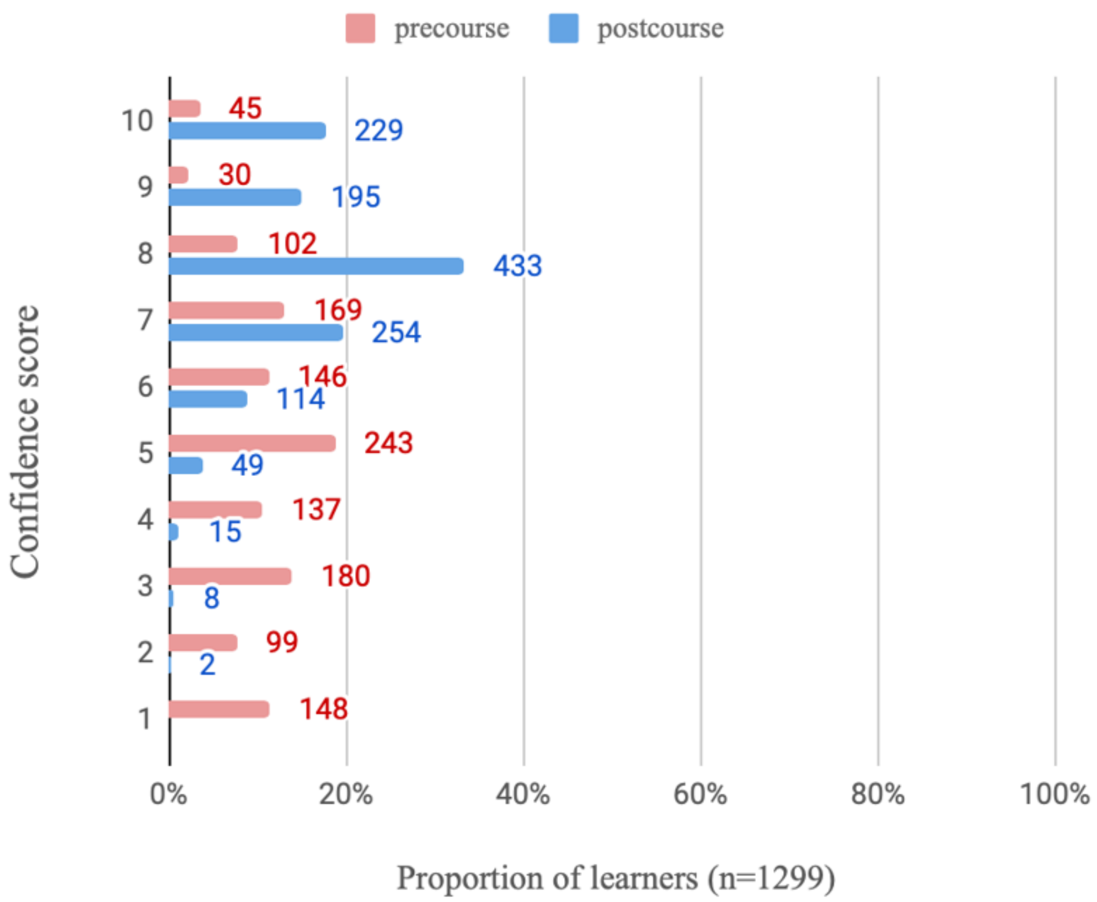


Figure 3. Distribution of confidence scores with videoconferencing consultations specifically for management of knee osteoarthritis for participants (n=1299) who answered this question pre- and postcourse (where scores of 1=not confident at all and 10=extremely confident).

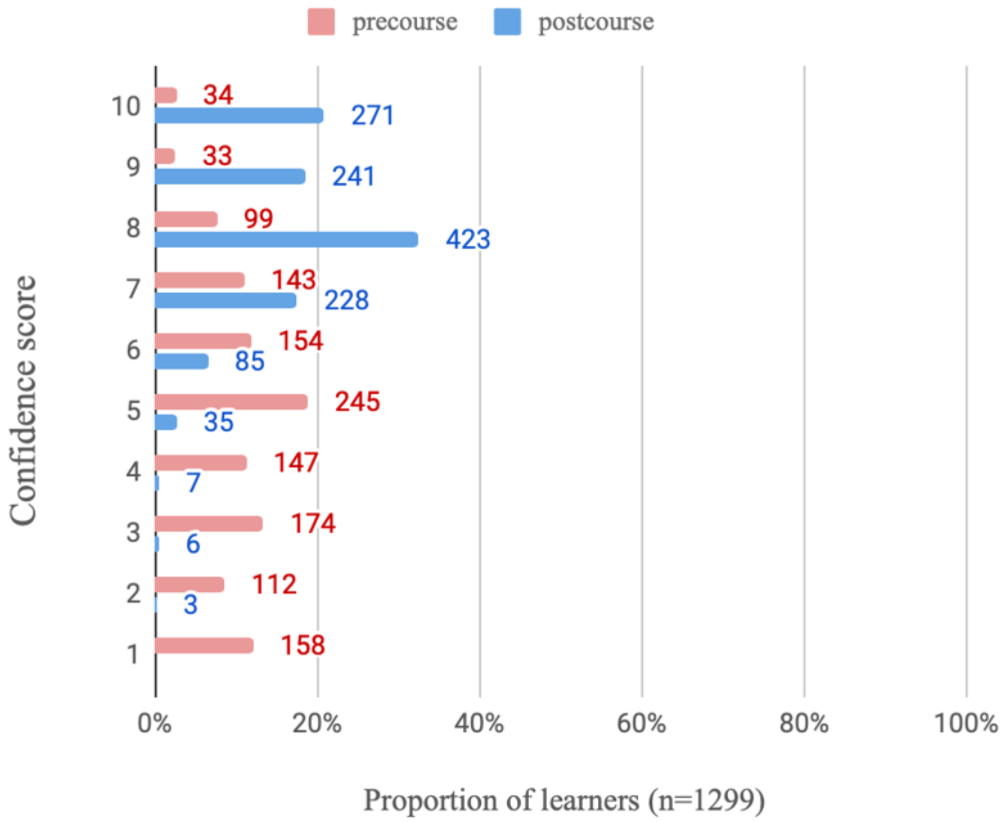


Figure 4. Distribution of scores (n=1299) regarding likelihood to use education in a treatment plan for patients with knee osteoarthritis (where scores of 1=not at all likely and 10=extremely likely).

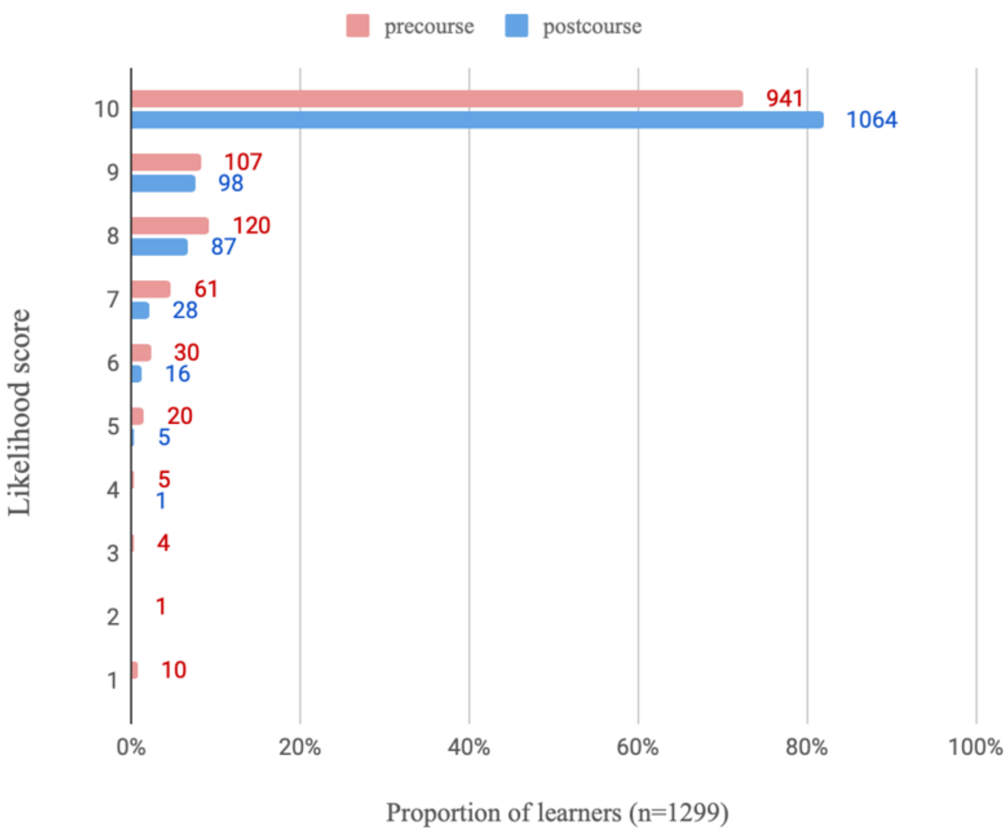


Figure 5. Distribution of scores (n=1299) regarding likelihood to use strengthening exercise in a treatment plan for patients with knee osteoarthritis (where scores of 1=not at all likely and 10=extremely likely).

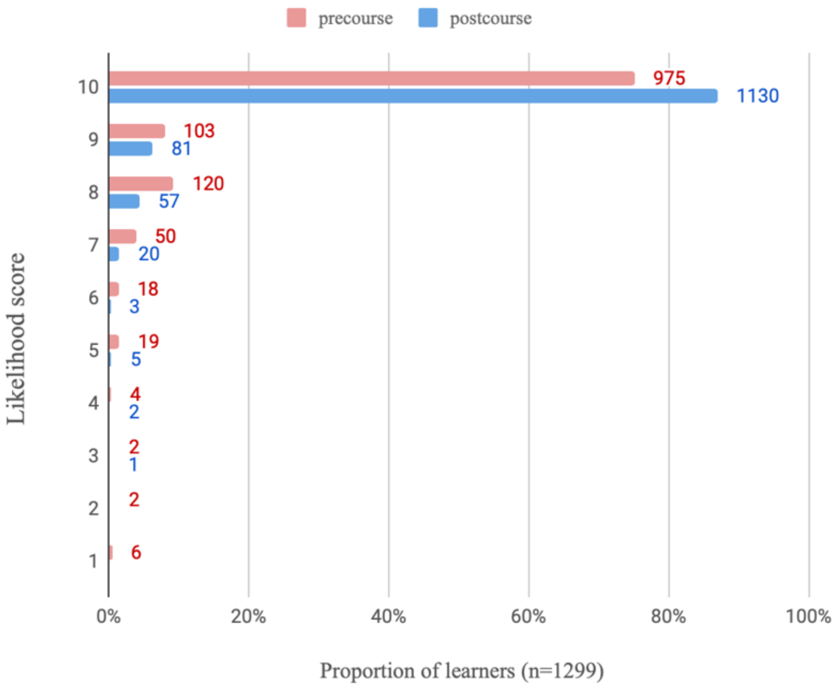
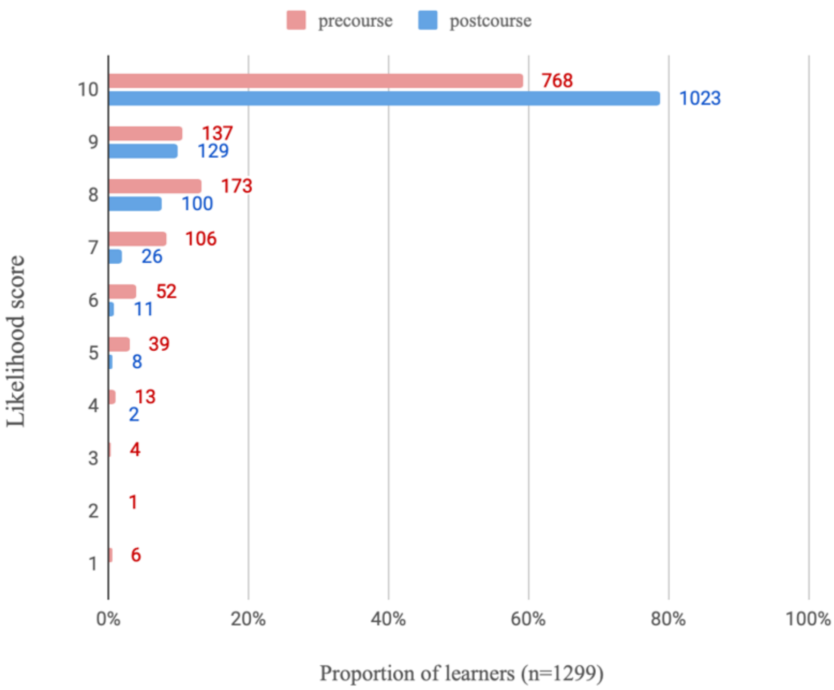


Figure 6. Distribution of scores (n=1299) regarding likelihood to use physical activity in a treatment plan for patients with knee osteoarthritis (where scores of 1=not at all likely and 10=extremely likely).



Aim 3: Adoption and Implementation of Learnings From the PEAK e-Learning Modules at 4 Months

Demographic and clinical characteristics of the few learners who completed the 4-month adoption and implementation survey (n=149) are shown in Tables 1 and 2. Regarding health care setting, 48.3% (72/149) respondents were from private practice, 21.5% (32/149) from acute care hospitals, 10.7% (16/149) from rehabilitation hospitals, 16.1% (24/149) from community health center/settings, 1.3% (2/149) from Veterans Affairs settings, and 12.1% (18/149) from other settings. Musculoskeletal health care was the predominant area of clinical practice for respondents (106/149, 71.1%), followed by gerontology with 13.4% (20/149) of respondents.

Figure 7 shows learner perceptions about the usefulness of the e-learning modules 4 months after completion of the course. More than half described the e-learning program (85/144, 59.0%) and its downloadable resources (88/149, 59.1%) as extremely useful. About 90.1% (128/142) of learners had recommended the PEAK e-learning modules and/or downloadable resources to others.

Almost all learners indicated that the e-learning modules had changed/informed their usual practice in some way, with 29.9% (44/147) of learners indicating their usual practice was changed to a minor extent, 55.1% (81/147) to a moderate extent, and 14.3% (21/147) to a large extent. Learnings from the e-learning modules were incorporated into clinical practice in a wide variety of ways (Figure 8). More than half of all respondents used their learnings to structure/inform in-person consultations with patients (80/142, 56.3%) and used the patient information booklets in their practice (75/142, 52.8%). Five learners had translated the resources into other languages (Chinese/Mandarin, Greek, Hungarian, Portuguese, and Spanish). Only 4.2% (6/142) of respondents indicated that they had not incorporated any learnings into their usual practice.

Figure 7. Perceptions of 4-month survey respondents about usefulness of learnings.

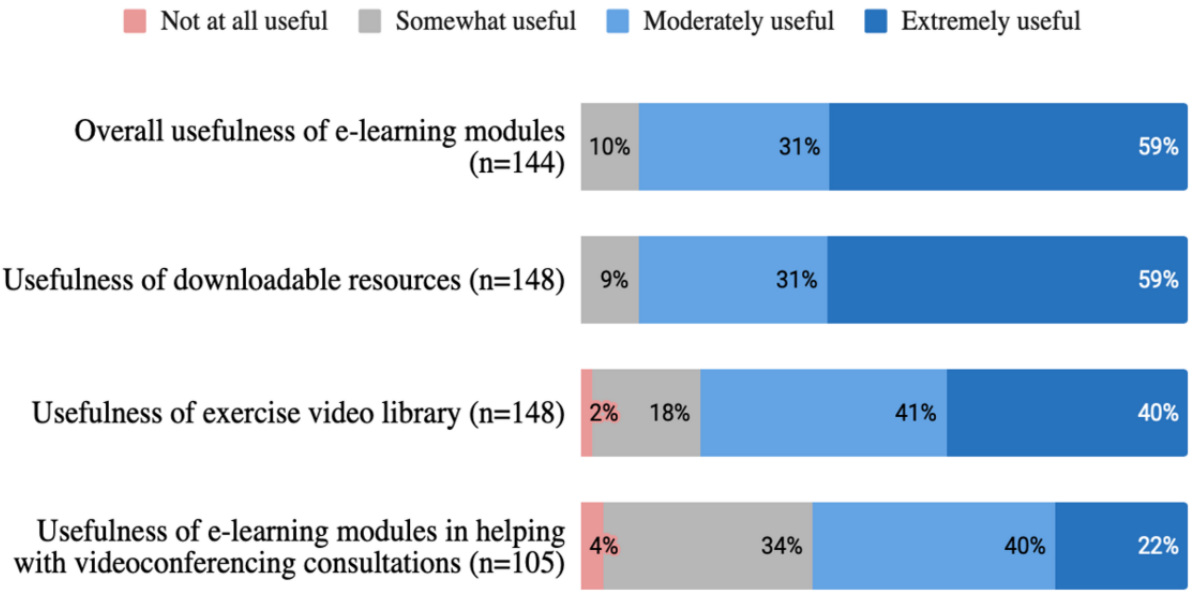
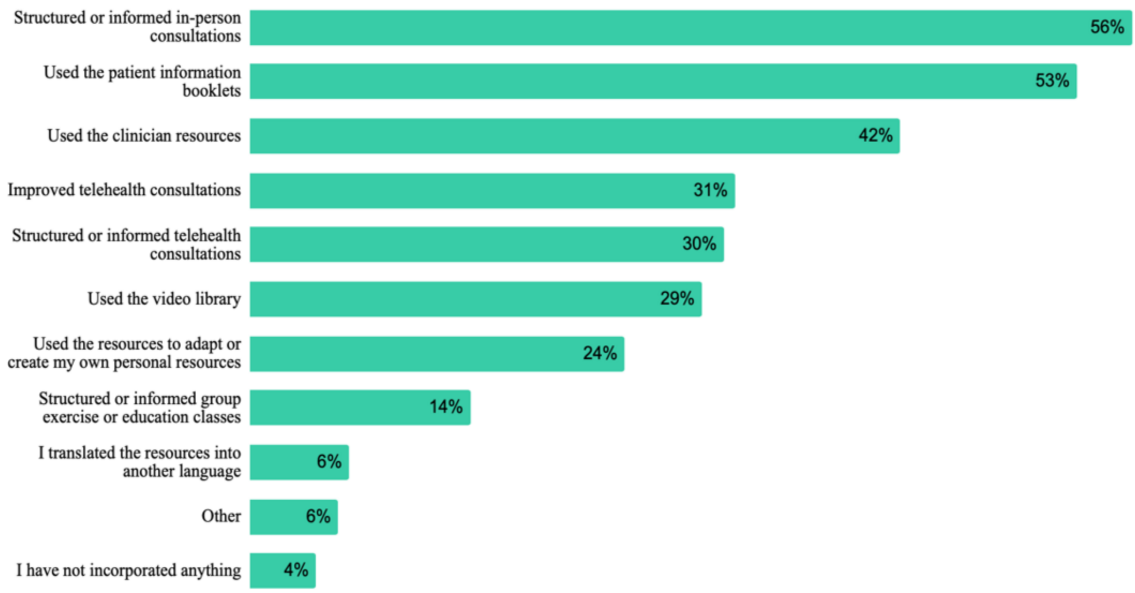


Figure 8. Strategies used by respondents (n=142) at 4 months to incorporate learnings into usual practice.



Discussion

Principal Findings

This study evaluated the reach, effectiveness, adoption, and implementation of learnings from the PEAK e-learning modules in a *real-world* context when the e-learning program is provided free of charge to users globally. Our findings showed a broad reach of the program from clinicians (mainly physiotherapists) across the world, predominantly driven through word of mouth, professional organizations, and social media. However, attrition was considerable from registration to the completion of the program. The learners who completed the course reported greater confidence in videoconferencing and increased likelihood of using education, strengthening exercises, and physical activity to manage knee OA. Four months after completion, learnings had been adopted in a range of musculoskeletal health care settings, predominantly by physiotherapists. Most respondents (85/144, 59.0%) to the follow-up survey described the e-learning program as extremely useful, and almost all (146/147, 99.3%) indicated that learnings had changed or informed their usual practice in some way. Collectively, these findings suggest that a self-directed e-learning approach may be an effective and scalable method for educating clinicians in a real-world context when resourcing for human instructors is not possible. Asynchronous e-learning programs also have additional advantages, including flexibility in pacing learning and overcoming the time and costs associated with travel by learners to attend educational courses [27].

The findings of this real-world evaluation are aligned with those of our previous qualitative evaluation of the training program in a research context [20]. The PEAK e-learning modules were originally developed by our team at the University of Melbourne to train 15 physiotherapists to deliver care in the context of a clinical trial [25] comparing videoconferencing with face-to-face care by physiotherapists for people with knee OA (ongoing). Training for the trial included not only the e-learning modules (as evaluated in this study) but also *practical* synchronous components, whereby physiotherapists participated in a mock initial consultation via videoconferencing with a physiotherapist researcher (AJK) followed by 4 practice video consultations with 2 pilot patients with chronic (>3 months) knee pain (recruited by research staff). Although there was 100% completion of the e-learning modules by the 15 physiotherapists in the PEAK trial, module completion was mandatory to deliver care in the trial, and physiotherapists were financially compensated for their time spent in training. Our qualitative study [20] exploring the trial physiotherapists' experiences with the training program showed that physiotherapists valued the self-directed and self-paced nature of e-learning, even though it was unfamiliar to them. Similar to this study, trial physiotherapists reported increased confidence and ability to deliver care through telehealth. They valued the combined package of e-learning modules and the practical components. In contrast, this real-world evaluation focused only on the asynchronous e-learning modules. Despite the lack of structured practical learning components, learners who completed the modules reported a 74% increase in confidence with videoconferencing for people with knee OA, showing that the modules can be effective at scale without practical components of training. These findings are consistent with those of other research showing preliminary evidence of the effectiveness, acceptability, and feasibility of an e-learning program to educate physiotherapists to deliver a group-based self-management complex intervention for low back pain and OA [28].

There are 37,113 registered physiotherapists in Australia [29]. Thus, our 2077 registrants from Australia represent 6% of registered physiotherapists, suggesting a broad reach to this population. Several factors likely contributed to the broad reach of the PEAK e-learning modules. The COVID-19 pandemic has accelerated a rapid shift to telehealth service delivery for physiotherapy services [30,31]. We released the e-learning modules on April 1, 2020, as part of global efforts to facilitate adoption and implementation of physiotherapy via telehealth [10]. The content of the program is relevant to a wide number of clinical professions, as evident by learner enrollment data, particularly for professions that use exercise and physical activity to manage chronic diseases. Moreover, the telehealth module is relevant to any health professional. Although we did not collect data on why learners registered for the PEAK e-learning modules, it is highly likely that its focus on telehealth was of interest to many, particularly given that allied health clinicians worldwide have described inadequate training, resources, and confidence in telehealth delivery as a barrier to implementing telehealth services during the pandemic [11,32]. Educational courses are considered by many clinicians as a practice-changing phenomenon [27]. Our e-learning modules were free of charge to the learner, which probably also contributed to the large number of people registering for the learning program, spanning 97 countries. Financial constraints are known to be a barrier to participation in professional development among health professionals [33], particularly among those from resource-limited countries [34,35]. A recent systematic review showed that physiotherapists value time as well as accessible and trustworthy resources when undertaking learning and professional development activities [36]. Our e-learning modules, developed by expert researchers at a respected university, delivered at no cost over the internet and able to be undertaken in a self-paced manner aligns with these values. Indeed, a recent survey of 464 health care workers from Sub-Saharan Africa showed that web-based professional development opportunities were accepted and that self-paced internet or computer-based learning is a preferred learning modality [35].

Consistent with the literature showing greater dropout rates with web-based learning compared with traditional classes [37], we observed high levels of attrition across our e-learning program. The greatest attrition occurred between registration and account activation. Although 6720 people registered for access, only 60.52% (4067/6720) activated their account within the LMS. The reasons for attrition at this point are unclear but may be related to the unwieldy activation (several technical steps are required to create an account as an external user and potential security features such as firewalls/spam that blocked emails from the LMS platform) and navigation processes of the LMS, which were highlighted as barriers in our qualitative evaluation [20]. These factors are consistent with a systematic review of enablers and barriers affecting health sciences e-learning, in which one of the major barriers to e-learning is the lack of user-friendly technology [38]. Of the 4067 users who activated their account within the LMS, 61.00% (2481/4067) completed the precourse survey, 43.99% (1789/4067) completed the first module, 31.99% (1301/4067) completed all modules and the postcourse survey, showing relatively little attrition once learners engaged with the first module. The requirement to complete the precourse survey before commencing the first module may have been a barrier to progressing through the course. Only 9.00% (366/4067) of the learners with activated accounts dropped out from module 1 to module 2. Given that health professionals and students perceive that limitations in their knowledge and skills about OA are barriers to implementing OA care [22], and that clinicians have inadequate training, resources, and confidence in telehealth delivery [11,32], these factors may explain the high retention across the 3 modules. Overall, our findings appear consistent with the literature, where it is reported that 40% to 80% of students drop out of web-based classes [37]. Furthermore, physiotherapists express a preference for face-to-face workshops to address learning needs regarding the management of patients with persistent knee pain [39], regarding web-based learning formats as convenient, but not as effective as face-to-face learning. Given that the learners in our study came from 97 countries, many of which do not have English as the native language, it is likely that many experienced difficulties with the English language of the PEAK modules, probably contributing to the attrition we observed.

Our data show that the PEAK e-learning modules led to improved confidence in videoconferencing among learners, as well as an increased likelihood of using education, strengthening exercises, and physical activity to manage knee OA. The mean scores for the likelihood of using these interventions were already quite high precourse, with most learners (at least 88%) already using these strategies at the time they enrolled in the modules. This likely explains why the mean change in these scores was quite small. In contrast, confidence with videoconferencing was quite low among our sample precourse, and most (939/1305, 71.95%) were not offering videoconferencing to their patients with knee OA, leading to large improvements (64%-74%) in confidence outcomes postcourse. Interestingly, our adoption and implementation data (n=149) showed that 55.7% (83/149) of respondents used their learnings to structure or inform *in-person* consultations versus 30.2% (45/149) who used learnings to structure or inform *telehealth* consultations. It is not clear why there was a greater implementation of learnings in in-person consultations. However, this may be due to physiotherapists experiencing system-level and technological barriers to adopting and implementing telehealth during the pandemic [11,12,32] or related to the preferences of patients and health care professionals for in-person consultations [11,12].

From an implementation perspective, the proportion of respondents who reported using patient information booklets (79/149, 53.0%), clinician resources (63/149, 42.3%), and video library (43/149, 28.9%) from the PEAK program is noteworthy despite the small sample size (n=149). Furthermore, some of these resources had been translated into 5 languages by users. Twenty-four percent of respondents indicated that they created their own personal resources from the materials provided. These findings are relevant to other developers of e-learning programs for health professionals, highlighting the importance of embedding an *implementation tool kit*, which contains clinically relevant resources that can be used in patient interactions to facilitate care delivery.

Strengths and Limitations

The strengths of our study include the evaluation of an e-learning program in a *real-world* context. This resulted in a broad reach across the globe, including low- and middle-income countries, as well as those where English is not the native language. Although the program was targeted to physiotherapists, our study participants included not only physiotherapists but also a range of health professionals as well as students, educators, and researchers. Limitations include our relatively short 4-month follow-up of adoption and implementation of learnings, and the low response rate (11% of those invited) to the 4-month email survey, leading to a small sample size (n=149). In addition, owing to the high attrition rate between pre- and postcourse surveys, our findings may overestimate the effectiveness of the PEAK e-learning modules, given that people who found the course useful may be more likely to have completed all modules and the postcourse survey than learners who did not find the modules useful. We also used custom-designed self-reported questions to determine changes in confidence and likelihood of using education, strengthening exercise, and physical activity in an OA treatment plan. As such, it is not clear if the improvements we observed pre- to postcourse are of *clinical* relevance. Future research should consider collecting patient-level data to determine whether improvements in clinician knowledge and confidence with e-learning translate into better clinical outcomes for patients with the health condition of interest. Although we did not develop the e-learning modules and embedded resources through formal co-design methods, we did refine the e-learning modules based on qualitative feedback from the physiotherapists who used the e-learning modules as mandatory training for the PEAK trial. The embedded patient and clinician resources were developed iteratively over many years by our research team, and consumers with OA provided feedback on resource content during this time. However, we may have seen less attrition with the e-learning modules had we co-designed these modules with physiotherapists at the outset.

Conclusions

In conclusion, this study provides evidence of reach and effectiveness of an asynchronous e-learning program provided globally free of charge in a real-world setting among physiotherapists. The PEAK e-learning modules offer clinicians an accessible educational course to learn about best-practice knee OA management, including telehealth delivery via videoconferencing. Attrition across the e-learning program highlights the challenges of keeping learners engaged in self-directed web-based learning.

Acknowledgments

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Conflicts of Interest

KLB receives consulting fees from Wolters Kluwer for UptoDate knee osteoarthritis clinical guidelines. The Physiotherapy Exercise and Physical Activity for Knee Osteoarthritis (PEAK) e-learning modules are now hosted for free on the FutureLearn (The Open University and SEEK Ltd) platform; however, the University of Melbourne will receive a share of any revenue arising from sales of course upgrades.

Multimedia Appendix 1

Survey questions embedded within the Learning Management System.

[DOCX File , 27 KB - mededu_v7i4e30378_app1.docx]

Multimedia Appendix 2

Four-month implementation survey questions emailed to learners who completed all modules and the post-training survey within the Learning Management System.

[DOCX File , 38 KB - mededu_v7i4e30378_app2.docx]

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Abbreviations

LMS: Learning Management System
NRS: numeric rating scale
OA: osteoarthritis
RE-AIM: Reach, Effectiveness, Adoption, Implementation, and Maintenance

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Original Paper

Simulation-Based Teaching of Telemedicine for Future Users of Teleconsultation and Tele-Expertise: Feasibility Study

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Abstract

Background: Health care professionals worldwide are increasingly using telemedicine in their daily clinical practice. However, there is still a lack of dedicated education and training even though it is needed to improve the quality of the diverse range of telemedicine activities. Simulation-based training may be a useful tool in telemedicine education and training delivery.

Objective: This study aims to assess the feasibility and acceptability of simulation-based telemedicine training.

Methods: We assessed five telemedicine training sessions conducted in a simulation laboratory. The training was focused on video teleconsultations between a patient and a health care professional. The assessment included the participants' satisfaction and attitudes toward the training.

Results: We included 29 participants in total. Participant satisfaction was high (mean score 4.9 of 5), and those that took part stated the high applicability of the simulation-based training to their telemedicine practices (mean score 4.6 of 5). They also stated that they intended to use telemedicine in the future (mean score 4.5 of 5).

Conclusions: Simulation-based training of telemedicine dedicated to video teleconsultation was feasible and showed high satisfaction from participants. However, it remains difficult to scale for a high number of health care professionals.

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KEYWORDS

telemedicine; teleconsultation; simulation training; health care; training; education; digital training; medical education

Introduction

Telemedicine activity has increased considerably worldwide in the past decade. The quality and quantity of telemedicine activities, however, are not yet optimal and could be improved [1]. In France, to improve the quality of telemedicine practices, the Ministry of Health has included telemedicine in the medical curriculum for medical students and residents in recent years [2]. Telemedicine education and training (ET) has also been included in the publicly funded continuing professional development activities available to all physicians. Nevertheless, the proportion of health care professionals (HCPs) trained in telemedicine practice remained limited before the start of the COVID-19 pandemic despite the high demand at the time [3].

Telemedicine ET can involve various components related to clinical guidelines, techniques for remote interactions with the patient, management of a clinical exam performed by another HCP, or the safe and secure use of the technology to support individual and organizational changes [4,5]. The purpose of telemedicine ET may also be to decrease resistance to telemedicine due to potential misconceptions and to increase knowledge and acceptance of the safety and effectiveness of its practice [4].

Simulation-based training has been shown to be an effective method in medical education and should be considered for telemedicine training [6-12]. In simulation-based training, experience creates knowledge that can be transferred to other situations, and failure can be used as leverage in the acquisition of new skills [13]. The objective of the study was to assess the feasibility and acceptability of simulation-based training in telemedicine.

Methods

Study Design

We conducted a mixed methods research study, including qualitative analysis of the participants' perspectives and quantitative assessment of their attitudes toward the training.

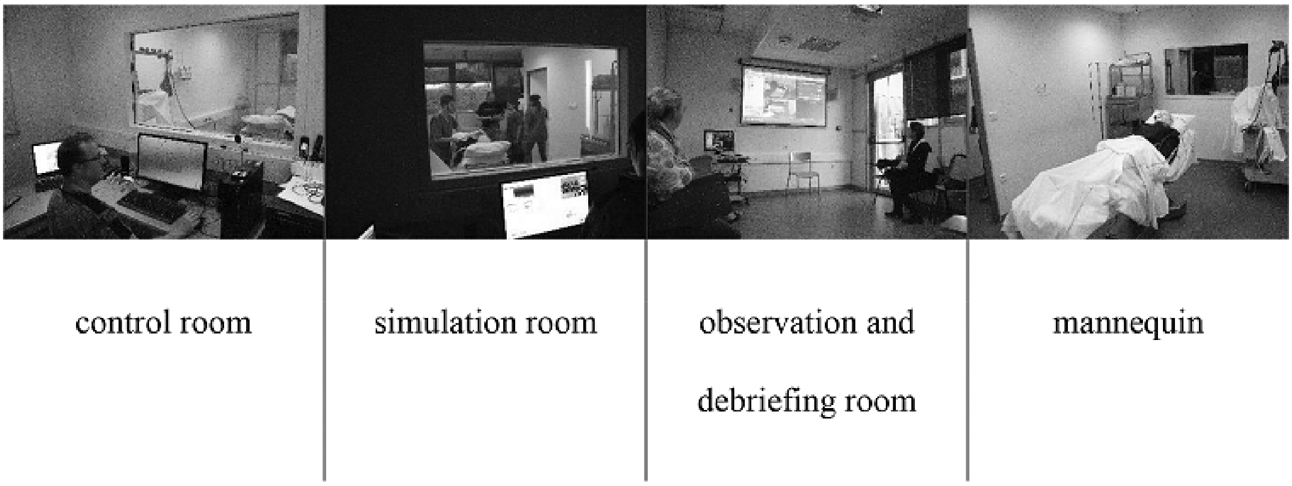
Training Session Design

The training sessions were designed by the Network for Neurological Emergencies at Besançon Regional University Hospital in France and the medical simulation laboratory team at the University of Franche-Comté Medical School. The methodology was based on the guidelines from the *Haute Autorité de Santé* (French National Authority for Health) on simulation-based training in health care [11].

Training Session Content

We conducted the training sessions at the simulation laboratory (MedSim) of the University of Franche Comté Medical School. The laboratory has two simulation rooms equipped with cameras, sound systems, and medical equipment, and two observation rooms (used for observation and debrief sessions) equipped with a screen and a projector. Each simulation room is connected to a control room from which medical devices and a simulation mannequin are managed (Figure 1). Trained actors were used to perform scenarios alongside the participants.

Figure 1. Pictures from the medical simulation laboratory MedSim at the University of Franche Comté Medical School, Besançon, France.



Each training session lasted 4 and a half hours. Each session included an introductory component to present the training team, the simulation laboratory, and the program (1 hour). This was followed by a session in which the participants introduced themselves and discussed their initial ideas about telemedicine (1 hour). The training included two scenarios, which both started with a brief (10 minutes), followed by the simulation (20 minutes) and a debrief (30 minutes). The debrief included four steps (description, analysis, application, and summary) and involved discussions between the participants guided by the teaching team. A general debriefing for the whole session (30 minutes) was conducted after the debrief of the second scenario. The training session ended with a survey.

Scenarios were simulations of routine situations, in which the HCPs participated directly or attended as observers. They were designed to provoke discussion about telemedicine as an integrated part of the participants' routine practices and were not intended to provide technical training on the use of telemedicine.

The first scenario (Textbox 1, Figure 2) focused on understanding what telemedicine is and introduced the ideas of the practical framework, purpose, legal framework, advantages, and limitations of telemedicine. The aim was to reveal the participants' prior knowledge and attitudes by presenting them with questions that they may be required to answer in routine practice. It was also intended to encourage the participants to seek information on topics such as the differences between a teleconsultation and a physical consultation, legislation, technology, data security, and the medical specialties available via telemedicine in their own health care facilities.

The second scenario (Textbox 2, Figure 3) was set up to encourage participants to think about the advantages and disadvantages of telemedicine, and how to perform a teleconsultation, guide a clinical examination by telemedicine, direct the participant in repositioning the hardware, and search for clinical signs again if the initial examination was unhelpful.

Textbox 1. The first scenario of a telemedicine simulation-based training course conducted in Franche-Comté Region, France between 2018 and 2019.

Simulation room

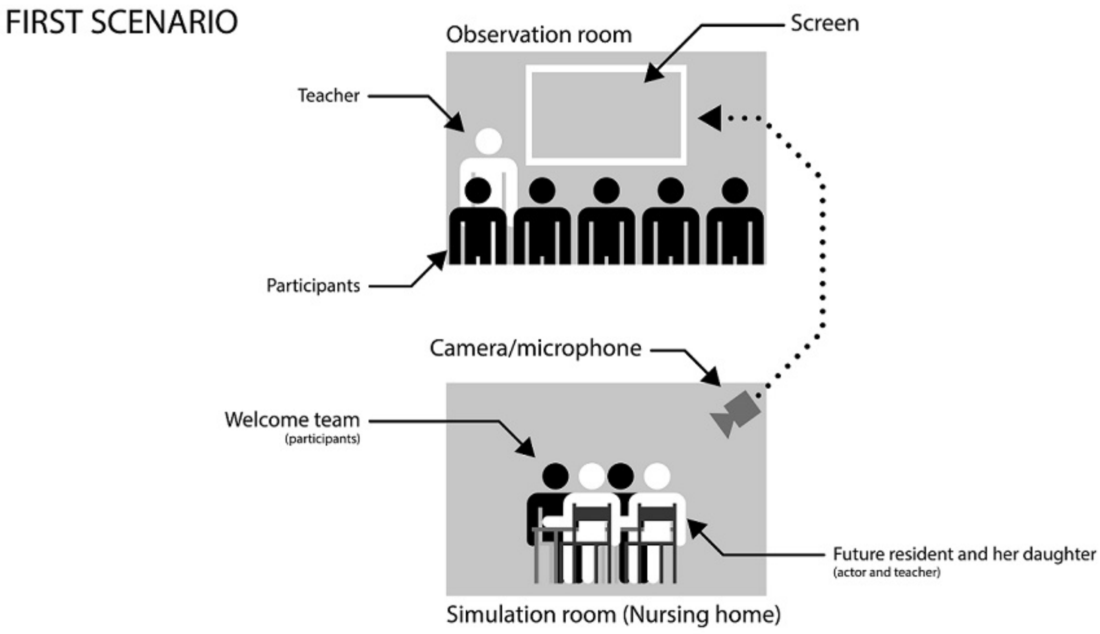
The administrative office of a nursing home in which two paramedical professionals (participants) meet with future residents and their families (actors) to answer questions about the home.

Scenario content

An older woman with diabetes and no cognitive dysfunction arrives for a meeting at a nursing home with her daughter, who is a retired teacher living in Paris. They are considering transferring the older woman into the nursing home because her daily life has become difficult due to diabetic retinopathy and living alone far from her daughter. The nursing home's brochure showcases its telemedicine system, and a manager and nurse welcome the visitors and answer their questions concerning the use of telemedicine including:

- "Will I be able to keep seeing my family doctor?"
- "Isn't telemedicine just a cheap substitute for real medicine?"
- "Can I choose whether or not to have teleconsultations?"
- "What about data security and confidentiality?"

Figure 2. Organization of the first scenario of a telemedicine simulation-based training conducted in the Franche-Comté Region, France between 2018 and 2019.



Textbox 2. Content of the second scenario of a telemedicine simulation-based training conducted in the Franche-Comté Region, France between 2018 and 2019.

Simulation room 1

The nursing home teleconsultation room contains an examination table and a telemedicine cart (screen linked to a computer with the required telemedicine software and a remote-controlled high-definition camera). The cart and camera are not set up in the ideal orientation for a teleconsultation. The patient (actor) is lying on the examination table. A nurse (participant) has requested the teleconsultation.

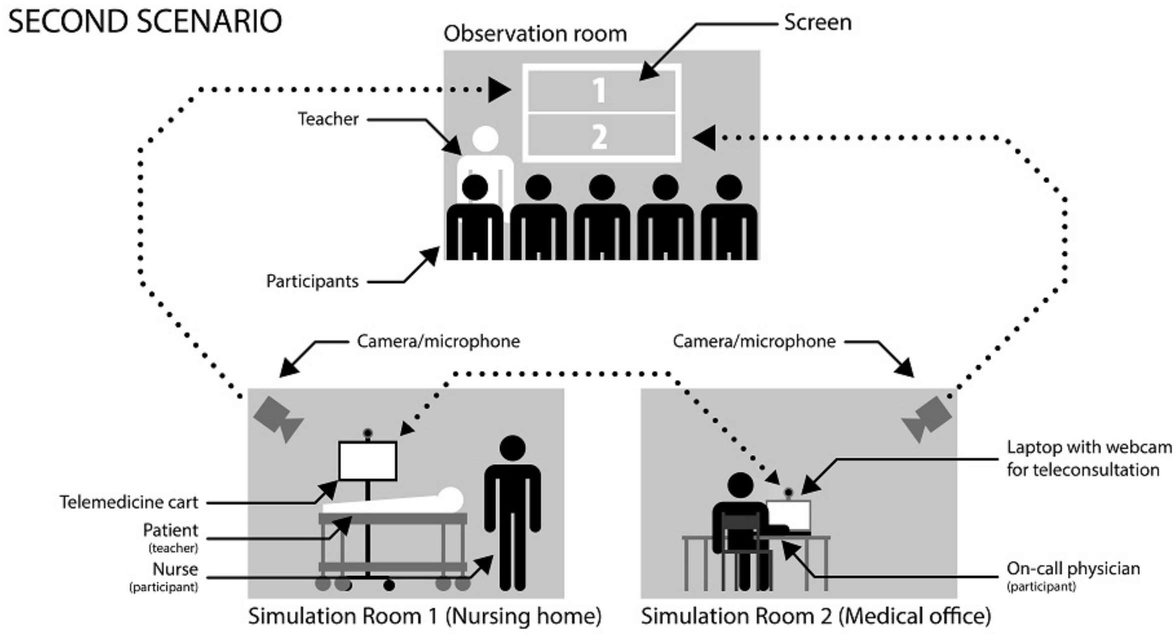
Simulation room 2

The on-call physician's office where a consulting physician (participant) has a desk with a laptop computer equipped with the required software and an integrated webcam.

Scenario content

An older patient in a nursing home presents with calf pain. The calf is red, hard, and swollen. The patient is disoriented but still able to communicate and has complained of calf pain since that morning. There is no on-site physician and the weather conditions make travel impossible, so the on-call physician (medical professional participant) is contacted to conduct a teleconsultation. The nurse (paramedical professional participant) helps the patient in the teleconsultation room. The physician must conduct the teleconsultation from the office.

Figure 3. Organization of the second scenario of a telemedicine simulation-based training course conducted in Franche-Comté Region, France between 2018 and 2019.



Study Recruitment

Training sessions were scheduled from May 2018 to September 2019 and were publicized by the regional health agency (ARS) to all HCPs in the region who were interested in setting up a telemedicine project. Participants included primary care physicians practicing in nursing homes, hospital geriatricians, health care managers, and nursing home nurses. The training was funded by the ARS of Bourgogne-Franche-Comté.

Data Collection

The training sessions were conducted by three of the authors (EMDB, BB, JAR). EMDB and BB are practicing physicians (neurologist and emergency physician, respectively) who are experts in telemedicine and simulation training. They have both completed training courses in health care teaching using simulation training as part of their continuing professional development. JAR is a health care manager and is also the head of teaching at the MED-SIM health care simulation training laboratory. She is qualified to train others to teach using simulation.

Two of the three session leaders were present for each training session. For the initial introductory discussion, the leaders asked questions related to the participants' prior experiences and preconceptions of telemedicine, the telemedicine projects they could become involved in, and their current professional situation. In the debriefing sessions, the leaders used the participants' feedback and reflections as starting points for guided discussions around the key teaching aims.

Two months prior to the first official session, we conducted a trial session with 4 participants, based on which we made minor changes to the scenarios and structure of the course. In terms of participant recruitment, we accepted all participants who signed up to the training sessions. There was no additional selection process or sampling.

The data were collected at the simulation laboratory. No other participants were present during the data collection. During the discussions, author KC made field notes of the key themes raised by the participants.

A satisfaction survey was conducted at the end of the training with 11 Likert scale questions from 1 (low) to 5 (high) and was a standard questionnaire provided by the MED-SIM simulation laboratory. It has been validated internally by the laboratory and is offered to all participants at all training sessions conducted there. A translation of the items included in the questionnaire is provided in the Results section. We calculated the mean score for each item. Due to the small sample size, we did not conduct any statistical comparisons.

Ethics Statement

Ethics committee approval was not required for this study in accordance with French legislation. All participants gave their oral consent to the anonymous use of their data for the purpose of this research.

Results

We conducted five training sessions with an average of 6 participants per session. There were 29 participants in total, including 17 physicians (10 nursing home general practitioners, 4 geriatricians, 2 rehabilitation physicians, and 1 pediatrician in a residential care home) and 12 paramedical professionals (10 nurses and 2 health care managers).

Many of the physicians were initially wary of the idea of performing teleconsultations due to concerns about protecting the patient-physician relationship, constraints of remote clinical examinations, staff being overworked, and payment of private physicians working in nursing homes. The paramedical professionals were less hesitant and mostly had concerns about the distribution of responsibility and logistics.

After the first scenario, participants were particularly interested in data security and had learned that telemedicine is no different to any other tool that could be used to improve the level of care provided for patients. Participants also had a better understanding of telemedicine project implementation methodology, the types of patients who could benefit from telemedicine, and the physical setup of the teleconsultations.

During the second scenario, participants were disoriented by using the technology to communicate. Despite being experienced in physical consultations, the physicians were unsettled and seemed to forget how they would normally communicate with a patient. Their omissions were often remedied during the consultation and the participants noticed the phenomenon of the physicians being disorientated and raised it as a discussion topic during the debrief. The paramedical professionals had the same difficulties, with the addition of being anxious about the technical part of the consultation. Participants noted the limitations of remote communication due to no direct eye contact, lack of visibility and clear understanding of roles of all participants, and delays due to audio/video lags, which can make it difficult to have synchronized conversations.

By the end of the second scenario, the physicians had realized that it was possible to delegate a clinical examination under supervision and to have a high level of confidence in the diagnosis and next patient management steps. Participants also began to imagine themselves in these situations rather than speaking about the concepts in abstract terms. The paramedical professionals showed confidence in clinical examinations supervised by the remote physician.

The results of the survey are presented in Table 1 and the qualitative results are presented in Textbox 3.

Table 1. Survey results of a telemedicine simulation-based training conducted in Franche-Comté Region, France between 2018 and 2019.

	Mean score (out of 5)
Content of the training session	
Adherence to the advertised program	4.7
Extent to which the teaching content met your expectations	4.7
Application to professional practices	4.6
Teaching	
Quality of teaching	4.9
Quality of the materials used	4.8
Overall satisfaction	4.9
Practical aspects (access to the laboratory, welcome rooms, and equipment)	4.6
Impact of the training	
I understood the ideas, methods, and techniques that were taught	4.7
I intend to put these into practice	4.5

Textbox 3. Sample of comments from the satisfaction questionnaire of the simulation-based training conducted in the Franche-Comté Region, France between 2018 and 2019.

Positive comments

- "Helpful discussions with the session leaders"
- "The course leaders had a lot of practical experience and used very concrete examples"
- "Teaching based on discussions using each person's questions as a starting point"
- "Really relevant debrief sessions"
- "High quality of teaching using real-life examples"
- "Good consideration of the applications and the range of possibilities"

Negative comments

- "We would need to train all the staff before putting this into practice"
- "It might be possible to implement this down the line but not immediately"

Discussion

The telemedicine simulation-based training sessions that were delivered in this study demystified teleconsultations by addressing the participants' preconceptions and underlying concerns. This study also prioritized a practical understanding of the specificities, benefits, and limitations of telemedicine practice. To our knowledge, this was the first study conducted in France to evaluate simulation for multidisciplinary telehealth training in a broader context than acute telestroke management, which was the sole focus of the previous study [14].

The participants' feedback regarding the training showed that it reduced their uncertainty toward telemedicine and addressed some of their concerns, particularly for those who had no prior experience of telemedicine. It also enabled them to think about situations in which telemedicine would be helpful and showed that conducting a teleconsultation took them out of their comfort zone and made them forget their usual practices. This is in line with similar results obtained in a study evaluating student nurse practitioners' perceptions of a simulated gerontological telehealth visit, as well as studies evaluating simulation for telehealth competencies of medical or nursing students [15-17].

The simulation brought to light the fact that telemedicine meets the same criteria as so-called classical medicine (including in terms of medical ethics and patient rights) [18]. In addition to the purely knowledge-based questions about telemedicine from a medical perspective, participants also asked questions about the effectiveness of communication between the different people involved in a teleconsultation such as putting the patient at ease, effectively addressing one of two people, and leading the dialogue to optimize the transmission of information. Practicing communication skills during telehealth visits is also relevant for remotely delivering bad news to the patient or the family [19].

The presence of a telemedicine cart in the room during the first scenario allowed the participants to present the concept clearly and concretely to the future nursing home resident and her daughter. In this scenario, the participants became the *experts* in the tool, and the physical presence of the equipment substantially helped them with their explanations [20].

The main limitations of this teaching method are time and financial cost (eg, number of staff required, preparation, and testing of different scenarios), equipment needed, and the low number of participants per session, which is necessary to maximize the impact. Technical issues may also create difficulties. A simulation laboratory necessarily involves the installation and maintenance of multimedia devices and their connections. Additionally, telemedicine training sessions require specific devices, which further complicates the different interfaces. The number of sessions that it is possible to run is therefore also limited by the availability of people with the required technical and human competences.

Due to the rapid increase of telemedicine during the course of the pandemic, in situ simulation for telemedicine training directly from the health care settings may be a more practical and cost-effective method than using a simulation lab [21]. Simulating video teleconsultations through easily accessible software may also be a pragmatic approach to large-scale telehealth training [22].

The artificial nature of communication during teleconsultations requires specific training, which could be delivered by an expert in communication and public speaking. This could lead to the development of a teleconsultation protocol, which could improve communication by avoiding misunderstandings and hesitations, both between the HCPs and with the patient.

Until now, HCPs who are motivated and involved in setting up telemedicine projects have learned this new way of medical practice through experience. As the use of telemedicine becomes more widespread, users who have no prior experience need to integrate these concepts into their practices. In this context, *on-the-job* learning is less desirable.

It therefore seems necessary to establish practical training frameworks with the principal aim of allowing participants to structure telemedicine practices, especially teleconsultation practices, in the most effective way possible. Learning by simulation would seem to be the most appropriate solution. This type of approach is being developed in the United Kingdom, where simulation training is being used to teach webside manner to medical students for video teleconsultations [23]. Simulation-based teaching of telemedicine is an immersive and practical approach that is particularly suited to the continuing professional development of medical and paramedical health care personnel who are involved in an operational telemedicine project. This training could complement an Inter University Diploma in Telemedicine, which primarily caters to people who are setting up a telemedicine project and requires a greater level of personal investment.

The effectiveness of simulation-based learning in health care is well documented [8,9]. In addition to skills, simulation can be used to teach practical techniques to medical and paramedical personnel [24]. According to Policard [25], experience-based learning and reflecting on practices "help to create a shared vision of the situation/problem, as well as common operational frameworks that aid communication and promote teamwork." Simulation exercises also facilitate teamwork and the implementation of procedures, which has a positive impact on patients [26,27]. Simulation-based training would therefore meet the needs of HCPs by providing a pragmatic approach and concrete examples of what a telemedicine act looks like in practice. However, the cost of this means that it may only be a short-term solution. Ultimately, relevant university teaching curricula should integrate telemedicine training [28].

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Authors' Contributions

BB and KC contributed toward the conceptualization, methodology, investigation, resources, writing of the original draft, reviewing and editing, visualization, supervision, project administration, and funding acquisition. EMDB contributed toward the conceptualization, methodology, validation, investigation, resources, reviewing and editing, and funding acquisition. JD contributed toward the validation, reviewing and editing, and visualization. JAR contributed toward the resources, review and editing, and funding acquisition. TM contributed toward the validation, reviewing and editing, and supervision.

Conflicts of Interest

None declared.

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Abbreviations

ARS: regional health authority
ET: education and training
HCP: health care professional

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