Educating future physicians in the time of COVID: A scoping review of online medical education

L'éducation des futurs médecins en contexte pandémique: Un examen de la portée de l'éducation en médecine en ligne

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Executive Summary

Background

The COVID-19 pandemic, and our rapid move to online delivery of medical education, has significantly changed the work of medical educators and administrators, highlighting an important knowledge gap.

Objectives

Our scoping review was designed to respond to an urgent need to identify, organize, analyze, and share information about how medical education has been, and could be, best delivered in online formats, specifically:

- What do we know in the literature about delivering: a) effective, b) resilient, and c) inclusive online Undergraduate Medical Education? What do we need to explore?

- Given the importance of hands-on clinical and procedural skills in Undergraduate Medical Education, how can we guide decisions regarding best curricular formats amid COVID-19?

Methodology

We used a rapid scoping review methodology, following and adapting the Joanna Briggs Institute manual chapter on scoping reviews that includes the steps: 1. developing the review questions and review objectives; 2. determining the eligibility criteria; 3. developing the search strategy; 4. extracting, analyzing, and discussing the findings; 5. drawing conclusions and 6. discussing the implications for practice and further research.

Results

453 articles were ultimately included. These studies spanned the globe; however, the greatest number originated in the United States (103), with India (23), Germany (21) and the United Kingdom (19) being the next largest groups. In terms of populations, 283 studies focused on medical students, 17 involved teachers and other staff, while 129 included both groups. Eighty-eight papers focused on the pre-clerkship/clinical years while 245 focused on the clerkship (clinical) phase of UGME. One hundred and eighty-eight studies considered both pre-clerkship and clerkship.

Of the 264 research/evaluation studies, 224 were Quantitative, 16 were Qualitative, 13 were Mixed Methods. Eleven were Review articles. Among these 264 research articles, the most common data collection methods were surveys (197), with tests being second (59). In descending order, the remaining methods were focus groups (9), other (8), interviews (7) and user data (3). We identified 41 studies that claimed a particular theoretical orientation, whether with respect to research or education. The most frequent theoretical orientation was Constructivism (8), with Adult Learning Theory (general) (5) being the second largest.

We identified a wide variety of online learning modalities being used, including virtual lectures, patient simulations, tutorial groups, serious games, academic panels, and e-learning modules. These modalities incorporated a wide variety of online learning tools. We documented 616 total instances of online tool use in the 453 studies that met inclusion criteria. Diverse apps were included in online UGME delivery. Of the 32 apps featured, the most common category was student engagement apps (e.g., polling apps) (12), while the second most common group of apps related to Self-Directed Learning tools (8).

We focused on three thematic areas (effectiveness, resilience, inclusion). Effectiveness predominated (68%), followed by Resilience (17%) and, Inclusion (14%). Our qualitative analysis identified strengths in the three thematic areas, including flexibility of learning pace and location, and new roles for medical students in UGME design and delivery (Effectiveness); greater access to virtual clerkships for students from underserved communities, institutions, and countries (Inclusion); and new attention to psychological safety and wellbeing in virtual contexts (Resilience). Challenges identified included gaps in technical proficiency for teachers and learners, and challenges with fair and accurate online assessment (Effectiveness); barriers to accessing internet

and virtual tools, and inequities in residency selection process for historically excluded medical students (Inclusion); and increased isolation amid reduced psychological and community supports (Resilience).

Key messages

Medical education would benefit from:

- more rigorous, theoretically informed research in online learning, particularly in the vast area of Simulation and Virtual Reality
- broadening the types of research questions being addressed about online learning
- more in-depth, qualitative investigations of the experiences of online learning

Medical educators should:

- identify content areas that are amenable to online learning
- consider virtual electives and rotations to increase exposure to niche areas
- seize the opportunity to think critically about inclusion
- find opportunities to integrate feedback into online learning resources wherever possible
- consider the benefits of online assessment
- embrace creativity born of necessity
- design and implement curriculum focused on telemedicine
- ensure that online education is safe, inclusive, and supportive

Dedication

Our valued teammate and friend, Ryan Clow, Director, MedIT Enterprise Systems, Dalhousie University, died suddenly in the early stages of our Scoping Review. Ryan played a key role in developing our proposal and plan. This project was conducted in tribute to him and is dedicated to his memory.

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Background

For more than a century, Undergraduate Medical Education (UGME) in North America has followed a Flexnerian pattern (Irby et al., 2010). This involves an orientation to clinical foundations and scientific principles in the first two years that are largely classroom, simulation, or laboratory based (pre-clerkship). This is followed by an apprenticeship-based rotation through various clinical specialties with a focus on mastering various clinical, communication, and procedural skills during the last two years (clerkship). Certainly, in-person, face-to-face instruction based on a philosophy of hands-on, experiential learning is the hallmark of medical education (Yardley et al., 2012).

In recent years, educational developments related to information and communication technologies have emerged as promising practices in medical education. Innovations related to videoconferencing and distributed medical education (MacLeod et al., 2019), digital anatomy laboratories (Darras et al., 2019), web-based learning modules (Cook et al., 2010), virtual reality (Nicholson et al., 2006), and a host of others have been described in the literature. However, these practices have been largely sidelined, overlooked, and treated as "one-offs"—interesting to consider, but not part of our mainstream "way of doing business."

COVID-19 has disrupted all facets of healthcare and Healthcare Professions Education systems (Sklar, 2020). For example, healthcare delivery has largely shifted to telemedicine, with implications for the educational format and content of medical education programs globally. Medical education itself has shifted rapidly to online medical education curriculum delivery (teleteaching) and home-based work by medical education faculty and staff involved in planning, administering, and supporting medical education (telework). Medical education programs grappled with which educational activities should be "continued, postponed, adapted, dropped, and added" (Tolsgaard et al., 2020, p.741), while simultaneously assessing the skills, knowledge, and support required by medical education workers in this pandemic context.

Prior to COVID-19, and its accompanying work-from-home orders, medical campuses had slowly started implementing digital technologies via Distributed Medical Education (DME) to link multiple medical campuses (MacLeod et al., 2019). Medical Education programs gradually reduced formal lectures and increased hands-on, self-directed, and interprofessional learning, using technology to replace and/or complement anatomy and laboratory learning (Irby et al, 2010; Rose, 2020; Skochelak & Stack, 2017). However, integration of digital literacy into the curriculum and medical education workforce remains to be fully realized (Topol, 2019).

In the case of medical education, the need to prepare future physicians has never been so urgent (Rose, 2020). COVID-19 has sparked a revolution in medical education's face-to-face pre-clinical curriculum; its content—including lectures, tutorials and other small group interactions, clinical skill simulations, assessments, and more—has moved online. This digital revolution in medical education is arguably under-researched and long overdue (MacLeod et al., 2019; Skochelak & Stack, 2017; Topol, 2019), with the pandemic requiring medical education communities to adapt to better meet the already changing needs of learners, faculty and staff, and the healthcare workforce based outside the traditional classroom and clinical settings (Rose, 2020; Torda et al., 2020). COVID-19, and the rapid changes it has prompted, offers opportunities to reimagine medical education (Torda et al., 2020), thus making a more effective, resilient, and inclusive medical education community. To do so, we require "rapid, curated, expert advice that can… inform [journal] readers about new training in skills needed to mitigate the ongoing effects of the disaster and prepare the workforce for future disasters" (Sklar, 2020, p.1).

However, online medical education is not merely the online extension of face-to-face learning (MacLeod et al., 2019; Symeonides & Childs, 2015), and involves new forms of work in planning, administering, teaching, and supporting medical education (MacLeod et al., 2017). Faculty Development and IT departments will be vital in ensuring that online UGME is effective, sustainable, and inclusive for diverse medical education workers. In addition, we require further insights into issues related to online medical education, including: the comparability of online learning experiences across sites; the extent to which learning

technologies improve teaching and learning; and understanding new modes of work performed by medical education staff (Tummons et al., 2016).

Online instruction has become an integral part of medical education (Ellaway & Masters, 2008; Jowsey et al., 2020; Zhang et al., 2019), as well as higher education more broadly (Bliuc et al., 2007; Ibrahim & Nat, 2019). Until recently, there was limited evidence that either distance-based or blended instruction led to different learning outcomes compared to traditional methods; further research comparing, and elucidating the differences between, each method needs to be done (Ilic et al., 2015; Rowe et al., 2012). However, online teaching offers the advantages of being flexible (especially when presented in an asynchronous format), practical for teachers and, for the most part, accessible to learners (Chick et al., 2020). Perhaps most importantly, this teaching approach is also inevitable within the context of a pandemic. Teleteaching intends to be learner-focused, based on principles of active learning (Jowsey et al., 2020); ideally, it offers learner-teacher and learner-learner interaction (Authement & Dormire, 2020).

The transfer of instruction online does not come without challenges. Quality of online teaching is related to the competence and engagement of the instructor, as well as the behaviour of the learners behind their screens (Evgeniou & Loizou, 2012). Un-engaging online courses lead students to perceive online learning as dense and dry (Ilic et al., 2015). Furthermore, teachers will have to consider that e-learning is "what the student actually does, and it often, therefore, occurs out of sight, and even out of scope of the teacher" (Ellaway & Masters, 2008, p. 456).

Given its novelty, many instructors are less accustomed to e-learning and institutions lack clear guidelines about how to support and recognize their faculty members for their efforts to expand their teaching (Morin, 2020). The pandemic, therefore, provides us with the unique opportunity to re-imagine online teaching and learning and concretize procedures for its delivery. Medical Education faculties will need to elucidate roles for faculty and staff in e-logistics and administration, e-assessment, and e-community support (Authement & Dormire, 2020; Ellaway & Masters, 2008).

The COVID-19 pandemic, and our rapid move to online delivery of medical education, has significantly changed the work of medical educators and administrators, highlighting an important knowledge gap. Our scoping review was designed to respond to an urgent need to identify, organize, analyze, and share information about how medical education has been, and could be, best delivered in online formats.

Objectives

We conducted a scoping review focused around the effectiveness, resilience, and inclusivity of online Undergraduate Medical Education (UGME). We were particularly interested in how embodied, hands-on, clinical and procedural skills, were dealt with during the era of online learning and physical distancing. Our goal is to share the evidence synthesized through our review with Canadian and international medical education audiences, to support them in making decisions regarding online learning.
Our specific research questions were:

1. What do we know in the literature about formats for delivering effective, resilient, and inclusive online Undergraduate Medical Education? What do we need to explore?
2. Given the importance of hands-on clinical and procedural skills in Undergraduate Medical Education, how can we guide decisions regarding best curricular formats amid COVID-19?

Methods

We followed seminal guidance for scoping reviews, which notes the six steps to conducting a scoping study (Arksey & O'Malley, 2005) and as elaborated on by subsequent authors (Colquhoun et al., 2014; Levac et al., 2010). Specifically, we: 1. developed the review questions and objectives; 2. determined the eligibility criteria; 3. developed the search strategy; 4. extracted, analyzed, and discussed the findings; 5. drew conclusions and 6. discussed the implications for practice and further research.

Our scoping review was, in fact, a rapid scoping review: "a form of knowledge synthesis that accelerates the process of conducting a traditional systematic review through streamlining or omitting a variety of methods to produce evidence in a resource-efficient manner" (Hamel et al., 2020). Modifications to the methods recommended in the scoping review chapter of the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis (Peters et al., 2020) were made to accommodate a compressed timeline. Specifically, we started with an initial search of the most recent literature and conducted iterative searches to supplement findings in areas where the findings were limited. Also, the protocol was developed in parallel with conducting the first three steps of the scoping review, which were refined in response to the evidence that emerged from a broad search of the literature.

Search Strategy

Our scoping review followed a three-pronged JBI search strategy with an aim to locate both published papers and grey literature. An initial limited search was conducted in MEDLINE (Ovid) to identify relevant articles on this topic. The text words in the title and abstracts used in the retrieved articles as well as the index terms used to describe the articles were used to develop a full search strategy (See Appendix 1). To expedite the review and respond to the timely challenge of the online teaching and learning environment during the COVID-19 pandemic, we conducted iterative search strategies starting with a broad search of the topic from January 2020 to March 2021. This scan created the basis for an assessment, in consultation with various stakeholders, including IT professionals, medical school administrators, and expansion of the search to the references of included studies and further targeted searches of select bibliographic databases.

Information Sources

We searched MEDLINE (Ovid) (January 1, 2020 to March 2, 2021), Embase (Elsevier) (January 1, 2020 to March 3, 2021), CINAHL (EbscoHost) (January 1, 2020 to March 2, 2021), PsycINFO (EbscoHost) (January 1, 2020 to March 2, 2021), Education Resources Information Centre (ProQuest) (January 1, 2020 to March 2, 2021), and Scopus (Elsevier) (January 1, 2020 to March 2, 2021). The search used index and text words to describe the main concepts of UGME and remote delivery/virtual technology, with parts modified from previous related reviews (Barteit et al., 2020). We used the advanced search functions of Google to conduct grey literature searches of relevant conference proceedings (e.g., International Association for Medical Education (AMEE), Canadian Conference on Medical Education (CCME), Association of American Medical Colleges (AAMC)) and Medical School websites.

Study selection

Citations were exported from the databases and imported into systematic review management software, Covidence, for automatic removal of duplicates. We screened possible documents using Covidence in accordance with our inclusion and exclusion criteria and guided by the review question. Two team members screened each possible source in two phases: 1) title/abstract level and 2) full-text level. Following a pilot phase of title/abstract screening, the research team met weekly to discuss conflicts and refine inclusion and exclusion criteria to calibrate the review in response to the available evidence. Final inclusion and exclusion criteria are below in Table 1. Conflicts were resolved by three senior members of the review team (AM, PC, RP, with PC leading). Search results are reported here in full in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram (see Appendix 2).

Inclusion/Exclusion Criteria

Please see Appendix 2, Summary of Inclusion and Exclusion Criteria.

Participants

This scoping review considered studies that included undergraduate medical students. We defined medical students as students enrolled in a degree granting institution that confers MD (Medical Doctor) or MBBS (Bachelor of Medicine, Bachelor of Surgery) degrees. Because medical education is sometimes an interprofessional endeavour, we included studies where medical students were joined by other health professions students like nurses and physician assistants. We excluded studies focused on postgraduate medical education (medical residents) and/or practicing physicians (may be referred to as attendings or staff), even those that included medical students but did not focus on undergraduate-level curriculum and content because

the context of postgraduate education is significantly different than undergraduate medical education. We included studies that focused on faculty, staff, and administrators who were involved in the planning and delivery of undergraduate medical education. There were no geographic exclusion criteria.

Concept

The concept of interest in this scoping review was teaching and learning within the online context. This included teaching, learning, and assessment conducted in UGME programs, as well as the remote work by administrators, staff, and faculty who made it possible. Our focus was on teaching and learning of skills, knowledge, and procedures that are developed to ensure UGME curriculum outcomes are met. This included the development, implementation, and/or evaluation of curriculum focused on biomedical knowledge (foundational basic and medical sciences) and/or clinical skills (communication and procedural) and/or the assessment of these knowledge and skills, as well as learning resources created and/or delivered by medical school staff and/or faculty. We also included Self-Directed Learning (SDL) strategies, resources, and approaches as they related to the UGME learning and could be applicable in the context described below.

Context

This review considered studies within the online, remote-delivery context. This includes all online learning and distance, digitally mediated delivery and reception of instruction in UGME programs. The context focusses on the contemporary circumstances of teaching and learning during a global pandemic, and therefore is restricted to accounts of the work and learning possible with the resources available under lock-down, with most of the population located at home. Therefore, we excluded reports of teaching and learning in UGME programs that relies on technology that is not easily available (such as virtual and augmented reality, sophisticated simulation technology, etc.). However, as noted in the description of the Concept of interest, various digital learning resources are included in the context. These online resources include e-learning tools, learning management systems, videoconferencing platforms, Massive Open Online Courses (MOOCs) [when relating to medical school curriculum only], and open education resources like textbooks and videos focused on UGME content. Our review excluded studies of blended learning and hands-on simulation, and any other form of curriculum delivery that required a face-to-face component, unless these methods involved, or were being compared to, an online-only course or learning opportunity (e.g., telehealth and video conferencing with a simulated patient).

Types of Sources

This scoping review included both qualitative and quantitative studies with primary and secondary data, as well as Letters, Opinions, and Commentaries relating to online UGME in the COVID era. Because of this public health emergency, the urgency of publication has resulted in many preliminary findings being published in shorter and more efficient journal sections. We also included other review articles that met the study inclusion criteria. Only studies published in English were included because of the cost and time involved in translating non-English studies. The review included studies published in 2020 and 2021; this timeframe was chosen due to 2020 marking the declaration of COVID-19 as a global pandemic, the international shift to primarily online UGME necessitated by COVID-19, and proliferation of research on the topic of online UGME due to this broader international shift to virtual work and learning.

There is a large volume of literature that focuses on online Simulation and Virtual Reality in medical education. In both domains, our initial scan identified hundreds of relevant articles fitting our preliminary inclusion criteria. After reviewing the goals of our review, and in consultation with experts in simulation, virtual reality, and information technologies, we decided to exclude articles that required uncommon and/or expensive technologies that would not be reasonably expected for a student to access at home.

Data extraction

Data extraction was completed by all members of the team. Extracted data included details about the population, concept, context, methods, types of online UGME, and key findings pertaining to the review questions (See Appendix 3: Data Extraction Template). We collaboratively developed the data extraction form to reflect our research questions and thematic areas of focus, based on a JBI template. The form was piloted by team members using a sample of included documents (approximately 10%). We iteratively modified the form based on the pilot, and when it appeared that there were possible areas for improvement based on feedback and

discussion amongst team members. The team extracted relevant data from each included document, and a random sample (approximately 10%) was extracted in duplicate and discussed for any discrepancies.

Data Analysis and Presentation

We used a combination of inductive and deductive approaches to analyze our data. This included mapping the knowledge generated based on the results of the search, screening, and data extraction. We organized the evidence to address our research questions with a particular focus on identifying challenges, opportunities, and promising practices. As we engaged in the parallel extraction and analysis process, we continued to meet regularly as a team, allowing for new ideas and topics of discussion to arise through conversation. We also engaged in regular conversations with local knowledge users to ensure our review was practically oriented (See Table 2, Stakeholder Engagements). These conversations directed the structure and focus of our analytical work.

Stakeholder	Focus of Meeting
Associate Dean, Undergraduate Medical Education, Dalhousie University	Provided advice about areas of interest/concern for the undergraduate curriculum.
Director of Simulation, Faculty of Medicine, Dalhousie University	Provided guidance about managing studies focused on online simulation
Evaluation Specialist, Undergraduate Medical Education, Dalhousie University	Provided guidance around question of student evaluation of online learning
Service Delivery Manager, Medical Information Technology (MedIT), Faculty of Medicine, Dalhousie University	Provided on-the-ground insight about transition to online learning across the UGME curriculum.
Instructional Designer, Educational Developer, Centre for Learning & Teaching at Dalhousie University	Provided on-the-ground insight about supporting students and staff transitioning to online learning across the Higher Education curriculum, including technical/logistical challenges, threats to student wellbeing and implications for inclusive higher education.

Table 1: Stakeholder Engagements

Our iterative analytical approach allowed us to incorporate stakeholder feedback after an initial round of data extraction and coding. We also used Qualitative data analysis software (ATLAS.ti) to code, in more detail, the key messages from each of the 453 documents included in our review. One team member (PC) conducted coding. Through further discussion and analysis, we arrived at the results presented below.

Results

General overview

We identified 3018 studies initially, with 1044 of these duplicates. Of the remaining studies, 1245 of these were deemed irrelevant. 1974 studies underwent title and abstract screening, of which 709 were deemed eligible for full text screening. In this phase, 256 studies were excluded for the reasons listed in Table 3, below. 453 articles were ultimately included in our study.

Included studies spanned the globe; however, the greatest number of studies originated in the United States (103), with studies in India (23), Germany (21) and the United Kingdom (19) being the next largest groups.

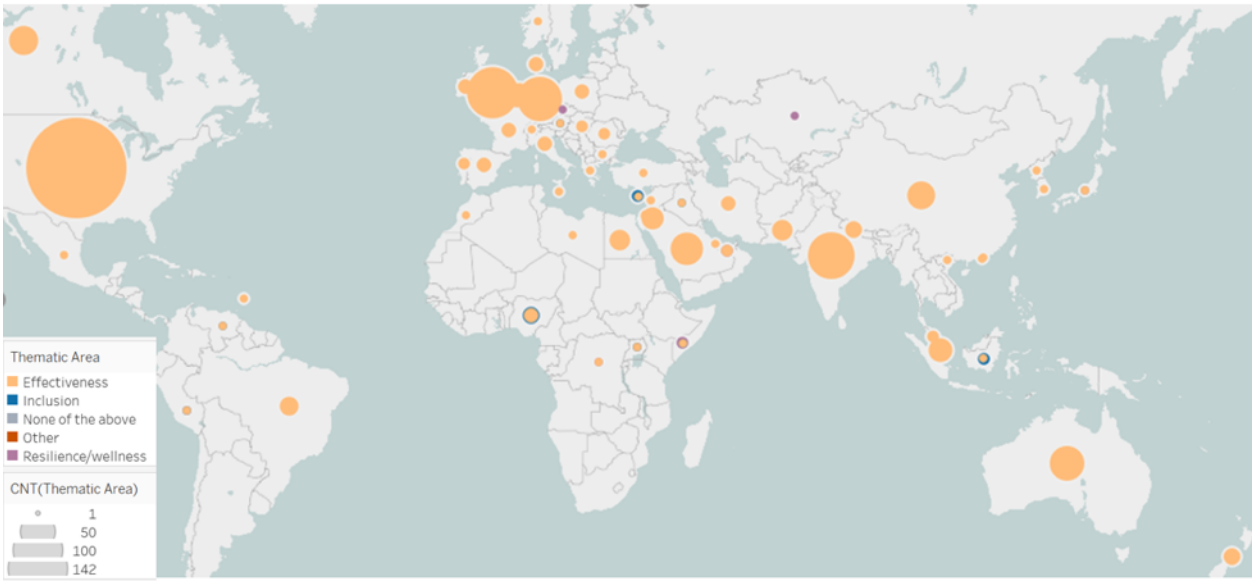


Figure 1: Thematic areas by geographic location

Of these studies, 246 (54%) were research/evaluation, 140 (31%) described innovations, 63 (14%) were opinion pieces, with 4 (1%) studies being another format.

Article type	# Studies	% of total
Research or Evaluation	246	54%
Descriptive piece	140	31%
Opinion piece	63	14%
Other	4	1%
Grand Total	**453**	**100%**

Table 2: Types of included studies

Of the 246 empirical research/evaluation studies, 218 were Quantitative, 15 were Qualitative, and 13 were Mixed Methods. 11 research studies were Reviews.

Research Type	# articles using research type	% articles using research type
Quantitative	218	89%
Qualitative	15	6%
Mixed Methods	13	5%

Table 3: Research approaches for included research and evaluation studies

With the total included research/evaluation studies (264), the most common data collection methods were surveys (197), with tests being second (59). In descending order, the remaining methods used were focus groups (9), other (8), interviews (7) and user data (3).

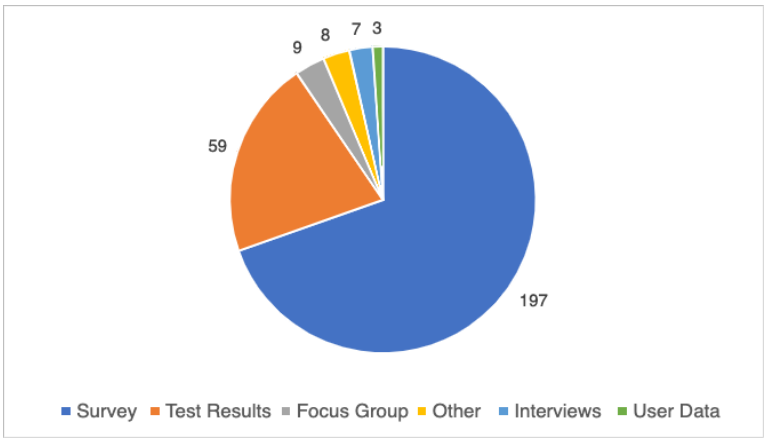


Figure 2: Data collection methods

We identified 41 studies that claimed a particular theoretical orientation, with respect to research and/or education. The most frequent theoretical orientation was Constructivism (8), with Adult Learning Theory (general) (5) being the second largest theoretical orientation.

Theory	# Studies
Constructivism	8
Adult Learning Theory	5
Community of Inquiry	3
Social Learning Theory	3
Self-directed Learning	3
Cognitivism	3
Professional Learning Theory	2
Affective Learning	2
Active Learning Theory	2
Self-determination Theory	2
Networked Learning Theory	1
Gunawardena's Knowledge Construction Framework	1
Humanistic Learning Theory	1
Master Adaptive Learning (MAL) Theory	1
Cognitive Apprenticeship Theory	1
Transactional Distance Theory	1
Unified Theory of Acceptance and Use of Technology (UTAUT)	1
Interpretivism	1

Table 4: Theoretical orientations of included studies

Planning and curriculum models used in included studies were heterogeneous. Kern's Six Step approach to curriculum development model was the most used framework, with 4 studies using this model. In total, 17 planning models and frameworks were featured in included studies:

- Overbaugh's guidelines

- Mayers multimedia principles
- ADDIE model
- Disciplined Agile Delivery Methodology (DAD)
- Four-Component Instructional Design (4CID)
- Kalamazoo Consensus Framework
- Kern Curriculum Model
- MASMDOA framework
- Plan Do Check Act (PDCA)
- RACE model
- RE-AIM program evaluation framework
- Garrison's SDL dimensions of behaviour
- spaced repetition model
- SWOT analysis
- The Polarity Approach for Continuity and Transformation (PACT)
- Work Skill Development Framework
- Gamification

We identified a wide variety of online learning modalities being used, including virtual lectures, patient simulations, tutorial groups, serious games, academic panels, and e-learning modules. These modalities featured in our included studies included incorporated a wide variety of online learning tools. We documented 616 total instances of online tool use in the 453 studies that met inclusion criteria for our scoping review. The featured digital tools are listed in Table 8 below.

Virtual Tools	# Used
Communication Platforms (e.g., Zoom, Teams, Slack)	171
Learning Management Systems (e.g., Moodle, BrightSpace)	69
Assessment tools (e.g., ExamSoft, Google Forms)	56
Videos (e.g., MP4)	33
Apps (e.g., Poll Everywhere, Kahoot)	32
Slide Software (e.g., PowerPoint)	28
E-learning platform (i.e., In-house platforms)	22
Simulation tools (e.g., eCREST electronic Clinical Reasoning Simulation tool)	17
Social Media (e.g., Twitter, Instagram)	14
E-learning modules (i.e., In-house modules)	15
Serious Games (e.g., "Laboratorium Of Epidemiology" serious game scenario)	14
Anatomy tools (e.g., Acland's Video Atlas of Anatomy)	14
Repositories: lecture, image, video, cases (e.g., www.radoncvirtual.com Lecture repository)	12
Online resources: miscellaneous	14
Virtual Reality tools (e.g., Direct Ophthalmoscope simulator tool)	10
Recordings: lectures, audio (e.g., MP4)	10
Websites (e.g., Soton Brain Hub website)	10
Podcasts (e.g., Eyes for Ears Podcast)	9
Digital images (e.g.,	8
Virtual microscope/slides (e.g., virtual microscope software)	7
Lecture capture tools (e.g., Kaltura)	7
Cameras (e.g., GoPro)	6
Blogs (e.g., WordPress, Edublogs)	5

E-learning design platforms (e.g, Exelearning 2.5)	5
Telemedicine platforms (e.g., Epic Systems telemedicine portal)	5
Digital books (e.g., iBooks)	5
MOOC (e.g., Coursera, edX, Udacity)	4
Software (e.g., Eclipse, Precision treatment planning software)	3
Electronic Health Records	2
Infographic tools (e.g, Canva)	2
Discussion Board (e.g., Ask Me Anything)	1
Wiki (e.g., Campus Pack Wiki Tool)	1
Grand Total	616

Table 5: Virtual tools featured in included studies

Diverse apps were included in online UGME delivery. Of the 32 apps featured in included studies, the most common category was student engagement apps (e.g., polling apps) (12), while the second most common group of apps related to Self-Directed Learning tools (8).

App type	# used
Student Engagement	12
Self-Directed Learning	8
Curriculum design	5
Video Player	4
Clinical content	2
Teaching resource	1

Table 6: Types of apps featured in included studies

In terms of populations, 283 studies focused on medical students, 17 involved teachers and other staff, while 129 included both groups in their focus.

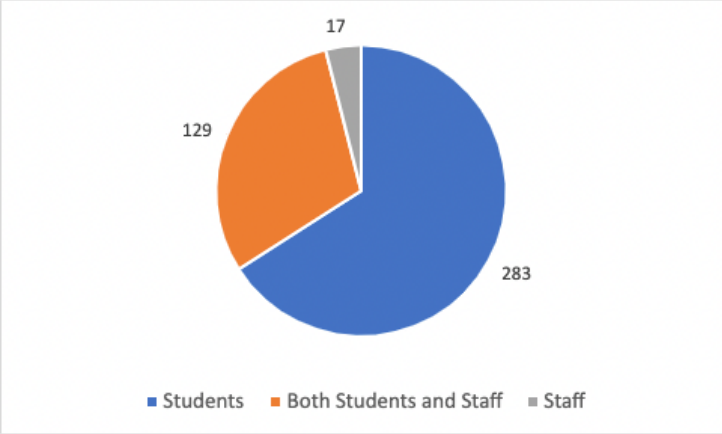


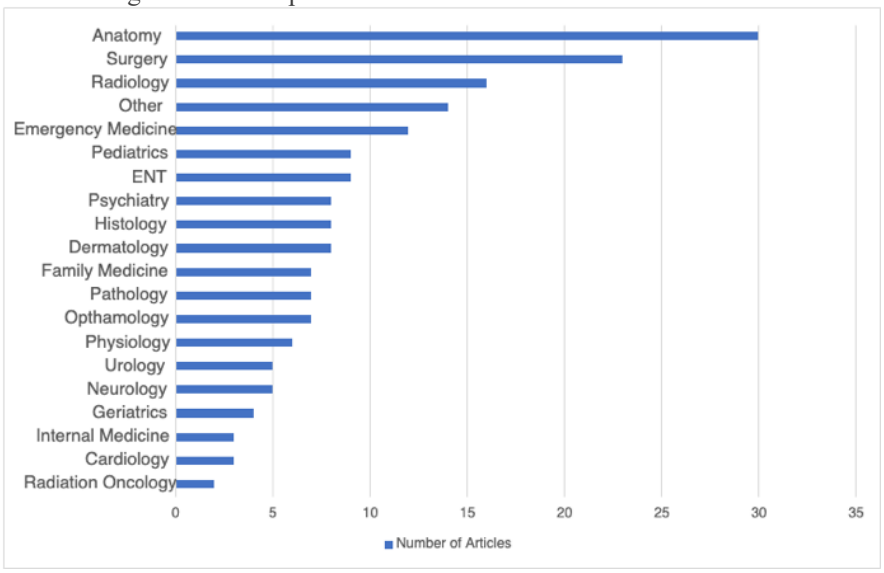
Figure 3: Populations represented in included studies

88 papers focused on the pre-clerkship/clinical years while 245 focused on the clerkship (clinical) phase of UGME. 188 studies considered both pre-clerkship and clerkship phases.

UGME level	# Studies
Pre-clerkship	88
Clerkship	245
Full Program	188

Table 7: UGME levels represented in included studies

Not all included articles focused on a particular medical education content area. However, of the 186 that did, the following areas were represented:



*Other category: Forensic Medicine; Endocrinology; Gastroenterology; Global Health; Microbiology; Nephrology; Regenerative Medicine; Respirology; Virology; Wilderness Medicine

Figure 4: Specialty focus areas in included studies

Of our three thematic areas, Effectiveness predominated, marking 68% of included studies. Resilience/wellness came second, with 17% of total studies, and studies with an Inclusion focus constituted 14% of the total included literature.

Thematic Area	Total	Percentage
Effectiveness	409	67.94%
Inclusion	82	13.62%
Resilience/wellness	103	17.11%

Table 8: Thematic areas represented in included studies

Qualitative results

As noted in the Methods section, we conducted Qualitative analysis of study results and conclusions extracted from included studies. In this section, we will explore qualitative findings for each of the three thematic areas: Effectiveness, Inclusion, and Resilience/Wellness within online UGME. We will share strengths and challenges in each of these areas.

Effectiveness

A significant portion of our results were focused on effectiveness (409 papers). These papers answered the question "did it work?" These included studies that evaluated the efficacy of a particular virtual learning tool or curriculum, descriptive papers that documented an online innovation, or opinion pieces that discussed challenges for online learning, for example.

Strengths	Challenges
1. Flexibility	1. Poor internet connectivity and infrastructure
2. Innovative teaching approaches	2. Inadequate online learning devices
3. Innovations in virtual resources, curricula	3. Lack of appropriate physical space
4. Minimization of barriers for student progression to residency	4. Incompatible microphones, cameras, and software, and more
5. Expanded role of medical students in UGME design and delivery	5. Physical ailments caused by increased screen use
6. Expanded role of residents in UGME teaching	6. Diminished student engagement and participation
7. Multiple potential channels for in-class communication	7. Logistical, financial, legal, psychological, and ethical challenges involved in online assessment
8. Development of telemedicine skills	8. Delivering hands-on skill and/or clinical learning offered by traditional clinical electives and clerkships, cadaver-based learning
9. Innovations in formative assessment for students and teachers	9. Gaps in technological proficiency (both students and teachers)
	10. Threats to residency transition: exposure to specialties, references, interviews
	11. Establishing online teacher presence
	12. Diminished connection, belonging, spontaneity found in face-to-face interactions
	13. Emotional detachment brought by screen-mediated interactions

Table 9: Strengths and Challenges: Effectiveness of online UGME

Inclusion

A smaller portion of our results (82) addressed the theme of inclusion. We classified a study as focusing on inclusion when it addressed any element of equity, diversity, or inclusion with respect to accessing, and/or participating in, online medical education.

Strengths	Challenges
1. Virtual clerkship rotations	1. Inequitable access to internet, equipment, other resources
2. Innovative, low-cost simulations	2. Inequities in residency selection process

3. Greater accommodation of diverse communication and teaching/learning needs	3. Disproportionate impact of COVID, online learning on HE students, staff, low-resource countries
4. Innovations in inclusive teaching and learning	4. Expensive UGME tools
5. Increased resource sharing	
6. Development of innovative, low-resource curriculum materials	
7. Revising virtual curricula to be more inclusive	
8. Greater attention to digital divides	

Table 10: Strengths and Challenges: Inclusion in online UGME

Resilience

103 studies addressed the theme of Resilience. We classified a study as focusing on this theme when it addressed any element of learner or educator well-being with respect to online learning, with a particular focus on issues of anxiety and burnout.

Strengths	Challenges
1. Transition to online learning has proven staff and stude resilience	1. Fear and uncertainty about the future
2. Virtual offerings have assuaged student fears and frustrations	2. Increased isolation, grief, and loss amid fewer supports
3. Great time and/or flexibility for at-home wellness activi	3. Difficulty focusing and reduced motivation and time management
4. Virtual offerings can be designed for psychological safet emotional wellbeing	4. Increased levels of anxiety and depression
5. Virtual tools can help reduce test anxiety	5. Risk of unmanageable workloads for staff
6. Virtual platforms can offer emotional an psychological supports, Virtual mentorsh peer support, and informal check ins	

Table 11: Strengths: Resilience in online UGME

Discussion

Strengths

1. Effectiveness:

Flexibility of learning pace and approach was overwhelmingly the most cited benefit of online UGME by students. This flexibility enabled students to:

a. access learning materials quickly and from anywhere;
b. review materials as often as desired;
c. adapt learning according to their individual needs and preferences; and
d. exert greater control over progress and the rate of information intake.

Understandably, the COVID era has ushered in a groundswell of educational innovations. Despite pressures of time, and in many cases, resources, international medical educators forged opportunities for experimentation and reflection. The challenge of engaging students in fully virtual curricula, for example, sparked many new teaching skills and strategies for online UGME. This has generated new best practices, how-tos, and a greater global proficiency at online UGME design and delivery (Jiang et al., 2021; Said & Schwartz, 2021). In many cases, we noted that these new practices involved a more student-centred, active learning orientation (Wayne et al., 2020), and medical students notably took on new roles in UGME curriculum design and delivery through peer teaching (Traba et al., 2021), tutoring (Pettitt-Schieber et al., 2021), and curriculum development (Roll et al., 2020).

Teachers and curriculum designers seized on COVID as curriculum, weaving current events into their classes to explore diverse topics such as public health, epidemiology, public health education, virology, and more (Kercheval et al., 2020; Willey et al., 2020). Teachers integrated new, innovative tools in their work, including using GoPro cameras to convey the vantage point of a surgeon in the operating room—but also capturing the patient perspective, providing evidence that technology and professional values such as patient centredness can uniquely coincide in virtual UGME (Chao et al., 2020; Jack et al., 2021). Shifting to home-based teaching and learning has also led to other adjacent innovations, from rethinking allocation of physical space to exploring hybrid models for teaching and learning (Castellucci, 2020; Oyeleye, 2021), and digital work more broadly. New partnerships and educational support programs have also emerged in this era, evidenced by one study (Abler et al., 2020) that explored interprofessional e-tutors who supported teachers and students in creatively and effectively sharing their ideas in multiple virtual formats.

These teaching innovations have been accompanied by an explosion of novel online tools and curricula for use within UGME programs. These new technologies span multiple UGME formats, from lectures and tutorial groups, to clinical electives and clerkship rotations. They include the use of GoPro first person footage in operating theatres, as noted above; virtual microscope slides (Guiter et al., 2021); virtual anatomical platforms (Naglik et al., 2020; Sagoo et al., 2020); open access resources such as digital medical libraries (Barton & Round, 2020; Forestell et al., 2020), collections (Buendia et al., 2021), and apps (Levin et al., 2020) for specialty content (e.g., Radiology, ENT, Emergency Medicine); serious games (Georgieva-Tsaneva & Serbezova, 2020;); medical MOOCs (Ibrahim et al., 2020); and much more. Existing virtual resources, such as social media, YouTube videos, podcasts, and infographics, have also been woven into curricula in innovative ways (Geha & Dhaliwal, 2020; Hill & Pasik, 2020). Thanks to these tools and platforms, summative assessments also were deemed effective via online learning (Jaap et al., 2021), providing educators with more frequent, and more diverse, opportunities and formats for engaging students and assessing their progression.

Online UGME offered several benefits for student progression, including filling gaps in face-to-face clerkships, thereby scaffolding the complex transition to residency (Dawoud et al., 2020; Song & Haley, 2020). Virtual clerkships offered medical students exposure to diverse specialties, opportunities to connect with new staff, peers and programs, and engagement with resident and physician teachers who could serve as mentors and/or residency references (Chao et al., 2021). Several studies described the increased workloads caused by COVID for clinical teaching faculty; resident teachers therefore played an increased role in these clerkships, as well as other UGME programming (Basu & Marimuthu, 2020). This more prominent role for resident teachers offered several benefits, including: new teaching partnerships between residents and clinical faculty; involving residents to serve as simulated patients offering high quality clinical feedback; and designing more sophisticated teaching strategies grounded in resident teachers' high technological proficiency (Shin et al., 2021; Traba et al., 2021).

Within learning spaces, online UGME platforms enabled new channels for teacher-student communication. Online videoconferencing platforms like Zoom and Teams offer multiple formats for discussion: chat boxes, breakout rooms, message boards, in addition to on-screen conversation. Several studies noted increased participation in virtual UGME offerings, with students and teachers acknowledging the benefits of these new channels in everyday UGME (Caton et al., 2021; Dwivedi et al., 2020). Several studies described successful approaches such as having two teachers leading virtual sessions, with one monitoring the chat box so students can ask questions as they arise—a key concern given the importance of student engagement and participation (Xie & Bower, 2020). Some teachers reported hearing more often from more

students, while one study observed much greater interaction between clerks and preceptors in virtual clerkship offerings (Alkarani & Thobaity, 2020).

Access to telemedicine skills and knowledge was a commonly cited strength of online UGME across the literature. COVID's rapid shift to virtual medical education mirrors the broader shift to telemedicine, as clinical spaces closed to the broader public and health professionals moved patient appointments online (Jumreornvong et al., 2020). The pandemic period has enabled medical schools to embrace and integrate telemedicine principles and practice into the formal curriculum—across the preclinical and clinical years. Telemedicine is most likely here to stay, which makes medical students' virtual patient simulations and telemedicine consultations highly important developments (Sklar, 2020; Ylä-Soininmäki et al., 2018). These developments notably avoided additional resource burdens for these institutions, who identified a need to teach students how to build patient rapport online, conduct restricted physical examinations, and ensure confidentiality and consent in telemedicine appointments (Boylan et al., 2020; Coffey et al., 2020; Guadix et al., 2020a). Our review identified a growing call for developing further research, policy, and practice in this crucial area, spanning from ethics to best practices (Peterseim & Watson, 2020; Sklar, 2020).

Generally, preclinical courses (lectures, tutorial groups) had fewer adjustments to make to online teaching and learning. Clerkship courses, as a rule, faced more complex challenges in transitioning mostly face-to-face clinical rotations to a virtual format (Sasidharan et al., 2020). We noted exceptions, however: some programs and specialties seemed to enjoy a smoother transition to online UGME. These tended to be specialties that involved a greater degree of technological sophistication in their clinical tools already (Chao et al., 2020; Song & Haley, 2020), as well as those specialties that were underrepresented (or even absent) in the preclerkship curriculum (e.g., Radiology, Radiation Oncology), and were therefore motivated to develop online programming to expose undergraduate medical students to their specialty as a possible residency choice (Durfee et al., 2020; Kahn et al., 2021).

2. Inclusion:

Innovations in online UGME policy and practice open opportunities to reflect and address historical inequities at individual, institutional, and international levels (Keegan & Bannister, 2020). While arguably, more challenges than successes persist in this area, increasing awareness of historical white supremacy and colonialism over the past year have coincided with COVID-era UGME innovations in promising ways. As we rethink medical education amid this virtual transition, previously under-addressed questions of access and inclusion demand our attention (Tabari & Amini, 2021). Existing barriers to Historically Excluded (HE) students and low-resource areas, institutions, and countries have only been exacerbated by COVID era UGME (Al-Mendalawi, 2020; Brown, 2020); however, creating new ways of teaching and learning (Keegan & Bannister, 2021)—and sharing these resources widely (Bakkum et al., 2020; Cevik et al., 2021)—can offer rich opportunities for attracting, retaining, and supporting the diverse future physicians the field requires.

As predominantly first-generation medical students, HE students are particularly dependent on clinical experiences for learning about professional pathways, programs, values, and cultures. Residency references, for example, are particularly vital, as many HE students lack social capital networks enjoyed by many more privileged students (Brown, 2020; Cevik et al., 2021). Virtual clerkships are particularly important for these students, as they face multiple additional barriers to residency placements. Moving clerkships online can increase access to students who may face economic and geographic barriers, particularly those HE students in under-resourced medical programs and those who lack faculty mentors in specialties of interest (Song & Haley, 2020). Virtual UGME can open multiple channels for inclusive teaching, mentoring, and sponsoring diverse learners (Srinivasan, 2020). It can increase representation of diverse students, teachers, and patients, in curriculum materials, websites, and more, while ensuring that virtual conferences and lectures offer authentic representation from multiple groups (Antonoff, 2021).

Home learning amid COVID has sparked the development of low-cost and low-bandwidth educational materials, from simulators using easily accessed materials (Sellers et al., 2021), to online UGME formats that enable downloading lectures, asynchronous participation, and lower-bandwidth modalities such as discussion boards (Burns et al., 2021; Dilly et al., 2020). A broader shift toward virtual learning has also meant greater student centeredness in UGME approaches, thereby accommodating more diverse learning needs—

from curriculum design, teaching and learning to assessment. The lack of commute also benefits students who are disabled and/or ill, thereby increasing access to UGME curriculum. Our review shows that, when shared equitably, local online UGME innovations can have a global impact (Cevik et al., 2021) and help reduce disparities in educational access. Attention to digital divides is a crucial strength of online UGME in the COVID era, as universities, companies, and governments are being called on to address inequitable access to online learning by ensuring that all students, institutions, and countries benefit from virtual innovations (Stoller, 2021; Tabari & Amini, 2021).

3. Resilience/Wellness:

The COVID era of UGME brought significant emotional tolls for students and staff involved in the rapid transition to online teaching and learning. Medical students heard "troubling stories from residents in New York about what it was like to be in the hospitals" (Kelly, 2020, p. 345), compounded by very real fears about risk to themselves and their loved ones, and their mortality as both citizens and medical professionals in training. While many residents were called to action in the COVID effort, "Meanwhile," a student author notes, "many students only a few years or months behind in training were left feeling powerless as the profession we chose continued to struggle. We watched from behind our computer screens as we completed online curricula regarding COVID-19 and the remainder of our abridged clerkships" (p.345).

Despite the mental health burdens over the pandemic period, necessity has bred innovation for resilience and wellness. In many studies, we learned of creative initiatives via virtual channels to support teacher and learning wellbeing (Guerandel et al., 2020). The sheer ability of UGME staff and students to transition to an online format has provided a well-deserved sense of pride, grit, and resilience (Kapila et al., 2020; Wayne et al., 2020). Virtual course offerings and online resources have scaffolded teaching and learning, and addressed student fears about falling behind, and an uncertain future (Srivastava et al., 2021; Yuan et al., 2020). Virtual workshops and simulations have offered multiple tools and formats to experiment and innovate to ensure the psychological safety and wellbeing of all participants, particularly involving sensitive or upsetting topics (Boylan et al., 2020; Tabari & Amini, 2021). Review platforms and serious games enabled students to learn and prepare for high stakes exam, while reducing test-taking anxiety (Kalleny, 2020).

The well documented versatility of online UGME programming, and time saved from commuting enabled some students to increase participation in wellness activities at home (Joshi & Bodkha, 2020; Polujanski et al., 2020). Students also benefitted from greater versatility and student-centeredness of online modalities that increased autonomy and reaped emotional, psychological, and physical benefits. The rapid transition to online UGME has also sparked more purposeful attempts at forging online community, via online peer mentorship (Wilcha, 2020), psychological programming and daily or weekly practices such as "Team huddles" and check ins (Guerandel et al., 2020; Hilburg et al., 2020).

Whether amid a pandemic or not, human involvement in online UGME is an embodied, emotional process that unfolds against a broader historical, social, and political background. This understanding is especially crucial given the well documented pre-COVID mental health crisis spanning the medical education continuum, which has only deepened with the fallout. More than ever, students and teachers reported in the literature of the key role that presence, psychological safety, and emotional connection play while participating in online UGME.

Challenges

1. Effectiveness:

The studies included in our review revealed complex challenges to the effectiveness of online UGME. Some of these challenges were unique to the transition to online UGME—the speed with which programs had to pivot to an online format, and the intensive time, workload, and resources needed was demanding.

Regarding the ongoing, post-COVID integration of online learning in UGME delivery, however, there were additional, ongoing challenges beyond this transitional period. We report on them here. We note that these challenges fall into three general categories in our included studies:

1. Material challenges to effective learning and teaching in online UGME:
    a. poor internet connectivity and infrastructure,
    b. inadequate online learning devices,
    c. lack of appropriate physical space,
    d. incompatible microphones, cameras, software, and more,
    e. physical ailments caused by increased screen use.

2. Pedagogical challenges to effective learning and teaching in online UGME:
    a. diminished student engagement and participation,
    b. logistical, financial, and moral challenges involved in online assessment,
    c. challenges to focus, increased domestic distractions,
    d. barriers to delivering hands-on skill and/or clinical learning offered by traditional clinical electives and clerkships, cadaver-based learning,
    e. gaps in technological proficiency (both students and teachers).

3. Relational challenges to effective learning and teaching in online UGME:
    a. establishing online teacher presence,
    b. diminished connection, belonging, spontaneity found in face-to-face informal social interactions (both students and teachers),
    c. emotional detachment brought by screen-mediated interactions (students, teachers, patients, cadavers in Anatomy education).

The widespread transition to online UGME also posed significant teaching challenges as faculty and staff worked to adapt to this new reality.

Many studies noted diminished student engagement and participation. Pivoting online meant adapting teaching and learning strategies to this new context; keeping students engaged despite a lack of face-to-face interaction was noted as challenging (Atreya & Acharya, 2020; Mian & Khan, 2020). In addition, this transition, of course, unfolded amid a global pandemic, further challenging the demands on student and teacher capacity for engagement (Sindiani et al., 2020). Still, even these challenges generated new innovations and approaches, including integrating breakout groups and in-class assignments to support student engagement (Caton et al., 2021; Dwivedi et al., 2020).

Virtual assessment for UGME staff was a commonly cited concern in the literature. While, as noted above, formative assessment thrived during the home-learning period, summative assessment remained a central issue. Clinical skills assessment required access to tools and demonstrations not always possible via virtual technologies (Sasidharan et al., 2020). Knowledge testing was commonly cited as an area of concern, with a focus on ethical, logistical, legal, and psychological implications of high stakes testing in a virtual environment (Baral & Baral, 2020; Dong et al., 2020). Virtual OSCEs (Wilcha, 2020), commercial assessment platforms (Jones, 2020), and virtual proctoring programs (Prigoff et al., 2020) are ways that medical programs addressed this challenge for the programs that had the resources for these initiatives, but the consensus is that online summative assessment remains challenging and problematic for the long term (Prigoff et al., 2020).

As clinical spaces closed to most medical students globally, a common concern for UGME staff and students alike was the issue of access to clinical skills practice and clinical experiences more broadly. In pre-clerkship, Anatomy educators were particularly challenged, with cadaver-based dissection a rite of passage and cornerstone for anatomy education (Harmon et al., 2021; Jones, 2020). This loss of haptic, hands-on, embodied learning also challenged staff and students involved in clerkship education, which was structured around face-to-face clinical learning, including bedside teaching. In the literature examining student experiences with online UGME in this period, practical and clinical learning were common sources of dissatisfaction—accompanied by understandable anxiety about their ability to progress through their program to residency (Brown, 2020). Students felt uncomfortable with their lack of exposure to traditional clinical clerkship experiences, along with the knowledge, informal professional socialization, and diverse clinical scenarios they offer (Chinelatto et al., 2020; Kelly, 2020). At the same time, the inaccessibility of bedside teaching, medical instruments, specimens and other clinical teaching aids was a challenge within virtual clerkship offerings (Sasidharan et al., 2020).

Gaps in technological proficiency also challenged staff and students amid the rapid shift to online UGME. Staff and students in resource-poor countries were particularly challenged, as a lack of reliable internet infrastructure prior to COVID meant building capacity for IT support and instruction from the ground up. In more resourced countries, proficiency was still an issue, with time and resources for "virtual upskilling" not always readily available (Alqudah et al., 2020; Iqbal et al., 2020; Wang & Xu, 2020). However, this barrier was mostly associated with older faculty in this literature.

The shift to online UGME posed significant challenges for medical students anticipating the transition to residency. Clerkship rotations are often crucial to this process, as students often use these experiences to inform their future choices for residency. References for residency applications were also threatened in this period, with students relying on supervision from preceptors in their chosen field who may give them a strong reference letter (Brown, 2020). This challenge was especially urgent for Historically Excluded (HE) students who relied on the connections, mentorship, references, and clinical experience they might not otherwise have access to.

The rapid transition to online UGME also presented challenges to online connection and community, between and among staff and students. Establishing emotional authenticity, safety, and a more "human" presence online was a challenge for UGME teachers and students alike (Hartmann et al., 2021). Some studies report a loss of personal connection between teachers and students in this setting. The literature also documents challenges to the social fabric of UGME programs, with diminished connection, belonging, and spontaneity found in face-to-face informal social interactions within UGME spaces (Kan et al., 2020). For staff, this meant loss of informal, spontaneous interactions such as "water cooler" conversations or chatting while walking down the hall together (called "collisions") (Coyle, 2018; Stoller, 2021). For students, this meant less informal interactions with teachers and fellow students, and the loss of important rituals, rites of passage, and Despite its benefits, ceremonies within their medical education (Cuschieri & Agius, 2020).

In a similar vein, online UGME during this period posed a myriad of challenges to emotional connection, including empathy, compassion, and humanistic values. The multitude of two-dimensional screen-mediated interactions with students, teachers, patients, and cadavers in Anatomy education challenged UGME community members to fully experience one another's full, embodied humanity (Jones, 2021). This included decreased emotional impact of both real patients on screens, virtual simulated patients, and onscreen cadavers in Anatomy labs. Possible impacts of this emotional detachment on medical student rapport, empathy, compassion, self-reflection, awareness of death, and sense of privilege remain to be seen (Hartmann et al., 2021; Harmon et al., 20201; Wells, et al., 2021).

2. Inclusion:

Despite its benefits, moving into virtual teaching and learning does not automatically make UGME more accessible. Barriers to engagement in UGME persist despite technological or pedagogical innovations. Online UGME is not necessarily, or straightforwardly, accessible to all students, who may experience barriers to engaging in online UGME due to many overlapping material, social, and historical factors (Antonoff, 2021; Brown, 2020; Guadix et al., 2020b; Jones, 2021; Sharma & Bhaskar, 2020; Alsoufi et al., 2020). The gaping inequities underlying medical education have only grown amid COVID and corresponding transitions to online learning (Abdulghani et al., 2020; Wang et al., 2020; Farooq et al., 2020; Karki, 2020). As Brown (2020) notes, "COVID-19 has once again teased apart the fundamental differences between the haves and the have-nots. Instead of health outcomes, however, a diverse workforce representing the populations that seek emergency care most commonly is at stake" (p.33).

Given the international focus of our review, we noted that there were significant disparities with respect to material resources, including: the ability to access dependable, high-speed internet particularly for students in low income families, rural areas, and/or low-resource countries (Cevik et al., 2021; Roy et al., 2020; Singh et al., 2021); barriers to appropriate devices (computers, tablets, routers) for online learning (Joshi & Bodkha, 2021; Singal et al., 2020; Singh, 2021); inadequate space in smaller homes (Atreya & Acharya, 2020); expensive internet and lack of financial support and infrastructure from governments; and related lower

computer literacy levels; and lack of IT departments, training, and support available for online UGME (Cevik et al., 2021; Jones, 2021; Joshi & Bodkha, 2021; Singh et al., 2021). From copyright protection to log in requirements (Bakkum et al., 2020), barriers to resource sharing globally and regionally are also factors in unequal access to high quality UGME programming (Bakkum et al., 2020; Cevik et al., 2021). Language barriers may also exacerbate these challenges, with a lack of online UGME resources in local languages (Cevik et al., 2021).

Our review demonstrates challenges to inclusive access to resources required for successful residency applications. This includes unequal access to clerkship experiences amid COVID, as well as challenges in the residency selection process, including implicit bias encountered within online residency interviews (Brown, 2020; Cevik et al., 2021). More broadly, COVID, and the accompanying shift to online UGME, has laid bare the inequities laying at the foundations of medical education. Challenges wrought by both the pandemic and virtual education have disproportionately impacted Historically Excluded (HE) medical students and staff, particularly those in low-resource institutions, regions, and countries. These UGME students and staff experienced greater illness and complications, greater burden for caregiving, greater loss of loved ones, more isolation and mental health challenges, more high-risk activities such as service sector work and public transportation, as well as more unemployment and financial devastation (Sharma & Bhaskar, 2020).

3. Resilience/Wellness:

There are several entwined emotional and psychological stressors involved in the pandemic and the subsequent shift to online UGME (Hilburg et al., 2020; Kaur et al., 2020; Sharma & Bhaskar, 2020). These crises unfolded against a backdrop of rampant burnout and mental health struggles for people across the medical education continuum, from UGME to early practice (Darras et al., 2020). The already complex, demanding, and high stakes nature of UGME was exacerbated by medical students' well-founded fears about the impact of COVID disruptions on readiness and access to clerkship, residency, and eventual practice (Coffey et al., 2020; Kapila et al., 2020). High stakes assessments were at times cancelled and rescheduled, increasing student uncertainty and stress (Kelly, 2020).

At the same time, many staff and students were facing unprecedented levels of personal stress and loss: Increased caregiving roles in the families and communities, death and illness of loved ones (Guadix et al., 2020a,b), feelings of disconnection, and loss of medical school community. These intense stressors were experienced disproportionately by Historically Excluded (HE) medical students, particularly those with mental health histories (Sharma & Bhaskar, 2020). These crises in wellbeing unfolded while students faced reduced formal and informal supports, made difficult or impossible by social isolation requirements and individualized, at-home learning (Hilburg et al., 2020).

It is not surprising that amid this scenario, medical students grappled with reduced academic performance, concentration, and motivation; and for some students, increased challenges with time management (Abdulghani et al., 2020; Goda et al., 2020; Singal et al., 2020); but also increased anxiety, depression, and other mental health challenges (Hilburg et al., 2020; Kaur et al., 2020; Sharma, 2020). Simultaneously, many UGME staff were facing dramatically increased workloads, particularly for women and disabled workers (Jones, 2021; Singal et al., 2020), and resident teachers, who amid COVID often stepped in to alleviate the dearth of faculty availability and were already facing crisis levels of burnout as a group (Darras et al., 2020; Keegan & Bannister, 2021).

Implications

Implications for Research on Online Learning in Medical Education:

The three themes of our scoping review, Effectiveness, Inclusion, and Resilience/Wellness are inextricably linked. Quality UGME, and medical care more generally, require attention to relational elements, social cohesion, and support for mental and emotional wellbeing; this need is particularly urgent for medical

students from Historically Excluded (HE) communities and low-resource countries, who faced disproportionate mental health burdens prior to COVID-19.

A common theme crossing all the literature we reviewed is acknowledgement that the COVID-19 pandemic has served as a catalyst to encourage medical schools to innovate and reimagine the format and delivery of medical education. We provide below a set of 12 implications, and related recommendations, for research, practice, and policy to capitalize on this moment of critical transition.

1) **Medical education would benefit from more rigorous, theoretically informed research in online learning:**

Of the 453 studies we reviewed, only 41 identified a theoretical orientation. More rigorous, theoretically grounded research is required. This is not surprising. Over the past few decades, scholars working in distance learning have noted that the field has been somewhat limited in terms of theoretical explorations (Keegan, 2014; MacLeod et al, 2017). This paucity of theoretically informed research was particularly notable in the articles reviewed in our study. Using a theoretical framework can be time-intensive, and we expect that many researchers may have skipped over this important step in their haste to publish research evidence as quickly as possible in response to the COVID-19 pandemic. There are some exceptions to this, notably the "Community of Inquiry" (CoI) model developed by Garrison et al. (2009). The CoI model, which encourages educators to attune to social, cognitive, and pedagogical presences, seemed to be the most widely used theoretical model identified in the literature we reviewed.

We believe that studies that take a deliberate theoretical perspective would allow us to explore previously un-, or under-, explored aspects of online medical education. Given the overall shortage of articles we found addressing issues of Resilience/Wellness and Inclusion, we encourage researchers to consider work that is informed by Critical, Sociomaterial, and Realist Theoretical Perspectives. An important example of how a realist perspective can enhance our understanding of online learning comes from Wong et al. (2010). Realist studies explore "what works, for whom and in what circumstances" (p. 1). Wong et al. (2010) demonstrated how different modes of delivery (i.e., in-person and online) suit different learners in different contexts; notably, learners will accept online learning if it is perceived as useful in a given context (better than non-online alternatives), easy to use (presents few technical issues), and it is compatible with their values and norms.

Theoretical Perspective	Potential Insights
Critical Perspectives	Critical approaches to online UGME (See Chow et al., 2021; Sandars, 2016) would be useful in helping us to learn more about issues of inclusion and exclusion in the digital world.
Sociomaterial Perspectives	Sociomaterial approaches to online UGME (See Fenwick, 2014; MacLeod et al., 2017; 2019) would broaden our investigations to focus on how specific technologies are influencing teaching and learning.
Realist Perspectives	Realist perspectives to online UGME (See Wong et al., 2010; 2012; Ellaway et al., 2020) would allow us to focus on what works for specific learners, in context.

Table 12: Potential theoretical perspectives for online UGME research

2) Medical education would benefit from broadening the types of research questions being addressed about online learning:

We limited our literature review to the field of medical education, which is very much based in a Positivist orientation. Specifically, our literature review was organized to focus on three broad areas: 1) Effectiveness, 2) Inclusion, and 3) Resilience/Wellness. A significant majority of the articles in our review fell under the effectiveness category (409, or 68% of total included studies).

Currently, the field of medical education is characterized by a focus on competency-based education (Frank et al., 2010). Within this climate, medical education has prioritized the development of observable and measurable benchmarks, checklists, entrustable professional activities, and ensuring the development of measurement, evaluation, and assessment tools that ensure that graduates are, in fact, competent to safely

practice medicine. Given the high stakes nature of UGME, and the traditional behaviourist focus on the transfer of knowledge (Ellaway & Masters, 2008), it is, perhaps, not surprising that much of the published literature focused on the theme of *effectiveness.*

Within the studies focused on effectiveness, we noted a predominance of articles focused on answering the more straight-forward question: *Did* our innovation work? In other words, will these online innovations be sufficient to ensure we are able to graduate competent clinicians? In comparison, Wong et al. (2010) differentiate two aspects of effectiveness that merit attention: 1) *whether* the innovation works or not (which they call efficacy) and 2) under what real-world circumstances the innovation *actually* works (which they call effectiveness). We thus call for studies envisioning a more holistic definition of effectiveness and efficacy.

Our research team was also somewhat surprised, however, that issues of *Inclusion* and *Resilience/Wellness* were not widely engaged in the literature (17% and 14% of included studies, respectively). We know, anecdotally, that the COVID-19 pandemic has had a significant impact on mental health and wellness, and that these difficulties may be exacerbated by issues of marginalization and social exclusion. However, by flattening traditional UGME hierarchies, online learning modalities offer rich possibilities in more student-centered learning designs, and active student participation in all aspects of online UGME design and delivery (Ellaway & Masters 2008). Sharing open access resources can be a powerful way of addressing international disparities in access to high quality UGME (Tackett et al., 2017). We encourage medical education researchers to consider potential research questions that address these issues.

Theme	Potential Research Questions
Inclusion	• How are learners from equity deserving groups experiencing isolation from peers? • How does a lack of in-person clinical experiences affect informal learning and mentorship for first-generation medical students? • How can we ensure equitable access to online learning tools and technologies, both within and among countries? • How can we center diverse student needs and perspectives, and support students in playing more active roles in online UGME design and delivery?
Resilience/Wellness	• What are the mental health impacts of increased screen time? • What are learners' concerns about the influence of online learning on their developing skills? • What are the implications of online assessment for test anxiety? • How does online presence affect the preexisting crisis regarding suicide, depression, burnout, trauma, and more in medical students? • How will learners' perceptions of support and community change with online UGME?

Table 13: Potential future research questions for Inclusion and Resilience in UGME

3) Medical education would benefit from more in-depth, qualitative investigations of the experiences of online learning:

A significant number of the articles we reviewed were derived from insights garnered through quantitative survey data (197 articles). Given the rapid turnaround of this work, we appreciate that a survey-based methodology is a manageable and efficient way to collect data from a larger group of people. These approaches also seemed to be the most suited for exploring issues of effectiveness.

However, related to items 1 and 2, above, we believe there is an opportunity to ask more critical questions, and delve more deeply into the experiences of medical students and educators with respect to online learning. Our perspective is that qualitatively oriented, open-ended explorations would allow for more in-depth and nuanced insights about the experience of medical education during COVID-19.

We acknowledge that time is undoubtedly a factor in this. The sources we reviewed were, for the most part, rapidly generated. Given that qualitative studies are difficult to quickly plan and execute, we acknowledge that feasibility unquestionably played a role. However, we hope that as vaccination rates increase and the era of

extreme physical distancing slowly comes to an end, medical education researchers will continue to explore the influence of online learning during COVID-19 using sophisticated qualitative methods.

4) The literature in Simulation and Virtual Reality is plentiful and merits its own review:

Simulation and Virtual Reality have long been promising modalities for online medical education (Ellaway & Masters, 2008, Nicholson et al., 2006). We require further research in this emerging field (Tang et al., 2018). We found several studies highlighting how simulation could reasonably be done online, and others showing how makeshift models (e.g., made of shoes, string, rubber bands, and other common objects) can help stand-in for regular procedural skills training. However, given the volume of sources identified in this review, and in the interest of feasibility, we excluded these articles if they required that learners have access to a set of specialty technologies that they could not reasonably be expected to have at home (e.g., Virtual Reality Goggles; Haptic-Enabled Simulator). We believe these topics merit their own focused scoping review, including a focus on teaching effectiveness, inclusion, and resilience. However, our review reflected the growing number of innovations in this area designed for usability in a home-learning context. Gamification is one way that simulators are being adapted to engage students, reduce anxiety, and facilitate simulation using only a desktop and internet connection (Ellaway & Masters, 2008; Georgieva-Tsaneva & Serbezova, 2020).

In addition, while we did not concentrate on these areas, we did informally note that they were generally well-supported and liked by learners. It may be worth considering whether medical students of the future should be given suitable technologies, like VR goggles, as part of their admissions package to facilitate home-based learning and practice. UGME developers continue to innovate in this area, while attempting to reduce reliance on expensive, face-to-face technologies that prevent access from home settings: for example, Judd and colleagues (2018) explore a method of Virtual Reality Fully Immersive Interactive Technology Teaching (VR FIITT) where a student may be fully immersed in a virtual reality teaching session via a smartphone transformed into a VR headset.

Implications for Practice for Online Teaching and Learning in Medical Education:

5) Medical education should identify specialties, content areas, and/or skills that are amenable to online learning:

Throughout our literature review, we noticed that there was a continuum of responses to online learning resources: ranging from interventions that were highly successful, to those that were not at all successful. Upon further analysis, we noted that very successful interventions were those where there was an authentic fit with the online environment. In other words, those areas of medical practice in which digital tools are part of the everyday work were particularly successful with the adoption of online learning tools.

Areas easily transitioned to online learning:	Tools:
Anatomy	Online anatomical atlases, images, virtual dissection
Basic/foundational Sciences	Web conferencing, lecture slides, online modules, open access resources
Cardiology	Digital recordings to develop auscultation skills, helping to identifying and classify murmurs
Dermatology	Digital images specific to dermatological findings
Psychiatry	Pre-recorded videos with simulated patients, web conferencing
Imaging	Digital images specific to radiology, radiation oncology, orthopedics
Lab Medicine	Virtual microscope, virtual histological resources, slides and images
Patient Interviewing (History taking)	Simulated patient web conferencing

Table 14: Specialties/topics easily transitioned to online learning

Other skills were more difficult to transition to the online environment. In particular, physical examination skills, regardless of context, were difficult to engage in a digital format. Communication skills—especially non-verbal skills—were more difficult to practice through video conferencing but moving virtual

exposed students to virtual care. Surgeries were easier to view for many students because they were no longer resigned to the back of the room, trying to look over the surgeon's shoulder. Real-time commentary could also be added to recorded videos. However, *practicing* and *assessing* surgical and procedural skills were much more difficult to manage from a distance.

6) Medical education should consider virtual electives and rotations to increase exposure to non-core clinical areas:

A consistent challenge in medical education, in pre-pandemic and pandemic times, is gaining formal curriculum time. This may be related to a reduction in formal lecture time to focus more on discovery-based, and experiential learning. Another challenge is that clinical clerks experience some specialties by "rotating" through them during their third year, but many specialties are not included in core clerkship rotations (typically involve Emergency Medicine, Family Medicine, Internal Medicine, Obstetrics & Gynecology, Pediatrics, Psychiatry, Surgery) during their undergraduate education (although electives are also required).

In our review, virtual programs (including clerkships, electives, and sub-internships), were found to be an efficient way to increase exposure to less well-known medical specialties. We identified virtual electives, clerkships, and sub-internships in Urology, Ophthalmology, Radiology, Surgery, Radiation Oncology, ENT, and more.

7) Medical education/educators should seize the opportunity to weave inclusion into all aspects of online UGME:

From an ethical perspective, online UGME administrators should be conscious of the cost burdens that online learning can shift to individual students and teachers, from the cost of learning devices to the cost of printing and home internet (Ellaway & Masters, 2008). Given the international scope of our literature review, we noted a significant divide in the literature underpinning all interventions and adaptations: Internet access. This difference was particularly pronounced in low-resource countries, where reliable internet could not be assumed, and was frequently cited as a factor confounding the success of online adaptations. In Uganda, for example, one study found Internet costs and poor internet connectivity were the most important barriers to e-learning reported by 199 (93%) and 179 (84%) students, respectively (Olum et al., 2020).

And while the temptation may be to assume that access to high quality internet can be taken for granted in higher resource countries, like Canada, we learned anecdotally about local medical students participating in medical education from their rural homes who did not have access to sufficient, high-speed Internet. Further, we learned anecdotally (and experientially) that people living in households with multiple people accessing a single broadband connection could find themselves with connection challenges. The fact that the stories related to difficulty accessing internet in both resource poor and resource rich nations have, for the most part, not found their way into the literature relates back specifically to Implication 3, above. We have not yet made the space for in-depth, qualitative investigations of online medical education.

In low resource nations, some innovative practices were developed to circumvent internet access challenges. These included adopting hybrid models, in which small socially distant in-person group discussions were allowed and using offline, downloadable learning materials. In Nigeria, a local technology company was mobilized to ensure all medical students had access to Internet services at a discounted rate (Oyeleye, 2021). These are ideas that could translate to any contexts. One further assumption we want to highlight here relates to the issue of teaching and learning from home. Domestic space for participation in online UGME cannot be assumed (Atreya & Acharya, 2020; Beltran-Sanchez et al., 2020; Sindiani et al., 2020; Singh, 2021; Snekalatha 2021). We also encourage medical educators to think critically about mandatory use of cameras in large group settings. Given that multiple people may be accessing a singular internet connection, and also in light of the fact that cameras allow some degree of access into personal, and previously private, spaces, we encourage educators to reflect on whether camera use is really necessary.

We noted in the literature a preponderance of articles offering "tips" for maximizing online education experiences, many of which involved preparing your physical space, and dressing professionally. We believe many of these tips are attempts to reproduce online what might have happened in person. However, as previous

research has shown, virtual teaching and learning are completely different teaching spheres, and must be treated accordingly (MacLeod et al., 2019; Symeonides & Childs, 2015). We encourage educators to embrace the differences of online and in-person feedback and think critically about why we hold certain expectations about participation. Practical barriers such as internet connectivity and gaps in digital literacy are important action areas to reduce disparities among medical teachers and learners around the globe (Topol, 2019).

8) Medical education should find opportunities to integrate feedback into online learning resources wherever possible:

It is well recognized in the context of education that meaningful feedback can improve performance (Ajjawi & Boud, 2018). This was also found in our review, where we noted that online learning resources were better received when they were accompanied by some form of authentic, actionable feedback. A diversity of approaches to integrating feedback were identified through the review, ranging from passive to active.

Opportunities for providing feedback were diverse and well-described. Interesting examples we noted included:

Examples of Integrating Feedback:
• Simulated patients trained to offer feedback through web-conferencing
• Uploading videos of a particular skills and recruiting experts to watch and offer critique
• Integration of quizzes and formative assessment tools
• Use of desktop simulations and serious games
• Providing textual feedback to student comments via discussion boards

Table 15: Examples of feedback integration in online UGME

Given the risk that e-learning resources feel depersonalized and decontextualized, integrating feedback on performance seemed to serve as a strategy to increase the sense that someone is "out there," following learners' progress, and invested in their success.

9) Medical education should consider the benefits of online assessment:

Online approaches to formative and summative assessment are promising, with digital formats, examination software, remote proctoring, and open-book exams surfacing as strong examples (Ellaway & Masters, 2008). Given the logistical challenges associated with bringing a full class of medical students together in the same physical space for examinations, particularly in geographically distributed programs, we believe online exams may be an innovation that continues after the pandemic era.

Potential challenges related to academic integrity should be addressed. In one noteworthy innovation, Ryan and colleagues (2020) found problematic, and surprising, student activities during online examinations, including posting content to social media. They developed an online learning module, and a set of related multiple-choice questions, to ensure students understood their academic responsibilities. This innovation made a significant difference.

Many policies and regulations relating to assessment are grounded in traditional face-to-face approaches (Ellaway & Masters, 2008). Virtual assessment poses rich potential for rapid, multi-modal, and interactive assessment practices. This modality must also be approached carefully, however, to minimize moral and legal risks. Online assessment can also bring significant costs, demanded by commercial assessment platforms and their need for powerful servers (Dennick et al., 2010), further widening the gap between "have" and "have not" institutions and countries.

We believe being clear and deliberate about student privacy, digital security, and academic integrity with respect to online examinations, as well as helping learners understand their rights and responsibilities, is

an important approach. Global sharing of assessment research and best practices is another key element of effective and inclusive online assessment.

10) Medical education should embrace creativity born of necessity:

Throughout the review, we noted many examples in which authors reflected that an online learning resource had been developed in an emergency, and out of necessity, but was nonetheless found to be effective, efficient, and/or interesting. It was surprisingly common, in the papers included, for authors to conclude their contributions with a note that the innovation should continue to be used post-pandemic.

We were struck by the diversity, and creativity, of online resources. Some of these had been developed in advance of COVID-19 and some in response to the pandemic. Whatever the educational context, there were a wide variety of resources available to improve the online learning experiences that were evaluated and found to be enjoyable, enriching, and effective.

Example:	Description:
Capsule	case-based question bank
Innerbody	interactive online anatomy and histology resource
Livestreaming	livestreaming neurological exams with real patients
Medical Reality Television	reality television set in an emergency department as a discussion prompt
Script	online prescribing tool
Speaking Clinically	library of patient interviews
Virtual visiting professorships	web conferenced meetings with clinical experts
GoPro simulations	viewpoints from surgeon, patient perspectives

Table 16: Sample innovations in online UGME

We believe medical educators should take advantage of these resources, integrating them where possible to enrich the learning experience. These may become curricular resources, study tools, or assessment strategies, for example. Further to this, a spirit of collaboration and open access curriculum development seemed to drive the rapid development and implementation of these tools. For example, Muller and colleagues (2021) described how all New York City medical schools came together to develop a set of guiding principles to inform the adoption of online learning in UGME. We encourage medical educators to maintain this collaborative approach, to maximize sharing of high-quality educational resources in a way that minimizes persisting inequities within and among individuals, communities, institutions, and countries (Ellaway & Masters, 2008).

Implications for Policy on Online Learning in Medical Education

11) Medical schools should design and implement curriculum focused on telemedicine:

A common approach crossing the literature we reviewed was that learners are now interacting with patients, teachers, and colleagues through telecommunications tools, like videoconferencing. Many of the papers we reviewed described the efficacy of this approach, and it seems unlikely that we will be returning to "the old way" of doing things. Now that we have widely experienced telemedicine (Sklar, 2020), it seems the likelihood of returning to 100% in-person appointments in clinical practice is small.

We believe the medical workforce of the future will need to be adaptive thinkers who are technologically literate. The physicians of the future practice medicine and "their ability to problem solve in complex situations (where unpredictable human factors must be taken into account), their ability to empathise with patients (and create trust), their ability to form functional inter-professional teams both in hospitals and in the community, their ability to use available technology and data and their ability to work innovatively with patients as partners" (Torda, 2020, p. 1149-50)

Telemedicine is an urgent and exciting area for growth in contemporary UGME. Medical curricula must be developed to ensure these technological and telehealth skills are being developed and assessed (Sklar,

2020). These programs should be monitored by the Committee on the Accreditation of Canadian Medical Schools (CACMS).

12) Medical schools must ensure that online education is delivered in a safe, inclusive, and healthy manner:

The tenet of "doing no harm" must fuel ongoing developments in online UGME policy and practice. As online UGME continues to grow, we must focus on addressing financial and other barriers to accessibility for individual medical students. These barriers, after all, often work against the support systems already in place to support inclusion and wellbeing. "Technology will not be the determinant of students' knowledge gain or well-being," Tabari and Amini (2021) argue, "but we need to continue to think about how it can be used for good without inducing harm, given that it opens so many opportunities for various types of support that may be difficult to secure in other ways" (p.127). The Committee on the Accreditation of Canadian Medical Schools (2019) Standard 3 focuses on Academic and Learning Environments, and states "A medical school ensures that its medical education program occurs in professional, respectful, and intellectually stimulating academic and clinical environments, recognizes the benefits of diversity, and promotes students' attainment of competencies required of future physicians" (p. 5). While this standard was originally developed with an in-person learning experience in mind, we believe that it is time to revisit this standard given the complexities of the online learning environment.

Conclusion

> "Think also at the level of the social contract between medicine and society, and our duty of care not just to patients but to learners. Are educational decisions fair and responsible when viewed through these lenses?" (Tolsgaard et al.,, 2020, pp. 742-743)

Around the world, the COVID-19 pandemic has served as a catalyst for institutions of medical education to reconsider, and diversify, approaches to teaching, learning, and assessment. Though it was very clear that there is an essential, in person, hands-on element involved with some aspects of medical education (Yardley et al., 2012), some knowledge and skills are, in fact, more amenable—and perhaps more effective—when approached using technological innovations. Initially developed out of a sense of urgency, many of these innovations have staying power. Now is the time to deliberately explore the fundamental advantages of these more contemporary approaches, as they compare with more familiar and expected approaches.

Our review indicated that there was no shortage of innovations attempted to facilitate the design, delivery, implementation, and evaluation of online medical education strategies. There were, however, significant gaps with respect to in-depth, qualitative explorations of the experience of transitioning to online learning. As a result, significant questions remain related to the safety and inclusiveness of online learning spaces and approaches, particularly for members of equity deserving groups, and those in low-resource settings. Further, we believe long-term health and wellness issues related to being a medical student during the COVID-19 pandemic, including, but not limited, first-hand experiences of online learning, will be a priority research issue for years to come.

Knowledge mobilization activities

Our team was committed to integrated knowledge translation (Kothari et al., 2017). This means that we approached our review in a collaborative method, working with knowledge users from various sectors throughout the process to refine our search, recognizing the unique expertise of knowledge users.

Activity and Reach	Type of Activity	Timing
Knowledge User Consultations **- local**	Exchange	Ongoing

We met with Dalhousie educators, administrators, curriculum designers, and IT professionals to engage in deliberative dialogue with respect to Online Medical Education. The focus of these consultations was to learn first-hand about challenges, ideas, and promising practices in the realm of online delivery of medical education. Our plan is to share emerging ideas from our work with this group.

***Knowledge User Consultations* – national**	**Exchange**	**May 2022**

In a series of national dialogues with educators, administrators, curriculum designers and IT professionals from the 17 Canadian medical schools, we plan to share emerging ideas from our work with these groups.

***Knowledge Mobilization Forum* – national**	**Exchange**	**September 2021**

As per the SSHRC Knowledge Synthesis Call for Proposal protocol, we will participate in the virtual or in-person SSHRC Knowledge Mobilization Forum. This will provide an opportunity to engage in interdisciplinary knowledge sharing, learn from colleagues, and make new connections.

Summary of Key Findings (Fact Pages)	**Dissemination**	**September 2021**

The results of our scoping review will be synthesized into a series of user-friendly fact sheets, highlighting suggestions for best practices and available supporting resources with respect to online delivery of medical education. These fact sheets will be shared with educational offices in the Faculty of Medicine at Dalhousie University and other Canadian medical schools. We will also make these fact sheets available to other Faculties/Schools of Health Professions Education who may be facing similar challenges.

Project Website	**Dissemination**	**October 2021**

We are in the process of working with a communications consultant to develop an interactive website that will make resources related to the online delivery of medical education widely available to our various stakeholders, including participants, knowledge users, and the general public. The website will be maintained by the project coordinator and will be collaboratively updated with our communications consultant.

***Publications* – journal articles**	**Dissemination**	**November 2021 – ongoing**

We intend to share the insights garnered through this scoping review in the format of peer-reviewed journal articles. We will target journals that focus on medical education, telework, and instructional technologies. We will publish in open-access journals to maximize the reach of our work and make use of open access green strategies, where possible.

Presentations – academic & professional conferences	**Dissemination**	**November 2021 – and ongoing**

We will share findings with researchers, decision-makers and knowledge-users at both academic and professional conferences focusing on Medical Education, telework, and Instructional Technologies. These may be face to face and/or online opportunities.

Professional Development Videos	**Application**	**December 2021**

We intend to develop a series of web-based videos called “Medical Education in a digital world” housed on the project website, and make them available through other web-based video sharing platforms (i.e. YouTube). The videos will offer advice about teleteaching and telework amid COVID-19 and will be aimed at faculty and staff (administrative, IT) involved in Medical Education. The videos will also be informative for learners who are seeking to understand more about the educational principles underlying digital teaching.

Integration of Findings	**Application**	**Ongoing**

Throughout the process, we will work collaboratively with educators, administrators, curriculum designers, and IT professionals involved in Medical Education at Dalhousie University, across Canada, and internationally, to ensure insights garnered through our scoping review are presented in a user-friendly and actionable manner. Our goal is to share our insights broadly and to provide a synthesized knowledge base about online teaching in medical education, ensuring informed educational practices.

Table 17: Knowledge Mobilization Activities

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Appendices

Appendix 1: Search Strategy

Database search strategies

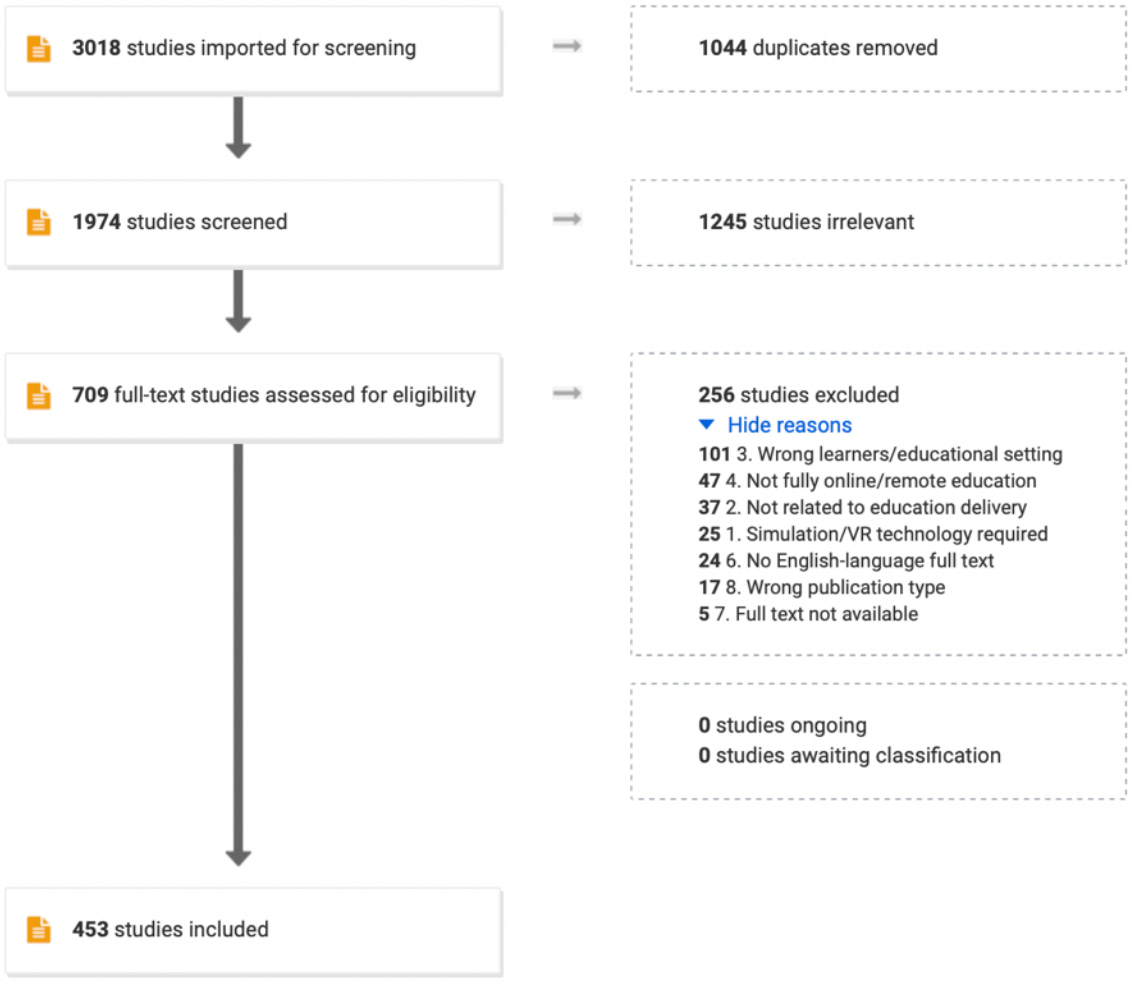
Ovid MEDLINE(R) ALL <1946 to February 19, 2021>

1 exp Education, Medical, Undergraduate/ 24639
2 UGME.ti,ab,kf. 17
3 (Undergrad* adj2 Medic*).ti,ab,kf. 7210
4 ume.ti,ab,kf. 454
5 Schools, Medical/ 25996
6 (medic* adj2 (student* or learner* or trainee* or school*)).ti,ab,kf. 82564
7 Students, Medical/ 35476
8 1 or 2 or 3 or 4 or 5 or 6 or 7 114689
9 computer-assisted instruction/ or exp simulation training/ or exp computers, handheld/ 29982
10 Education, Distance/ 4644
11 ((online or "on-line" or internet or web or webbased or virtual or multimedia or multi-media) adj2 (train* or educat* or instruct* or learn* or course* or workshop* or program* or teach* or module* or environment)).ti,ab,kf. 21599
12 exp internet/ and exp learning/ 2441
13 ("blended learning" or computer user training or computer-aided instruction or computer-assisted instruction or "computer-based instruction" or "computer-based learning" or e-learning or "electronic learning" or "internet-based instruction" or "massive open online course" or "m-learning" or MOOC or Moodle or "learning management system" or d2l or brightspace or "online course*" or "online learning" or tablet-based or "technology enhanced learning" or user-computer interface or "virtual learning" or "web-based education" or "web-based learning").ti,ab,kf. 9742
14 9 or 10 or 11 or 12 or 13 55739
15 8 and 14 5799
16 limit 15 to yr="2020 -Current" 676
17 from 16 keep 1-676 676

Appendix 2: Summary of Inclusion/Exclusion Criteria

	Inclusion	Exclusion
Population/Setting	• Medical schools that administer MD degrees • undergraduate medical education (UME/UGME) • medical students (not graduate or postgraduate) • skills, knowledge, and procedures that are part of UGME/UME curricular outcomes • workers (faculty, staff, administrators) involved with planning and delivery of undergraduate medical education	• Setting is not Medical School/UGME- • setting or skills are not core part of the curricular outcomes for UGME (e.g., specialty clinical skills and procedures that are part of resident training) • focuses on postgraduate medical education/residents, residency training programs (including fellows and interns), or graduate students in medicine [tag if relevant to key topics]- • focuses on undergraduate students outside medicine (e.g., nursing, kinesiology, physical therapy, veterinary) [tag if worth looking at for discussion]- • focuses on trainees/settings in other health professions [tag] • learning/training intervention designed for practicing health professionals, including residents, but tested with and delivered to some med students
Concept	• Curriculum delivery- extra-curricular components that are delivered by medical school staff or faculty (either directly or indirectly, by creating learning resources) • remote working for admin, staff, faculty • assessment- online learning resources within med school settings (e.g., describes the development, implementation, or evaluation of online learning tools and resources, e.g., MOOCs or open education resources such as textbooks and videos, with a reflection on the learning, teaching, or working context of undergraduate medical education)- self-directed learning (SDL) strategies/resources/approaches that are relevant to the remote learning context (i.e. available to learners remotely, not onsite)	• adaptation of med school admissions processes or residency placement (e.g. interviews) • online learning resources outside of med school settings (e.g., describes the development, implementation, or evaluation of online learning tools and resources, e.g., MOOCs or open education resources such as textbooks and videos, with no reflection on the learning, teaching, or working context of undergraduate medical education) • paper doesn't refer to teaching or learning environment within medical schools
Context	• online/internet-based e-learning-remote/distance (not on-site) instruction- papers pertaining to student, instructor, administrator, or staff perspective of teaching and learning online/remotely • includes curricular and extra-curricular education of academic knowledge (e.g., anatomy, human development, immune system) and clinical skills (e.g., surgical procedures, clinical communication, physical history). • must be teaching/learning that is applicable to the context of UGME in pandemic times • blended learning only where compared to an online-only course/learning opportunity • simulation only where explicit mention of home-based/remote design, e.g., patient simulation (aka standardized patients) via videoconference	• Distance learning / remote teaching without online/internet-based context (e.g., phone, mail, self-directed only) • Face-to-face instruction only • blended instruction that requires a face-to-face component unless compared to online/remote only • all simulation-based learning unless explicitly designed for remote learning/home use (e.g., patient simulation over videoconference) • VR applications unless it is clear that the VR can be done at home • e-learning that require learners to be on-site/ on campus • high-fidelity simulation is frequently in-person, unless described otherwise (e.g., VR, computer-based)
	Study type • includes researcher generated or collected data (e.g., primary research, review articles, program evaluations) • may include letters if there is also report of data (quant or qual) • include editorials/commentaries if reflective of faculty/admin/learner perspective on move to remote learning and working (essentially qualitative/experiential data)	

Appendix 3: PRISMA Diagram



Appendix 4: Data Extraction Template

Name		Description
Study ID#		Unique for each article.
Journal Title		Title of journal where the article was published.
Authors		Name of the authors of the article.
Article Type		Whether it is a research or evaluation article, an opinion piece (e.g., a perspective or commentary), or a descriptive piece (e.g., describing an intervention).
Article questions/objectives		As stated by the authors.
Theoretical/conceptual frame		Lens framing the research if stated by the authors.
Research type		Broad method: qualitative, quantitative, or mixed.
Study design		More specific method: review article, evaluation, qualitative or quantitative study.
Methods		Tools for data collection (and analysis if applicable/clear).
Setting	Institution	University name where the study took place or institutional affiliation of first author if not specified.
	Country	Country of origin of first author.
	Relevant population	If the article talks about students, staff, or both.
	Relevant UGME level	Whether the student population included those in pre-clerkship, clerkship, or both.
	Additional Populations included	If the sample included other types of participants (e.g., other health professions students, other undergraduate students, residents, and/or physicians).
Sample size		When the article described a study.
Context		Type of intervention/program/curricular component; subspecialty if relevant.
Content		Tools/technologies used duration of program if relevant.
Results/key findings or messages		A summary of the results and/or key messages contained in the article.
Thematic areas		If the article included discussion of effectiveness, resilience/wellness, and/or inclusion related to the intervention(s) and technologies discussed.

Appendix 5: Geographic origins of included studies

Top countries	Number of articles in each country	Percentage of articles in each country
USA	103	34.56%
India	23	7.72%
Germany	21	7.05%
UK	19	6.38%
Saudi Arabia	15	5.03%
Canada	14	4.70%
China	9	3.02%
Australia	7	2.35%
Singapore	6	2.01%
Pakistan	6	2.01%
Jordan	4	1.34%
Egypt	4	1.34%
Brazil	4	1.34%
Ireland	3	1.01%
Italy	3	1.01%
France	3	1.01%
Spain	3	1.01%
Nepal	3	1.01%
England	2	0.67%
Iran	2	0.67%
New Zealand	2	0.67%
Romania	2	0.67%
Netherlands	2	0.67%
Scotland	2	0.67%
Poland	2	0.67%
Denmark	2	0.67%
Korea	2	0.67%
United Arab Emirates	2	0.67%

Appendix 6: Qualitative Findings Tables

Strength	Examples	Studies
Flexibility	• access learning materials quickly and from anywhere • can retrieve and review materials as often as desired (e.g., repetitive video viewing), helping retention • adapt learning according to their individual attitudes, beliefs, needs and preferences • more control over scheduling • exert greater control over learning pace: progress and the rate of information intake • Greater balance between structure and flexibility • Can accommodate changing health status/personal circumstances • Time saved from commuting can be used toward studying, leisure activities	Agarwal 2020 Al-Mendalawi 2020 Alqudah 2020 AlSamaraee 2020 Baczek 2021 Baral 2021 Boylan 2020 Chinelatto 2020 Coffey 2020 Cuschieri 2020 Dedeilia 2020 Grześkowiak 2020 Hall 2020 Joshi 2021 Karki 2020 Polujanski 2020 Roberts 2020 Shahrvini 2021 Srinivasan 2020 Yaqinuddin 2020
Innovative teaching approaches	• Opportunities for innovation and experimentation (e.g., student engagement) • Codification of best practices • More student-centered, collaborative approaches (e.g., adult learning orientations) • Increased proficiency in online teaching • Drawing on COVID as curricular content • Patient centered simulation techniques • Rethinking allocation of physical space • Support for teachers and students from interdisciplinary e-tutors	Abler 2020 Al-Mendalawi 2020 Baral 2021 Colonnello 2020 Gintrowicz 2020 Pather 2020 Pennell 2020 Singal 2020, Stoller 2021 Stoller 2021 Wayne 2020 Yusoff 2020
Innovations in virtual resources, curricula	Clinical teaching: • Virtual microscope • GoPro first-person video footage • Virtual ward, grand rounds • Virtual surgical platforms • Digital medical libraries, collections • Specialty content • Medical MOOCs • Use of podcasts, infographics, blogs, videos, social media (Facebook, Instagram, Twitter), YouTube, apps • Serious games	Abi-Rafeh 2020 Amer 2020 Atreya 2020 Bakkum 2020 Belfi 2021 Bhaskar 2020 Buendia 2021 Buendia 2021 Cevik 2021 Chao 2020 Chao 2021 Drees 2020 Forestell 2020 Grzych 2020 Hau 2020 Hendriks 2020 Kalleny 2020 Levin 2020 Mustafa 2020 Naglik 2020 Quadri 2020 Ruthberg 2020 Shehata 2020 Silva 2021,

		Singal 2020 Triepels 2020 Wilcha 2020 Yaqinuddin 2020 Zikos 2020
Minimization of barriers for student progression to residency	• Virtual support for the transition from clerkship to residency • Exposure to specialties that are under-represented in the formal UGME pre-clerkship curriculum	Chao 2021 Dawoud 2020 Dwivedi 2020 Song 2020 Stoller 2020
Expanded role of medical students in UGME design and delivery	• Most medical schools experienced a shortage of faculty • Students often stepped in to design new curricula • Students took on more teaching and tutoring, peer learning and mentoring	Kaliyadan 2020 Pettitt-Schieber 2021 Roll 2020 Silva 2021 Traba 2021 Wilcha 2020
Expanded role of residents in UGME teaching	• Broader and deeper involvement of residents in UGME teaching with faculty shortages • More collaboration in teaching between residents and faculty • Residents serving as simulated patients • Tailoring teaching strategies to resident teachers (e.g., proficiency in online tools and technologies like mobile learning apps)	Basu 2020 Giordano 2020 Traba 2021
Multiple potential channels for in-class communication	• Multiple potential forms of communication between students and teachers • More involvement in chats, discussion boards, small group learning, etc for students hesitant to participate in face-to-face classroom • Zoom/Teams chat functions enabled real time questions in synchronous sessions • Online channels facilitated *more* communication between clerks and preceptors	Alkarani 2020 Caton 2021 Chao 2021 Dwivedi 2020 Naglik 2020 Xie 2020
Development of telemedicine skills	• Telemedicine used within both pre-clerkship, clerkship phases • Telemedicine simulations • Training in telemedicine skills (building rapport, restricted physical examinations, confidentiality issues)	Bigogno 2020 Boylan 2020 Chao 2021 Coffey 2020 Dawoud 2020 Guadix 2020 Jumreornvong 2020 Peterseim 2020
Innovations in formative assessment for students and teachers	• Recorded classes enable reflective practice, teacher feedback • New apps and platforms can provide more frequent and diverse forms of formative assessment (e.g., Kahoot!) • Learning Management System features such as discussion boards and wikis enable unobtrusive but informative means of formative assessment	Guerandel 2020 Kalleny 2020 McHugh 2021

Challenge	Example	Studies
Poor internet connectivity and infrastructure	• Unstable internet signals, low internet speed • Increased domestic for bandwidth, multiple users sharing home internet • Poor internet infrastructure in rural areas, resource-challenged countries • Power outages (e.g., weather disturbances)	Al-Mendalawi 2020 Almulhim 2020 Alqudah 2020 Alsoufi 2020 Atreya 2020 Beltran-Sanchez 2020 Chinelatto 2020 Dost 2020 Dutta 2021

		Joshi 2021 Olum 2020 Oyeleye 2021 Roy 2020 Singh 2021 Snekalatha 2021
Inadequate online learning devices	• Lack of laptops, cameras, headsets, monitors, microphones, etc. at home • Use of smartphones for online learning	Alsoufi 2020 Singal 2020 Singh 2021
Lack of appropriate physical space	• House layout, furniture, other equipment differ from a classroom • Lack of physical space often meant more distractions and interruptions in online learning	Atreya 2020 Beltran-Sanchez 2020 Dost 2020 Sindiani 2020 Singh 2021 Snekalatha 2021
Incompatible microphones, cameras, and software, and more	• Incompatible operating systems, microphone issues	Amer 2020 Cleary 2020
Physical ailments caused by increased screen use	• Eye strain, headaches, neck pain, back pain, sleep disturbance	Mehta 2020 Singh 2021
Diminished student engagement and participation	• Poor interaction between student and teacher • Students become passive observers	Hanafy 2021
Logistical, financial, legal, psychological and ethical challenges involved in online assessment	• Low student satisfaction • Logistical: supporting faculty, how to test at home • Financial: prohibitive cost of commercial online assessment platforms • Legal: lack of legal guidelines for online assessment, security concerns • Psychological: Online exam stress, uncertainty • Ethical: academic dishonesty, proctoring requirements	Elsalem 2021
Delivering hands-on skill and/or clinical learning offered by traditional clinical electives and clerkships, cadaver-based learning	• Student dissatisfaction regarding online practical, clinical learning • Inaccessibility of bedside teaching, instruments, specimens, other clinical teaching aids • Decreased exposure to clinical scenarios and professional values • Loss of haptic experiences (e.g., performing a physical examination on a live patient; dissection using cadavers)	Sasidharan 2020
Gaps in technological proficiency (both students and teachers)	• Learning curve for inexperienced teachers (time constraints, age) and students (particularly in countries lacking reliable infrastructure)	Alqudah 2020 Iqbal 2020 Wang 2020
Threats to residency transition: exposure to specialties, references, interviews	• Reduced exposure to specialties • Fewer opportunities for reference letters • Challenges of virtual interviews	Brown, 2020 Fong 2020 Kelly 2020
Establishing online teacher presence	• Less sense of personal connection between teacher and students • Challenges in adapting presence to the online setting	Alqudah 2020 Chinelatto 2020 Cuschieri 2020 Joshi 2021 Shahrvini 2021 Srivastava 2021 Stoller 2021
Diminished connection, belonging, spontaneity found in face-to-face interactions	• "Erosion of comradery" • "Team erosion" • Lesser sense of belonging for students • Limited interaction with peers (in class, out of class) • Loss of "water cooler" conversations," walking down hall together, "collisions"	Chinelatto 2020 Cuschieri 2020 Shahrvini 2021 Srivastava 2021 Stoller 2021

	• Lack of important rituals, rites of passage, ceremonies • Less spontaneous discussions, storytelling with peers and teachers	
Emotional detachment brought by screen-mediated interactions	• Implications for humanistic, patient-centered care • Decreased emotional engagement with/impact of virtual simulated patients • Threat to holistic view of cadaver • Challenges to rapport, empathy, compassion, self-reflection, awareness of death, privilege	Harmon 2021 Hartmann 2021 Wells 2021

Strength	Examples	Studies
Virtual clerkship rotations	• Enable historically excluded (HE) students more access to diverse specialties • Provide avenues for obtaining references for residency • Can help HE students build relationships and receive mentorship • Can provide clerkship access to students at underfunded universities	Antonoff 2021 Song 2020
Innovative, low-cost simulations	• Simulations don't necessarily require virtual reality or expensive simulators • Simulations can be held asynchronously to facilitate unreliable internet access • Low-cost simulators can be just as effective as commercial ones	Burns 2021 Sellers 2021
Greater accommodation of diverse communication and teaching/learning needs	• Flexibility of online learning modalities can offer learners multiple ways to participate	Boylan 2020 Ruthberg 2020 Stoller 2021
Innovations in inclusive teaching and learning	• Student-centered innovations benefit HE students • Greater access for ill and/or disabled students, particularly relevant amid COVID • Multiple forms of engagement more accessible to diverse learning strengths and needs • Removes geographic, economic, institutional barriers to high quality UGME	Al-Mendalawi 2020 Guerandel 2020 He 2020 Srinivasan 2020
Increased resource sharing	• More equitable access to high quality virtual UGME locally, nationally, and internationally • Emerging partnerships to increase access to free, open-source curriculum materials • Potential global impact of local innovations	Bakkum 2020 Cevik 2021 Kelly 2020 Sandars 2020
Development of innovative, low-resource curriculum tools and materials	• Online curricula are more easily shared across institutions and countries • These curricula can be designed with multiple levels of resources (e.g., equipment, reliable internet signals) in mind, thereby increasing access	Burns 2021 Sellers 2021
Revising virtual curricula to be more inclusive	• Overall innovation and reflection brought by COVID opens opportunities for integrating inclusion in all aspects of UGME policy and practice • New assessment and communication channels offer more holistic, equitable participation • Attention to implicit bias can inform curricular innovations • Virtual curricula can be tailored to diverse student and teacher needs, values, and approaches	Keegan 2021 Sandars 2020
Greater attention to digital divides	• Greater conversations about digital divides among and between countries are emerging • Institutions, companies, and governments are being called on to address inequitable access to online learning (via lack of equipment, connectivity)	Chinelatto 2020 Sabahat 2020 Tabari 2021

Challenge	Examples	Studies
Inequitable access to internet, equipment, other resources	• Lack of online learning equipment • Poor internet connectivity • Lack of domestic space for learning • International disparities in online resources and infrastructure • Gaps in computer literacy and IT infrastructure • Prohibitive costs of innovations such as commercial assessment platforms • copyright restrictions and login requirements that prevent resource sharing	Atreya 2020 Bakkum 2020 Beltran-Sanchez 2020 Cevik 2021 Cosnita 2020 Jones 2021 Joshi 2021 Roy 2020 Sindiani 2020 Singal 2020 Singh 2021 Snekalatha 2021
Inequities in residency selection process	• Lack of clerkship experiences • Barriers to specialty references and mentorships • Implicit bias re online residency interviews • Increased burden on Historically Excluded (HE) students	Brown 2020 Cevik 2021
Disproportionate impact of COVID, online learning on HE students, staff, low-resource countries	• Student differences in impacts of COVID and online learning transition • Widening equity gap between and within countries, regions, institutions • Gendered labor required by at home teaching and learning, and other work • Increased workloads • social, economic and cultural factors which interfere with personal and academic lives • unemployment of themselves and family members • need to take on jobs to support families • lack of or inequity in provision and access to educational technologies and remote delivery-platforms • increased levels of mental health stressors due to prolonged isolation and self-quarantine measures • Isolation exacerbated for international students • Rural and remote students and institutions face increased barriers	Antonoff 2021 Brown 2020 Guadix 2020 Jones 2021 Sharma 2020 Abdulghani 2020 Alsoufi 2020 Farooq 2020 Karki 2020 Wang 2020
Expensive UGME tools	• Prohibitive costs of innovations such as commercial assessment platforms	Cosnita 2020

Strength	Examples	Studies
Transition to online learning has proven staff and student resilience	• Opportunities to claim resilience and demonstrate adaptability • Tolerance for uncertainty, grit, and stress resilience key skills for medical practice	Kapila 2020 Wayne 2020
Virtual offerings have assuaged student fears and frustrations	• Virtual programs have helped reduce student anxieties and increased motivation • New feedback practices can help reduce student anxiety and frustration during skills practice • Teacher interactions, mentorship opportunities, and tutorial interactions have provided support and continuity	Srivastava 2021 Yuan 2020
Great time and/or flexibility for at-home wellness activities	• Some students, in some programs, were able to use their previous commute time to engage in self-care (including sleep) • Some students benefited emotionally, psychologically, and physically from greater autonomy and versatility of online learning	Joshi 2020 Polujanski 2020
Virtual offerings can be designed for psychological safety and emotional wellbeing	• Complex, sensitive topics can be broached carefully and creatively • Connecting virtually can help enhance wellbeing and replace some informal connections lost to online learning	Boylan 2020 Tabari 2021

Virtual tools can help reduce test anxiety	• Test review platforms and serious games can help reduce the pressures involved with high stakes exams • Playfulness and interactivity can help diffuse stress and build trust	Kalleny 2020
Virtual platforms can offer emotional and psychological supports, Virtual mentorship, peer support, and informal check ins	• Virtual peer mentorship and online psychological supports like counselling can offer supports to students and teachers • Daily practices like check ins can ensure connections and reduce isolation • More purposeful attempts at forging community	Gibbs 2020 Guerandel 2020 Hilburg 2020

Challenge	Examples	Studies
Fear and uncertainty about the future	• Fears about lack of preparation for clerkship, residency, medical practice • Uncertainty regarding how COVID may affect testing, and future progression through UGME	Coffey 2020 Kapila 2020
Increased isolation, grief, and loss amid fewer supports	• Increased caregiving roles, death and illness • Isolation from traditional networks • Reduced supports • Feelings of disconnection amid emotional struggle	Guadix 2020 Shahrvini 2021
Difficulty focusing and reduced motivation and time management	• Strain of COVID and transition to online learning • Reduced concentration • Greater challenges with time management in online format • Challenges in motivation	Abdulghani 2020 Goda 2020 Singal 2020
Increased levels of anxiety and depression	• Increased mental health challenges for all medical students • Increased mental health risks for Historically Excluded community members • Challenges for students with previous history of mental illness • Perceived lack of support and empathy from medical schools associated with greater student stress	Abdulghani 2020 Goda 2020 Hilburg 2020 Sharma 2020 Villanueva 2021
Risk of unmanageable workloads for staff	• Transitioning to online learning has resulted in dramatically increased workloads for some staff • Resident teacher involvement in UGME has increased amid COVID-19 • This involvement risks further burdening residents with mental health challenges	Darras 2020 Keegan 2021

Appendix 7: Reference List for Included Articles

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