An update on developments in medical education in response to the COVID-19 pandemic: A BEME scoping review

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Abstract

Background

COVID-19 has fundamentally altered how education is delivered. Gordon et al. previously conducted a review of medical education developments in response to COVID-19, however, the field has rapidly evolved in the ensuing months. This scoping review aims to map the extent, range and nature of subsequent developments, summarizing the expanding evidence base and identifying areas for future research.

Methods

The authors followed the five stages of a scoping review outlined by Arskey and O'Malley. Four online databases and MedEdPublish were searched. Two authors independently screened titles, abstracts and full texts. Included articles described developments in medical education deployed in response to COVID-19 and reported outcomes. Data extraction was completed by two authors and synthesized into a variety of maps and charts.

Results

One hundred twenty-seven articles were included: 104 were from North America, Asia and Europe; 51 were undergraduate, 41 graduate, 22 continuing medical education, and 13 mixed; 35 were implemented by universities, 75 by academic hospitals, and 17 by organizations or collaborations. The focus of developments included pivoting to online learning (n=58), simulation (n=24), assessment (n=11), well-being (n=8), telehealth (n=5), clinical service reconfigurations (n=4), interviews (n=4), service provision (n=2), faculty development (n=2) and other (n=9). The most common Kirkpatrick outcome reported was Level 1, however, a number of studies reported 2a or 2b. A few described Levels 3, 4a, 4b or other outcomes (e.g. quality improvement).

Conclusions

This scoping review mapped the available literature on developments in medical education in response to COVID-19, summarizing developments and outcomes to serve as a guide for future work. The review highlighted areas of relative strength, as well as several gaps. Numerous articles have been written about remote learning and simulation and these areas are ripe for full systematic reviews. Telehealth, interviews and faculty development were lacking and need urgent attention.

Practice Points

- Most developments to date focused on pivoting to online learning and simulation, making these areas well poised for full systematic reviews.
- Research on telehealth, interviews and faculty development to teach in remote environments was lacking and urgently needed.
- Several exemplary articles demonstrated the power of collaboration, highlighting opportunities for enhanced cooperation in medical education in the future.

Background

The novel coronavirus disease (COVID-19) has profoundly impacted the way medical education is delivered across the continuum. The need for physical distancing to limit spread of the virus, concerns about the supply of personal protective equipment (PPE), risks of contracting the virus in the clinical environment, and stressors on faculty and trainee well-being have created significant challenges. The impact of these disruptions is likely to be far-reaching, as students have reported a reduction in confidence and preparedness levels (Choi et al. 2020), and some medical schools have even graduated students early to be able to augment the workforce (Glenn 2020). Additionally, students have reported that their disrupted training experiences during the pandemic are likely to impact their specialty selection (Byrnes et al. 2020). Disruptions in clinical experiences have also forced accreditation bodies to adapt requirements for graduate medical education programs (Nasca 2020).

Despite many challenges, the COVID-19 pandemic has also highlighted several opportunities, including enhanced global cooperation in higher education and research (Buitendijk et al. 2020), engaging students and trainees as agents of change (Reardon et al. 2020), and embracing technology and telehealth as powerful tools for both teaching and patient care (Keswani et al. 2020, Pears et al. 2020). As educators have rapidly employed educational developments to mitigate disruptions and harness opportunity, journals have fast-tracked peer review and publication in order to more rapidly disseminate findings to the broader community of educators facing shared challenges. Busy educators now find themselves juggling the maintenance of educational programs amidst the disruption with need to stay abreast of the high volume of emerging literature.

Prior reviews have attempted to capture the breadth and depth of rapid medical education developments in response to COVID-19 and thereby provide educators with easily referenced resources summarizing work to date. Dedeilia et al. (2020) performed an early review through 18 April 2020 that included letters, commentaries, editorials and perspectives due to the paucity of studies with empiric data or descriptions of implemented innovations. In order to capture the subsequent increase in the volume and quality of developments that followed, Gordon et al. (2020) conducted a rapid systematic review of articles published from 1 December 2019 - through 24 May 2020, but chose to exclude letters, editorials, commentaries, and perspectives. The authors highlighted several areas, including pivoting educational delivery from classroom-based learning to virtual spaces, replacing clinical placement-based learning with alternate approaches, and supporting direct patient contact with mitigated risk. Additional areas addressed, albeit less extensively, included training for care of patients with COVID-19, service reconfigurations, assessment, well-being, faculty development and admissions. The authors noted a scarcity of articles meeting criteria for education quality, and lack of detail or evaluation data. The majority of articles reviewed (67%) did not offer any outcome data, and those that did largely reported Kirpatrick Level 1 (satisfaction / reaction). Several of the articles reviewed did, however, explicitly state future plans for evaluation of educational effectiveness. Intentions for future work thus indicated a need for short-term updates as the field was rapidly evolving. Since this review, a flood of additional developments has continued to emerge in the literature.

The aim of the current scoping review is to map the extent, range and nature of medical education developments in response to the COVID-19 pandemic since our prior review; to

summarize and disseminate current research findings of this rapidly expanding evidence base; to identify gaps in the existing literature for future research; and to determine areas of focus for future systematic reviews.

Methods

Similar to our prior review, this scoping review was conducted in a rapid timeframe (~8 weeks from inception to completion). The speed with which the review was conducted, however, did not compromise rigor or systematicity, which we employed from the search strategy to the synthesis (Gordon et al. 2019a). The work was guided by our previously published framework (Gordon et al. 2020) and the model for scoping reviews described by Arksey and O'Malley (2005). A study protocol was drafted a priori and posted on the BEME website. The reporting aligns with the overarching requirements in the STORIES (STructured apprOach to the Reporting In healthcare education of Evidence Synthesis) statement (Gordon and Gibbs 2014) and BEME guidance (Hammick et al. 2010), as there is no clear framework for reporting scoping reviews in the field.

The five stages of a scoping review were followed (Arksey and O'Malley 2005):

Stage 1: identifying the research aims / questions (as stated above)

Stage 2: identifying relevant studies

Stage 3: study selection

Stage 4: charting the data

Stage 5: collating, summarizing and reporting the results

Stage 2: identifying relevant studies

Aligning with the procedures in our prior review (Gordon et al. 2020), we electronically searched four databases (MEDLINE, EMBASE, CINAHL and PsychINFO). These 4 databases were selected as they contain almost all the journals that publish on medical education. We searched PubMed from May 1, 2020 – September 09, 2020, allowing for three weeks of overlap in our search dates with the prior review to ensure no primary studies were missed. We hand searched MedEdPublish for the same time period. We searched the remaining databases from January 1, 2020 to September 19, 2020, as delineating by month in these databases wasn't possible. Studies that were included in our previous systematic review were removed.

After consultation with a librarian, we updated our original search strategy (Gordon et al. 2020) to enhance specificity and to better comply with current searching and reporting standards. We utilized the Accelerator Polyglot search translation tool to develop the searches (Clark et al. 2020). The full search strategy can be found in Appendix 1. Hand-searching of references of the primary papers was not conducted, as the author team was concerned speed would be compromised for minimal added benefit given the short time frame from the onset of the pandemic.

Deduplication was conducted using Endnote (Bramer et al. 2016.) Retrieved citations were then uploaded in DistillerSR (Evidence Partners, Ottawa, Ontario, Canada), an online data management system for performing systematic reviews. Titles and abstracts were independently screened by two authors against an initial set of inclusion and exclusion criteria (see below).

Inter-rater reliability was calculated using Cohen's Kappa. Full texts were retrieved and independently reviewed by two authors against a revised set of inclusion and exclusion criteria based on the findings of the initial screen. The full text screening form appears in Appendix 2. Discrepancies at all stages were resolved through discussion, including a third author as needed, until consensus was reached.

Stage 3: study selection

We were initially uncertain if the evidence base would have improved sufficiently from our prior review (Gordon et al. 2020) to require outcomes as an inclusion criteria. Thus, we planned to revise our inclusion criteria to include outcomes after the initial screening if the evidence base was sufficient. This practice aligns with procedures outlined for scoping reviews, which allows for post hoc revision of criteria, as authors become more familiar with the evidence base (Levac et al. 2010).

Our initial inclusion criteria were as follows:

- Studies that described developments in medical education explicitly deployed in response to COVID-19.
- Studies in undergraduate, graduate or continuing medical education.
- Studies with medical students, residents, fellows, or physicians.
- Studies in any language.

After initial screening, we added the following inclusion criteria:

- Studies that consider Kirkpatrick's outcomes (Level 1: Reaction, Level 2: Learning, Level 3: Behavioral Change, Level 4: Organizational Performance) (Kirkpatrick 2016) OR other outcomes (e.g., quality improvement).

Our exclusion criteria were as follows:

- Opinion pieces, commentaries, editorials, perspectives, calls for change, needs assessments and other studies where no actual development had been deployed.
- Studies that described the development as a minor part of a larger package of planned measures.
- Studies that only have other healthcare professionals (i.e. other than medics)
- Studies that were included in our previous systematic review from December 1st, 2019 – May 24th, 2020

Stage 4: charting the data

We developed a data-charting form modified from the form used in our prior review (Gordon et al. 2020) to align with the aims of this scoping review. The form was loaded into Google Sheets to facilitate sharing of data. A team meeting was held to ensure shared understanding of terms, prior to article distribution. Primary studies were assigned to author pairs based on the focus of the development. This facilitated author teams developing a content area of expertise for reporting of results. Each author team piloted the data extraction form on one of their primary studies prior to conducting their independent reviews. At least one author in each team had participated in the prior review, further ensuring a shared mental model for data charting. All

discrepancies were resolved through discussion or involvement of the lead author. Quality assessments were not undertaken as these are not frequent in scoping reviews (Arksey and O'Malley 2005).

Data extracted included:

- Article identifiers (author(s), month of publication)
- Context
    - Geographic origin of development and local COVID-19 specific details
    - Participants (both type and number), level of medical education (e.g. undergraduate medical education (UME), graduate medical education (GME), continuing medical education (CME) or mixed)
    - Setting or institution responsible for educational delivery (e.g., university, academic hospital)
    - Medical specialty if applicable
- Description of intervention
    - Primary focus of the development
    - Stated purpose of deployment (i.e. what problem was addressed?)
    - Brief summary of development
    - Further description of development with any links to materials
    - Theoretical models or conceptual frameworks
    - Resources (details of cost / time / other resources)
- Intervention outcome(s) (modified Kirkpatrick outcome level or similar (Barr et al. 2008))

    - Level 1 participant reaction
    - Level 2a changes in attitudes; Level 2b changes in knowledge or skills
    - Level 3 behavioral change
    - Level 4a change in organizational practice; Level 4b change in clinical outcomes
    - Other outcomes (e.g. quality improvements, policy changes, checklist development, or other impacts)
- Summary of results
    - Lessons learnt
    - Key points from discussion
    - Summary of conclusion
    - What future research is indicated either implicitly or explicitly

Stage 5: collating, summarizing and reporting the results

Utilizing data from the Google Sheet, the authors collated the data into a number of tables and figures for easy visualization, to provide a map of the current evidence base. After charting the large volume of data, we also produced a narrative account of our findings that considers the extent and range of developments included in the review, as well as the outcomes assessed. We identified areas of educational developments that have been thoroughly addressed since the onset of the pandemic and those where a paucity of research exists. We also suggested areas for future primary and secondary studies (i.e. systematic reviews).

Results

A total of 12,627 records were identified through database searching, and an additional 31 by hand searching MedEdPublish. After deduplication, 7,237 records remained. After title and abstract screening, 6,752 records were excluded. Four-hundred-eighty-five studies underwent full text screening and 358 were excluded. Inter-rater reliability at the screening phase was κ=0.91, suggesting excellent alignment. The primary reasons articles got excluded were the full text was unavailable (n = 2); the development was not in medical education, or not explicitly deployed in response to COVID 19 (n = 53); the participants did not include medical students, residents, fellows or physicians (n = 9); the primary study was an opinion piece, commentary, editorial, perspective, call for change, needs assessment or survey, or other study where no actual development was deployed (n = 123); the development was a minor part of a larger package (n = 5); or no outcomes, Kirkpatrick's or otherwise, were reported (n=166). One hundred twenty-seven studies were included in the final analysis. The flow diagram for article identification is shown in Figure 1 (PRISMA 2015).

[INSERT FIGURE 1 NEAR HERE]

Table 1 provides a brief summary of all included primary studies, in addition to other key data. Please note that due to the large number of articles included in this scoping review, we cannot not list all the studies by author last name when presenting the results. We have chosen to cite exemplars that highlight our findings. The complete list of studies can be identified via

referencing the appropriate columns in Table 1. Figure 2 provides a graphic summary of the review.

[INSERT TABLE 1 AND FIGURE 2 NEAR HERE]

Month of Publication

Our last review ended May 24, 2020. This review, with enhanced search criteria, picked up 4 additional articles from April missed by the first review, and 17 articles from May. The latter are likely representative of articles that were in process when the last search was run or from the last week of May. June, July and August saw similar numbers of publications, with 32, 30, and 31 articles respectively. Thirteen articles were identified in September, but our search likely missed articles published later in the month due to the dates on which they were run. Overall the numbers demonstrate a continued acceleration of publications in medical education related to COVID since our last review (Gordon et al. 2020), despite the fact this review had more stringent inclusion criteria, namely reporting of outcomes.

Geographic origin of studies and local COVID-19 details

Table 2 and Figure 2 show the geographic origins of the included studies according to level of medical education (UME, GME, CME, or Mixed). Fifty-nine studies (46.5%) were conducted in the United States and five (3.9%) in Canada, for a total of sixty-four in North America. Four studies (3.1%) were conducted in South America, twenty (15.7%) in Europe, eleven (8.7%) in the Middle East, one (0.8%) in Africa, twenty (15.8%) in Asia, and two (1.6%) in Oceania (e.g., Australia and New Zealand). An additional 5 studies (3.9%) represented international

collaborations, which does not represent a significant increase in collaborative efforts compared to the prior review (Gordon et al. 2020), despite the elapsed time.

[INSERT TABLE 1 NEAR HERE]

Local COVID-19 conditions were well summarized by Sa Couto and Nicolau (2020): "Throughout the globe, universities (were) closed and classes suspended, with recommendations of prophylactic confinement to all not involved in patient care or first-need services. Alternatives to face-to-face classes rapidly emerged and telecommunication platforms (were) the new classrooms." Multiple authors described national authorities or regulatory bodies that called for the cessation of in-person activities. Several articles described the Association of American Medical Colleges (AAMC) recommendation to cancel all pre-clinical classes and in-person experiences, including core clinical clerkships and electives to protect learners and preserve personal protective equipment (PPE). Countries (e.g., United Kingdom, United Arab Emirates, Saudi Arabia, India, and Lebanon) shelter-in-place orders, mandatory lockdowns and curfews were all described. Medical students in Hong Kong were reportedly barred from entering the hospital. Graduate trainees had more variable restrictions on training described. In-person didactic activities were halted. The cessation of elective procedures and the impact of altered patient behaviors on case volume was noted to have the greatest impact on skills training.

Level of medical education, institutional setting, number of participants, medical specialty

Table 3 and Figure 2 map the number of studies by level of education and institutional setting. Fifty-one studies (40.2%) described developments in undergraduate medical education (UME), forty-one (32.3%) in graduate medical education, and twenty-two (17.3%) in continuing medical education. Thirteen studies (10.2%) reported multiple levels of learners. Thirty-five studies (27.5%) were conducted in universities, seventy-five (59.1%) in academic hospitals, ten (7.9%) as part of collaborations and seven (5.5%) were conducted by other groups such as state or national organizations. UME activities were largely university based, though a number of UME activities were administered by academic hospitals, which is not surprising given that pre-clinical and clinical learning activities are typically shared across sites. GME and CME activities were mostly run by academic hospitals, and to a much lesser extent, collaborations or national organizations. Overall, there remains a relative paucity of regionally and nationally organized efforts and collaborative work, considering we are globally facing similar challenges.

[INSERT TABLE 3 NEAR HERE]

The number of participants in each study ranged from 5 (Bautista et al. 2020, Gallardo et al.2020) to ~30,000 (Dubé, et al.). Approximately 1/3 of studies had more than 100 participants, though the majority of studies had less than 100 participants, and many did not report a precise number of learners.

Table 4 and Figure 2 chart the disciplines or medical specialties represented by the studies and educational level. The data is also graphically summarized in Figure 2. For twenty-one (16.5%) of the UME studies, a specialty is not described. Most core clerkships are represented by at least one study, though family medicine and psychiatry are notable gaps. General surgery and the surgical subspecialties are the most represented (eight studies, combined). Specialties are described for nearly all of the GME and CME studies, reflective of the differentiation that occurs at those levels. Again, the surgical specialties are the most represented in GME with fourteen studies. Multi-professional activities are most well-represented within CME with eleven studies, and to a lesser degree in GME and Mixed (five and four, respectively). These studies are mostly simulation-based, aimed at helping practicing clinicians care for patients with COVID-19.

[INSERT TABLE 4 NEAR HERE]

Summary of educational developments

One-hundred twenty-seven educational developments were described. Table 5 and Figure 2 map the focus of the development to the level of education (UME, GME, CME, Mixed). The focus of the developments, in descending order by representation included:

- Pivoting to online learning (58 primary studies, 45.7%)
- Simulation or training for treating patients with COVID-19 (24 primary studies, 18.9%)
- Assessment (11 primary studies, 8.7%)
- Wellbeing, mental health or learner support (8 primary studies, 6.3%)
- Telehealth (5 primary studies, 3.9%)
- Clinical service reconfigurations to support the response to COVID-19 (4 primary studies, 3.1%)

- Interviews for admission to medical school, selection to residency (4 primary studies, 3.1%)
- Service provision (2 primary studies, 1.6%)
- Faculty or professional development (2 primary studies, 1.6%)
- Other or multiple areas of focus (9 primary studies, 7.1%)

The types of studies were not evenly distributed across the educational continuum. A majority or near majority of the UME and GME primary studies were in the pivot to online learning category, with 31/51 or 60.8% of all UME studies and 20/41 or 48.8% of all GME studies. Similarly, a majority or near majority of CME and mixed primary studies were in the simulation or training to treat patients with COVID-19 category, with 14/22 or 63.6% of all CME studies and 6/13 or 46.2% of all mixed studies. There was a complete paucity of articles on telehealth, interviews, faculty development, clinical service reconfiguration and service provision.

[INSERT TABLE 5 NEAR HERE]

Pivoting to online learning

Nearly half of the developments identified in this review discussed a transition from in-person, face-to-face instruction to online learning: Fifty-eight articles (45.7%) described the pivot to online learning as the primary focus of their development, with an additional five articles (3.9%) describing a pivot as a part of their intervention. Of these, thirty articles (23.6%) described exclusively synchronous learning (i.e., students and instructors gather in real time, providing opportunities for interaction and feedback). Only four articles (2.4%) reported exclusively asynchronous learning (i.e., instructors prepare materials in advance and students access them at

their own pace.) An additional twenty-nine articles (22.8%) described developments that incorporated components of both synchronous and asynchronous learning.

Many articles highlighted the conversion of didactic sessions to synchronous video conferenced lectures on a variety of platforms (e.g., Zoom (the most popular), Microsoft Teams, WebEx, Skype for business). For synchronous sessions, several strategies were used to foster learner engagement and interaction, including the chat box, Breakout rooms, polling software, virtual whiteboards, annotate functions, quizzes and games (e.g., Kahoot, Jeopardy). Social media platforms (e.g., WhatsApp, Slack, Instagram, Twitter) were utilized in conjunction to promote dialogue, concurrently or after sessions. A number of active learning pedagogies were also tried, including case-based learning (CBL) (Steehler et al. 2020), problem-based learning (PBL; Coiado et al. 2020), team-based learning (TBL) (Jumat et al. 2020), and flipped classroom (Beer et al. 2020, Naidoo et al. 2020, Roy et al. 2020). For pre-recorded lectures and other asynchronous materials, a number of learning management sites were used to facilitate access (e.g., Canvas, Google Classroom).

Evaluations of both synchronous and asynchronous approaches were mixed. (See table 1, summary of results and lessons learnt columns.) Many learners agreed that the online formats were acceptable means of acquiring theoretical or content knowledge, however, teaching procedural, lab-based or clinical skills was more challenging (e.g., Joseph et. al. 2020, Khalil et. al. 2020, Shahrvini et al. 2020). Advantages to online learning cited included increased attendance, flexibility (access anytime, anywhere (e.g., Sud et al. 2020) and convenience / ability to work from home, less time spent travelling, self-pacing, time for reflection, multimedia

learning and scalability. A few studies leveraged the disruptions imposed by the pandemic as an opportunity to break out from traditional boundaries. Regional, national and international collaborations emerged (e.g., Balakrishna et al. 2020, Beer et al. 2020, Rose et al. 2020) allowing more educators to contribute and experts or those with different perspectives to be accessed, expanding local capacity to continue education during the crisis. Disadvantages of online learning cited included lack of social connections and interpersonal interactions with faculty and peers, passive participation, distractions of the online environment, communication challenges, "Zoom fatigue" (e.g., Lieberman et al. 2020), and cyber threats (e.g., "Zoom bombing" (Rasouli et al. 2020)) or information security issues. Discordance was seen across studies regarding learner engagement, participation and interactivity, with some studies describing "more", the "same" or "less" in the online environment (e.g., Coiado et al.2020, Jones et al. 2020, Evans et al. 2020, Wlodarczyk et al. 2020). This likely reflects the different levels of active or self-directed learning employed in each development. Poor internet connectivity (i.e., issues with speed and bandwidth), lags in audiovisuals, poor image resolution or voice quality, and technical issues with hardware and software were frequently cited additional challenges, that can be exacerbated by inequities in access (e.g., Rafi et al. 2020). From the subset of articles that evaluated faculty perspectives, faculty noted the significant additional level of faculty and administrative effort required to develop and implement remote learning and noted an urgent need for additional training, both in regards to technical tools, as well as effective teaching methods or best practices underpinned by theories. Notably, despite this expressed need, we found no faculty development activities focused on online learning in this subset of articles, and very few articles reported on the educational theories underpinning their work. Only a few

articles mentioned multimedia, social constructivism and blended learning theories (e.g., Naidoo et al. 2020, Jumat et al. 2020).

A large number of developments focused on mere replacing previously classroom-based activities (e.g., lectures, small groups, CBL, TBL, PBL, flipped classroom) to the remote online environment to address immediate needs. These developments tended to be focused on enhancing medical knowledge through a variety of formats. Only a handful of articles described innovative approaches to transform face-to-face learning to online learning. One article (O'Connell et al. 2020) developed a game based off the television series "So You Think You Can Dance?", involving several rounds of rapid-fire questions, as teams compete and are eliminated into a final "face-off". Another article (Clemmons et al. 2020) described standing up a new course focused on the COVID-19 pandemic, to address rapidly evolving basic, clinical and health systems science topics, including public health, and health equity. A few articles discussed communication skills training through video conferencing using actors or standardized patients (Carroll et al. 2020, Mohos et.al 2020, Shahrvini et al. 2020) and role plays (Newcomb et al. 2020). Three studies addressed oral case presentation skill development using virtual cases and video presentations (Geha & Dhaliwal 2020, Krawiec & Myers 2020) or remote participation in ward rounds (Pennell et al. 2020). Several studies described innovations for distanced procedural skill development with feedback, including surgical knot tying,(Co and Chu 2020;) basic suturing (Kuo et al. 2020), corneal repair of porcine eyes utilizing a remote wet lab (Pasricha et al. 2020), microsurgical skills training (Galardo et al. 2020), laparoscopic skill training (Jarry Trujillo et al. 2020), and ultrasound scanning using a simulator (Singh et al. 2020).

For continued clinical training in UME and GME, two types of developments identified: 1) remote image or slide review in specialties that do not typically have a direct patient encounter (e.g., pathology and radiology) to simulate “signouts” or “readouts” and 2) integration of remote learners into direct patient encoutners. In Pathology, Evans et al. (2020) and Samueli et al. (2020) used whole slide image repositories, Parker et al. (2020) utilized Pathpresenter, and Tang et al. (2020) used a camera enabled microscope connected to screen-share on Zoom. In Radiology, Gomez et al. (2020) and McRoy et al. 2020 used Pacsbin to enable construction of HIPAA compliant image libraries for remote case review and Matalon et. al (2020) and Recht et al. (2020) engaged in real-time and simulated remote readouts. In Obstetrics and Gynecology, Pennell et al. (2020) obtained patient permission to live-stream ward rounds via video on a mobile phone, allowing learners to participate in the patient interview and clinical decision-making. In Neurosurgery, multiple video inputs allowed virtual learners to participate in surgeries remotely, asking real-time questions of the team via Bluetooth headsets. In Otolaryngology, virtual ward rounds were broadcast across the African continent by a collaboration of ear, nose and throat surgeons (Goncalves et al. 2020).

Simulation or training for treating patients with COVID-19

Twenty-four articles (18.9%) focused exclusively on simulation or another type of training to support the care of patients during the pandemic. These represented twenty-three developments, as different aspects of the same development were discussed in two articles (Andreae et al. 2020a; Andreae et al. 2020b). One additional article (Carroll et al. 2020) described both a pivot to online learning and a training to help develop serious illness communication skills to facilitate difficult dialogue with patients with COVID-19. All described developments were implemented

as part of graduate or continuing medical education by either academic hospitals or collaborations. The majority of simulations were multi-disciplinary or multi-professional, reflective of how modern teams deliver care. The focus of trainings included both technical skills (e.g., proper donning and doffing of PPE, procedural skills, effective airway management, cardiopulmonary resuscitation) and non-technical skills (i.e., communication, leadership, teamwork, decision-making, situational awareness). On the whole, these articles tended to delineate resources and costs in greater detail than other developments in this review, facilitating replicability. They also tended to provide detailed descriptions of the simulation scenarios, checklists, or other educational materials. For examples, please see Conrad et al. (2020), figure 1; Andreae et al. (2020b) Tables 1-3; and LoSavio et al. (2020) Figure 1 (tracheostomy protocol) and Figure 5 (instruction script).

Three articles described interventions to train providers to treat patients with COVID-19 that were not simulation based: Suppan et al. (2020) conducted a rigorous, randomized controlled trial to explore the use of a gamified e-learning module to teach proper PPE selection. Despite evidence of effectiveness in teaching knowledge and skills, there was no significant difference in learner satisfaction with the gamified format compared to simply reviewing guidelines. Aluisio et al. (2020) described a curriculum that targeted “trainers of trainees” to rapidly disseminate information to treat patients with COVID-19 in low- and lower-middle income countries. Carroll et al. (2020) modified a pre-existing training to teach serious illness conversations using remote live actors, to address many of the acute challenges of caring for patients with COVID, particularly when resources are scarce.

Fifteen articles described *in-situ* training simulations, often with native teams in their "home" work environment which spanned emergency departments, intensive care units, operating rooms, labor and delivery units, general wards, urgent care centers, and diagnostic imaging suites. Many in-situ trainings were dual purposed as simulation-based clinical systems testing (SbCST) as described by Colman et al. (2019). SbCST is a form of quality improvement (QI), used to identify latent safety threats and system inefficiencies, to inform policies and guidelines for the COVID-19 response. Depending on the article, education was either a primary or secondary aim, and many articles described both Kirkpatrick and QI outcomes. A handful of these articles described training very large numbers of individuals: The Alberta Health Service launched an eSIM COVID-19 response team that implemented > 400 simulation trainings for ~ 30,000 front line healthcare worker (HCW) over 5 weeks across a geographically distributed Canadian Province (Dubé et al. 2020); Cheung et al. (2020) conducted 101 simulations for 1415 HCW in Hong Kong to standardize hospital-wide practices and minimize exposure to COVID-19; and Buléon et al. (2020) developed and implemented a procedural training curriculum and ensured 1143 HCW in France passed each of 6 stations over a 10 day period.

Five articles focused on conducting simulations in well-equipped *simulation labs* (Favier et al. 2020; Kesselman et al. 2020; Khan and Kiani 2020; LoSavio et al. 2020; Shi et al. 2020). These simulations were generally used to train smaller numbers of individuals (range 6-44) and had a primary mission of education, as compared to in-situ simulations. Three of these articles focused on conducting highly specific procedures wearing appropriate PPE. Favier et al. (2020) trained otolaryngologists and LoSavio et al. (2020) trained surgeons to perform tracheostomies.

Kesselman et al. (2020) trained interventional radiologists in endovascular procedures for COVID positive patients.

In the setting of a new pandemic, rapid dissemination of information and training is critically important. A few articles in this category described the exceptional use of previously developed resources (e.g. conceptual models, learning management platforms, collaborative networks). For instance, the Alberta Health System has 650 facilities and 125,000 employees which as part of its pandemic planning had embraced the concept of systems integration, an approach that brings many subsystems together into one, more unified system to enhance safety and quality of care. They were thus poised to launch COVID training in a centrally controlled, yet locally distributed manner. The authors noted that few other health systems in the world would have likely been capable of such a feat (Dubé et al. 2020). Adding to the impressiveness of what they accomplished, they rigorously tracked outcomes, identifying over 2500 systems issues and proactively mitigating them.

Assessment

Eleven articles (8.7%) focused primarily on assessment practices for online and remote assessment. A few other articles mentioned assessments as minor parts of a larger package. The majority of studies occurred in the academic hospital setting, with three in the university setting and one via a national regulatory body (table 1). Eight addressed assessment in medical students, while three addressed assessment strategies for residents or fellows. One dealt with assessment in anatomy, while five others focused on clinical specialties including pediatrics, internal

medicine, orthopedics and general surgery. Technological platforms utilized included Zoom, WhatsApp, Instagram, ExamHD and Open Notes. (See table 1 for details.)

Seven of the studies focused on evaluating medical knowledge. Amin et al. (2020) involved students in assessment design, having them write case-based questions for a question bank. Gupta et al. (2020) reported a technology enabled anatomy oral exam with no impact on obtained scores. Prigoff et al. (2020) and Sam et al. (2020) reported the use of open book exams with both studies reporting no negative impact on exam results. Gulati et al. (2020) described the use of short clinical scenario multiple choice questions on Instagram which students found both thought provoking and helpful in the consolidation of their learning. Malhotra et al. (2020) and Munshi et al. (2020) used online structured clinical vignettes as an assessment tool, reporting both student and examiner satisfaction with this process. Two of these studies commented on the need to investigate online proctoring (Prigoff et al. 2020, Sam et al. 2020), while Gupta et al. (2020) acknowledged technical limitations regarding proctoring and internet access.

Four of the studies reported assessment of clinical skills. Hannon et al. (2020) described a virtual objective structured clinical examination (OSCE) using Zoom. Although both staff and students appreciated the remote OSCE, students found the narrative physical exam flow to be awkward and preferred in-person exams. Krawiec & Myers (2020) described the development of a video recorded oral presentation assignment with students being assessed using a patient presentation tool that was not intended for virtual patients. Lara et al. (2020) looked at teleOSCEs via Zoom, finding no differences in mean score or failure rate when compared to live OSCEs. Lawrence, et al. (2020) described the adaption of previously deployed in-person OSCEs to a telemedicine

environment. While residents expressed enthusiasm for telemedicine training, they had concerns about their preparedness for telemedicine practice.

Wellbeing, mental health or learner support

Eight articles (6.3%) primarily focused on well-being, mental health or learner support and one additional article addressed well-being in combination with other areas. These interventions were spread across the continuum (3 in UME, 1 in GME, 3 in CME and 1 mixed). Developments addressed provider distress caring for patients with COVID-19, as well as isolation, fear and anxiety associated with the pandemic. Interestingly, three wellbeing interventions involved pediatricians, though in general pediatricians globally have seen fewer sick COVID-19 patients that adult practitioners.

Some of the most successful ideas leveraged existing structures in different ways. Sockalingam et al. (2020) and Steeves-Reece et al. (2020) used an existing collaborative network, the Extension for Community Healthcare Outcomes (ECHO). Project ECHO is set up as a tele-mentoring program for rural frontline clinicians in Oregon. Sockalingham et al. (2020) involved twice weekly sessions with case discussions focused on mindfulness, stress management skills, the humanities and reflections. Steeves-Reece et al. (2020) involved four times weekly sessions featuring community presenters sharing on-the-ground experiences treating patients with COVID-19. These two interventions reached 426 and 737 frontline HCW, respectively. Blankenburg et al. (2020) utilized the membership of the Association of Pediatric Program Directors (APPD) to conduct a prioritized needs assessment. This guided implementation of

‘Virtual Cafes’, hourly lunchtime sessions to share educational (36), clinical (11) and well-being (52) innovations, broadcast nationally on Zoom.

A few developments leveraged the humanities to support well-being. Babel et al. (2020) employed a professional storyteller to train teaching faculty to tell stories. Whilst the storytelling sessions were intended to support professional and emotional growth and foster resilience, a few participants found them triggering. The authors noted a more trauma-informed approach may be needed in the future. Chow et al. (2020) used “Cinemeducation”, hosting a film screening of The Next Pandemic, a documentary about the severe acute respiratory syndrome (SARS) pandemic. Following the film, faculty trained in guided reflection led small groups through an exploration of sensitive issues (e.g. blame, prejudice, personal and public impact etc.) to improve emotional preparedness for COVID-19.

The remaining studies dealt more directly with support. Mastroianni et al. (2020) paired surgical residents with psychology faculty for mental health support. Hodgson and Hagan (2020) described pastoral care tutors pivoting from face-to-face to virtual support on Microsoft Teams. Rastegar Kazerooni (2020) described using trained senior medical students to help junior students cope with anxiety using stress management techniques, exercise and other coping skills. The near-peer mentoring was carried out via a customized social media platform. Lee et al. (2020) described targeted, 1:1, virtual academic coaching using the Master Adaptive Learner framework. Two academic coaches tracked and analyzed students’ performance, with supportive interventions addressing content matters, study habits or learning strategies.

Telehealth

Five studies (3.9%) addressed telehealth. Four studies were in UME and one in GME. These interventions were conducted in a variety of specialties, with most implemented by universities or academic hospitals. Abraham et al. (2020) was able to rapidly incorporate telehealth into an Internal Medicine (IM) clerkship by utilizing existing telehealth modules created prior to the pandemic by the American College of Physicians (https://www.acponline.org/cme-moc/online-learning-center/telemedicine-a-practical-guide-for-incorporation-into-your-practice.) After completing the modules, students participated in a weekly telehealth clinic, allowing for ongoing, safe and meaningful patient care. Bautista et al. (2020) piloted an interprofessional rotation for five pharmacy and medical students, wherein learners engaged in collaborative outreach to vulnerable patients via telehealth. The pilot was well received. Long-term evaluation will be crucial as the innovation addressed a number of key learning outcomes (e.g., communication, teamwork, interprofessional practice, patient centeredness and health inequalities). Chandra et al. (2020) engaged medical students in follow ups after discharge from the emergency department using a script and a checklist, with faculty precepting remotely. Tsang et al. (2020) observed learners conducting remote neurologic histories and exams followed by debriefs with faculty preceptors. Huffman et al. (2020) focused on continued training of pediatric fellows. Faculty and fellows would meet for a pre-brief, then the fellow would lead the telehealth encounter with the faculty observing. This was followed by a debrief. Faculty and learners appreciated the intensity of supervision, rich feedback, and observation of other skills. Faculty worried about loss of autonomy and heightened scrutiny, but this was not felt by the fellows.

Clinical service reconfigurations or early graduation to support the response to COVID-19

Four publications (3.1%) focused primarily on early graduation or clinical service reconfigurations to promote provider safety and meet staffing needs. An additional three articles described clinical service reconfiguration as part of a larger package (i.e., multiple) interventions.

Two articles described the early graduation of medical students to support health systems overwhelmed by persons with COVID-19. Students who had satisfied their training program requirements were approved by the national authorities in Spain to engage in "non-registered" practice supervised by experts (Collado-Boira et al. 2020) or offered limited-licensing for 90 days to work on a completely voluntary basis (Flotte et al. 2020). Student reactions ranged from feeling unprepared and afraid to feeling gratified to contribute. Additional impacts included augmenting system capacity to care for high volume and high acuity patients. Five articles (Astani et al. 2020, Bandi et al. 2020, Dennis et al. 2020, Juprasert et al. 2020, Mastroianni et al. 2020) described either departmental or cross-departmental restructures designed 1) to hold providers in reserve, unexposed to COVID-19, 2) to meet critical staffing / patient care needs, or 3) to ensure various departmental missions (education, clinical care, research) continued despite the pandemic. For example, Astani et al. (2020) described the creation of two teams of radiologists, one image interpretation team and one clinical team redeployed to assist under the clinical supervision of internal medicine and infectious disease doctors. Juprasert et al. 2020 reported on a surgical department restructured to address clinical needs, prioritizing a reserve pool to limit exposures, condensing surgical services, implementing a procedural team, and deploying to support intensive care unit (ICU) expansion. The most remarkable article in this

group was perhaps Dennis et al. 2020. The authors described the development of a Trainee Pandemic Role Allocation Tool (TPRAT) - (www.covidstaffing.org). This schema categorized trainees according to their core specialties and clinical skill levels to facilitate *horizontal care delivery*, an institution-wide approach to mobilize the trainee workforce to meet immediate needs. The tool was initially deployed for 1053 trainees at Vanderbilt University, and has been taken up nationally by other hospitals.

Interviews for admission to medical school or selection to residency or fellowship

Four articles (3.1%) focused primarily on adapting to a remote interview process due to travel restrictions and logistical difficulties associated with the COVID-19 pandemic. One additional article (Xu et al. 2020), focused on both interviews as well as the pivot to online learning. All of these studies took place in an academic hospital setting and involved surgical or surgical sub-specialty programs. From the above papers, three focused on interviewing fellows (Day et al 2020, Molina et al. 2020, Vining et al. 2020) whereas the other two involved pre-interview medical students and residents (Xu et al. 2020, Patel et al. 2020). All studies utilized one or multiple technological platform, with four using Zoom (Patel et al. 2020, Molina et al 20202, Vining et al 2020, Xu et al 2020), two using Web Ex (Day et al. 2020, Xu et al. 2020) and two using google docs/forms (Patel et al. 2020, Molinda et al 2020).

Three studies (Day et al. 2020, Molina et al. 2020, Vining et al. 2020) described the process of moving interviews predominately online. These studies reported positive responses to virtual interviews, citing cost and time savings with the elimination of travel. Molina et al. (2020) reported their virtual interview process matched the in-person experience with regards to

participant perception and Vining et al. (2020) reported the interview flow as “seamless” per the majority of applicants and faculty. Whereas Molina et al. (2020) and Vining et al. (2020) described a completely virtual approach to interviews, Day et al. (2020) described a hybrid approach, with fellows interacting remotely over WebX “moving” from room to room *online* while two interviewers were *physically present* in rooms in the hospital. The authors highlighted some unanticipated “social distancing challenges” associated with this hybrid approach for the interviewers, but overall the experience was rated favorably by both applicants and faculty.

Xu et al. (2020) randomized prospective urology applicants to six programs to give virtual grand rounds. The presentations were meant to allow medical students to express interest in programs and for faculty to begin evaluating them prior to interviews. The authors reported 100% student satisfaction with the process, but cited problems with standardization across programs in virtual grand rounds delivery. Patel et al. (2020) described an informational webinar designed to educate trainees on the Core Surgical Training selection process for general surgery in the United Kingdom. This study reported over half (55%) of participants preferred the webinar to face-to-face tutorials regarding the interview process, but that participant experience was heavily influenced by internet capabilities.

Service provision

Only two publications (1.6%) described developments pertaining to service provision. The first publication described the establishment of a Crisis Management Team CMT) (Ashton, et al. 2020). The CMT identified unmet staffing needs at several regional hospitals in France during the first wave. Leveraging their social networks and leadership skills, they organized and

dispatched resident volunteers, matching resident skills to local needs. One thousand ninety-two volunteers registered, and 578 were deployed to areas critically impacted by the pandemic, particularly emergency departments (EDs), and ICUs with good effect. The intervention was inspirational in that it showed the potential of the newer generation of clinicians to take charge in times of crisis. The second publication described the integration of medical students into six different service projects to support the health system (Ayoub et al. 2020). Students supported triage efforts in call centers, addressed PPE shortages, assisted with diagnostic testing efforts, discussed care with families separated from hospitalized patients and ensured ongoing access to health appointments for disadvantaged persons. Feedback was strongly positive and highlighted the educational benefits on development of clinical knowledge and communication skills.

Faculty or professional development

Only two publications (1.6%) focused on faculty development (i.e. educator training) or professional development in light of COVID-19, though arguably several developments labelled as CME could be categorized as professional development. Buckley (2020) described the implementation of a virtual platform for ongoing faculty development using social networking amongst a cohort of regionally dispersed teachers. The aim was for faculty to collectively learn with and from each other to bridge knowledge gaps around virtual learning. Overall, this novel virtual method was highly valued by participants and allowed faculty to remain connected at a time where social distancing was imperative. Lang, et al. (2020) described the work of a multi-institutional collaboration, the Pediatric Overflow Planning – Contingency Response Network (POPCoRN). They created an inventory of high-yield topics in the form of succinct one-page living documents aimed at equipping pediatric staff and faculty to care for adult patients during

the pandemic. This intervention proved to be extremely popular and feedback received was overwhelmingly positive regarding its real-time utility.

Other or multiple areas of focus

Nine articles (7.1%) were difficult to categorize. Five articles focused on multiple areas and four articles categorized as "other" were diverse and did not clearly fit into another category. Iqbal et al. (2020) investigated the use of a free cloud-based App, Telegram, that allowed students to form groups or channels to facilitate sharing of educational resources, communication, collaborative learning, and wellbeing. Students found it effective, but some complained it created overload and caused distraction. Niburski and Niburski (2020) created a curated source of COVID-19 information (www.whohascoronavirus.com). The site contained a case tracker that utilized information from World Health Organization (WHO), as well as clinical information regarding treatment modalities, radiographic images, etc. collated from articles in the Journal of the American Medical Association (JAMA). Tang et al. (2020) described a self-ultrasound training program for radiology. Whilst this allowed learners to keep their scanning skills fresh, a major drawback was a lack of pathology. Gallardo et al. (2020) distributed surgical instruments to implement a home-based microsurgical skills training program for neurosurgery residents, involving low-cost items (e.g., a shoebox). Skills evaluations were conducted remotely via video.

Educational or other outcomes

Ninety-eight articles described Kirkpatrick level 1 outcomes (satisfaction or other forms of reaction. Seventy-three articles described Kirkpatrick level 2 outcomes, twenty-six discussed

changes in attitudes (2a) and a further forty-seven changes in knowledge or skills (2b). Only two articles described Kirkpatrick level 3, changes in behavior. Seven articles reported Kirkpatrick Level 4 outcomes, with six describing changes in organizational practice and one outlining a change in clinical outcomes. Eight studies reported no Kirkpatrick outcomes. The articles reporting Kirkpatrick levels 3 and 4 were predominately works focused on simulations to care for patients with COVID-19 or clinical service reconfigurations to extend the ability to provide care during the surge. Forty-three articles reported outcomes at multiple Kirkpatrick levels. One exemplary simulation article (Cheung et al. 2020) described outcomes at all 4 levels (summarized in Figure 1 in their paper). Participants were satisfied with the training and learning objectives were met (level 1). They demonstrated learning (level 2) in the form of proper donning and doffing PPE and hazard recognition. They showed changes in behavior (level 3) related to areas of personal strength (e.g., assertiveness and self-efficacy scores). They also showed changes in organizational practice (level 4), including standardization of airway management and infection control that have resulted in zero cases of COVID amongst HCW in Hong Kong.

Other measures of effectiveness were reported in thirty articles. Such measures included quality improvement (e.g., checklist development, identification of latent safety threats leading to practice changes), policy changes, development of best practices, or other impacts (e.g., staffing to augment capacity, healthcare workforce strengthening). One remarkable example was Aluisio et al. (2020). This academic – humanitarian partnership trained > 900 trainers in core competencies to care for COVID-19 patients. These trainers went on to train > 22,000 frontline healthcare workers HCW in low and lower-middle-income countries.

During data extraction, we noted that outcomes were reported in varying levels of detail, with some offering more subjective findings (e.g., Amin et al. 2020, Chow et al. 2020) and others offering details and specifics (Babal et al. 2020, Shi et al. 2020, Vining et al. 2020). The reviewers noted an overall lack of consistency in reporting of Kirkpatrick's educational outcomes. Many articles described Kirkpatrick's, but they were not labelled as such. A few articles claimed Kirkpatrick levels that were not actually achieved, reflecting variable application of terminology.

Discussion

Approach and methodology

The COVID-19 pandemic has challenged the global medical education community to rapidly innovate and disseminate their work. This has created a rapidly expanding evidence base that is quite rare in education. As such, the author teams conducting this and the prior review by Gordon et al. (2020) had to embrace methodologies not common within BEME in order to ensure methods that were fit for purpose. Gordon et al. (2020) chose a *rapid review* approach to explore an emerging topic in a compressed timeframe (4 weeks). The current team initially planned an update review with a similar methodology, but pilot searches revealed that a very large and divergent evidence base had emerged in the ensuing months. The immediate temptation was to choose to complete one large systematic review synthesizing all literature in detail. However, this was unlikely to produce a review with much depth or utility. Thus, the team decided to conduct a scoping review to map the broad array of developments to date, to guide future research and identify areas in need of more focused systematic reviews.

The scoping review approach offers a unique set of tools for evidence synthesis, but it must be employed for the correct purpose under the correct circumstances (Pham et al. 2014). Many scoping reviews in the field align with the rhetoric of 'scoping', but beyond use of the nomenclature, do not fully embrace the purpose or promise of such methods. For this review, the first instance of a scoping review within BEME, we wanted to map the extent, range and nature of medical education developments deployed in response to COVID-19 since the prior review. Detailed descriptions, content analyses, and quality assessments were not our purpose. Rather, we aimed to broadly chart the data, identify areas of convergence for future reviews, and more importantly, highlight areas with a paucity of outputs to guide future research.

Summary of Results

Our review showed that UME has received the most attention to date, followed by GME, then CME. Whilst the majority of interventions were implemented by academic hospitals and universities, the number of developments coordinated by national organizations, and regional, national and international collaborations (Table 3) have markedly increased since the last review (Gordon et al. 2020). As this is a global pandemic, this level of cooperation is heartening to see. These developments have shown pathways to break down historical silos in medical education, highlighting future opportunities to educate across traditional 'brick and mortar' or other boundaries. Collaborations have been effective not only in the realm of online learning (Balakrishnan et al. 2020, Beer et al. 2020, Domen et al. 2020, Duggan et al. 2020, Elledge et al. 2020, Goncalves et al. 2020, Rasouli et al. 2020, Rose et al. 2020, Thum DiCesare et al. 2020), but also in training to treat patients with COVID-19 (Aluisio et al. 2020), well-being / learner

support (Blankenburg et al. 2020, Sockalingam et al. 2020, Steeves-Reece et al. 2020), clinical service reconfigurations (Dennis et al. 2020), and faculty development (Lang et al. 2020). Buitendijk et al. 2020 argued that COVID-19 is an opportunity to rethink global cooperation in higher education and research, noting "we need global solutions to global challenges and universities need to work harder and better at collaborating." Future research should build on work to date and augment collaborations, as a means of providing greater access to expertise, increasing equity and lessening educational disparities.

We were surprised by the distribution of developments as it related to disciplines or medical specialties (Table 4). Arguably, emergency medicine and internal medicine (particularly pulmonary critical care) have been the most "frontline" specialties during this pandemic, yet relatively few educational developments (n=8 and 5, respectively) emerged from these specialties. Instead, we saw large numbers of developments published by surgery and surgical subspecialties (n=27) and pathology and radiology (n=15). We hypothesize that this skew may be reflective of the additional time afforded to these specialties for scholarship during the pandemic due to cancellation of elective procedures. The skew could also be explained by the urgent need within some specialties to provide alternative learning experiences, as clinical and procedural-based learning were markedly diminished (Aziz et al. 2020). We were also surprised by the relative lack of articles in core clerkship specialties like family medicine (n=2) and psychiatry (n=0). This gap is perhaps more surprising when one considers that these two specialties have been rapid telehealth adapters and may be best positioned to produce scholarly outputs in this area. Thus, in the future, we would recommend additional research in the

"frontline" specialties of internal and emergency medicine, as well as call on family medicine and psychiatry educators to help lead the field in telehealth interventions.

In terms of the focus of developments (Table 5), we identified tremendous activity in the realms of pivoting to online learning (n=58) and training for treating patients with COVID-19 (n=24). In the prior review by Gordon et. al (2020), pivoting to online learning and simulation were also well-represented with n=26 and n=8 primary papers, respectively. We also saw a fair number of developments in the domains of assessment (n=11) and wellbeing (n=8), adding to the 7 assessment papers and 2 well-being papers in the prior review. Clinical service reconfigurations were not addressed robustly in this review (n=4) but were addressed slightly more in the prior review (n=6). Arguably, clinical service reconfigurations are of greatest importance during peak surges, both to ensure adequate staffing through horizontal deployment, as well as to ensure some providers are held in reserve and not exposed if PPE is in short supply. An important article to highlight from this review is Dennis et al. (2020). They developed the Trainee Pandemic Role Allocation Tool (TPRAT) for horizontal deployment of trainees based on skillsets (www.covidstaffing.org) which may be a valuable resource for other institutions in future surges.

Future reviews indicated by findings

This scoping review clearly demonstrates that the literature base is robust enough to support more in-depth systematic reviews. The pivot to online learning category is large enough to support at least two future reviews, one focused on undergraduates and one focused on postgraduates. A narrative review was previously conducted by Gaur et al. (2020) that focused

exclusively on preclinical online learning in UME during COVID. Unfortunately, their review methodology was not systematic. Online learning in some form is undoubtedly here to stay, so educators must sort through the array of developments to identify what works, for whom, under what circumstances, paying particular attention to the differential impacts of synchronous, asynchronous and blended learning approaches. The simulation category is also robust enough to justify its own in-depth review in the near term. This scoping review has already identified several exemplary articles in this area: Cheung et al. (2020) achieved outcomes at all Kirkpatrick levels; Dubé et al. (2020) trained ~30,000 frontline HCW in 5 weeks! We have also identified potential areas of focus for future reviews, including in-situ simulations for systems testing versus training. Assessment, wellbeing, and clinical service reconfiguration are likely to have enough articles for smaller, focused reviews.

Future primary research areas indicated by findings

Many critical areas remained under-represented in this scoping review and should be prioritised by researchers and editors in the future. Three areas are of immediate concern and warrant explicit focus, namely, telehealth, interviews and faculty development.

First, whilst the use of telehealth has surged dramatically, up 8336% in the United States at the peak according to national claims data (Fair Health 2020), few developments (n=5) addressed education in telehealth. Given that telehealth is likely to persist for both safety and convenience long after the pandemic abates, studies in this domain are urgently needed. Telehealth warrants particular attention as it relates to two key educational areas: curricula and assessments (i.e., how

can learners be educated in optimal telehealth techniques and how can educators ensure learners achieve appropriate competencies from the use of these techniques?)

Second, developments addressing interviews for admission to medical school and selection to residency are under-reported (n=4). We suspect this is partly due to the timing of the application cycle and anticipate an increase in developments in the coming months. Several perspectives and society guidelines have already been published on the topic (e.g., Chou et al. 2020, Chretien et al. 2020), but due to lack of outcomes data they did not meet the inclusion criteria of our review. Of note, the last two decades have witnessed a redesign of admissions processes across the continuum, with increased emphasis on holistic reviews to minimize bias in selection. This has been accompanied by the administration of more complex assessments (e.g., multiple mini-interviews and situational judgement tests) (Dore et al. 2010, Patterson et al. 2016). How these can be practically administered during the pandemic is a pragmatic concern. There are also wider questions concerning the validity and reliability associated with such shifts to an online environment that are of equal, if not greater importance. Another concern is the potential for "over application" behavior on the part of applicants this interview season. This may stress the capacity of programs to manage the medical school admission and residency selection processes without significant innovations (Hammoud et al. 2020).

Finally, there was an almost complete lack of articles in the area of faculty development (1.6%). This was particularly surprising given the acute need for faculty training to teach using new modalities (e.g., Zoom), as well as the urgent need to "re-train" faculty deployed to other

services. We would strongly encourage the implementation and reporting of additional developments in this area.

Evolution of studies since last review

The growth in the literature since our previous review (Gordon et al. 2020) is quite remarkable given the addition of more stringent inclusion criteria (i.e., outcomes). However, the initial exponential growth in primary papers seems to have stopped at a steady output of ~30 papers per month. This initially seemed surprising, but upon reflection, the explanation is clear. We are witnessing a unique bottle neck effect, created by the capacity of top journals. These journals have hard limits to how many papers they are able to publish. Whilst there are options without such a bottle neck, many authors prefer to publish in traditional journals with impact factors, hence the limitation on space. This is a vital finding, as it creates a paradox for authors vying for limited space and editors peer reviewing work – every paper must count! From the perspective of secondary researchers, this is deeply problematic. If the evidence base is to grow and evolve, as indeed it should, each paper should build on the last, expanding on findings, refuting, supporting or evolving the work. With the clear identification of a bottle neck that is unlikely to change – authors and editors will likely continue to focus their efforts on articles that stand alone as a high-quality pieces, rather than enriching the wider tapestry of evidence in the field, building on prior work and reviews such as this.

Strengths and limitations

This scoping review carefully adhered to the five stages outlined by Arksey and O'Malley 2005. The scoping process allowed for evolution of the inclusion criteria after an initial look at the

literature, and we believe the addition of Kirkpatrick's and other outcomes contributed to the strength of this review. We completed the review within 8 weeks, to ensure the presentation of our findings was timely, to guide future developments and educational research. This was a remarkable feat for a review with 127 primary papers. We were able to do this and ensure rigor was not compromised, in large part due to an experienced team.

Of course, this review had several limitations. First, we limited our search to four databases to align with Gordon et al. (2020). Whilst this was consistent with practice in prior BEME reviews, we may have missed a few developments. Second, due to the accelerated time frame for this review, we did not conduct the optional sixth step for scoping reviews described by Levac et al. (2010) - consultation with stakeholders. This may have added insights beyond those in the literature. Third, we did not describe each study in detail nor conduct a thematic analysis, as that was beyond the scope of this type of review. For readers who wish to explore the studies in greater detail, Table 1 provides a searchable resource and expanded descriptions not provided in the text. Finally, unlike Gordon et al. (2020), we did not assess the quality of the study designs nor the quality of reporting. As the quality of the primary papers strongly influences the replicability of developments in other contexts, we strongly recommend that future full or focused reviews contain both types of quality assessments.

Conclusions

Institutional and regional mandates made in response to the COVID-19 pandemic have led to drastic changes in the delivery of medical education worldwide. This review collates developments through mid-September, demonstrating the extent and range of scholarly activity

to date. We have highlighted several exemplary articles, as well as productive collaborations on which future work can build. We have noted specialties that have published more extensively (e.g., surgery and surgical sub-specialties), and called on others to do more (e.g., emergency, internal, and family medicine). We have also called attention to relative areas of strength (e.g., the pivot to online learning and simulations), as well as areas in urgent need of development (e.g., telehealth, interviews and faculty development.

It is our fervent hope, that educators and editors will use this review as a roadmap to guide future developments. We are fast approaching the one-year mark from when COVID-19 was declared a pandemic. Whilst the initial months were understandably chaotic, with educators scrambling to find *any* possible solution to pressing problems, we are now entering a phase of maturation. In the next phase, we must determine what works, for whom, under what circumstances, so that we can determine which interventions should remain in a post-pandemic world.

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Table 1: Summary of all included primary studies

Author	Title	Month	Level	Learners	Specialty (or N/A)	Region	Organization responsible	Focus of development	Stated purpose of deployment	Brief summary of development or intervention	Resources (details of cost / time / resources)	Kirk-patrick Outcome	Other Outcomes (QI, impact, policy change, checklist, etc.)	Summary of Results (main details)	Lessons Learnt by development as stated by authors (barriers, challenges)	Summary of conclusion
Abraham et al.	Engaging Third-Year Medical Students on Their Internal Medicine Clerkship in Telehealth During COVID-19	June	UME	3rd year medical students; n=20	Internal medicine	USA	Academic hospital	Telehealth	Provide a diverse patient care experience despite COVID restrictions and increase skill and confidence with telehealth	Telehealth module for internal medicine clerkship: 1. Complete American College of Physicians online module on telehealth https://www.acponline.org/cme-moc/online-learning-center/telemedicine-a-practical-guide-for-incorporation-into-your-practice; 2. Attend Zoom orientation; 3. Attend once weekly supervised telehealth clinic.	Learning modules on telehealth (2 hours); Zoom orientation with 2 faculty members (1.5 hours); 30-minute patient appointments (6-8 per session, once weekly); Doximity dialer to mask phone number	1, 2a, 2b	ND	Student familiarity and comfort with performing assessment and exam via telehealth improved, however there was a wide range of comfort. Students were more confident in their ability to assess social determinants of health than the physical exam. Students were highly satisfied. Adequate case mix exposure.	Used online modules successfully; Formal assessment of telehealth was difficult, and feedback was informal --> checklist development could be useful; Challenge was short time frame for development	"We successfully developed a robust model in which medical students not only actively participated in, but also actively delivered, telehealth care to our patients." Success needs to be built on and expanded as telehealth is here to stay.
Aluisio et al.	Academic-humanitarian partnerships: leveraging strengths to combat COVID-19	August	CME	HCW: clinical providers, support staff, public health personnel, local policymakers at TOT sessions; n = >900	Multi-professional	Inter-national	Collaboration between international humanitarian group and a university	Simulation (training for treating patients with COVID-19)	Provide practical knowledge on preparing health systems and frontline providers for the COVID-19 pandemic	The program targets trainers of trainees (TOTs). Trainers disseminate what they have learned at TOT sessions. Teaching and evaluation focus on core competencies across eight modules: COVID-19 principles, infection prevention and control, screening and triage, diagnosis and management, stabilization and resuscitation, surge capacity, surveillance and risk communication and community education. Program is based on "vetted" materials from widely respected organizations such as WHO.	Not well detailed, but partnered with humanitarian organization, Project HOPE, which contributed substantial manpower	ND	Global impact on healthcare personnel readiness to treat patients with COVID in low- and lower-middle-income countries	>900 TOTs have trained >22,000 frontline healthcare personnel	Barriers included 1. logistical coordination (access to local personnel), 2. technology access (bandwidth limitations required audio-only alternatives at some sites), and 3. management of content matter volume (rapid evolution of COVID-19 data required 2 trainers, one focused on set materials and one on the most up-to-date research)	"Collaborative academic-humanitarian programs represent a viable approach to strengthen the response to global healthcare crises. The developed and implemented COVID-19 digital training program is a key example of how academic-humanitarian partnerships can be leveraged to strengthen healthcare training and capacity during pandemics."
Amin et al.	Step-by-step Guide to Create Competency-Based Assignments as an Alternative for Traditional Summative Assessment	June	UME	3rd year medical students	N/A	Middle East	University	Assessment	Replace traditional summative assessments with competency based electronic assignments	5 step model used to design an integrative, competency-based assignment as an alternative to summative assessment. Assignment consisted of writing questions for a question bank. Students were assigned specific integrated lectures and tasked with developing a case scenario. Rubrics for grading were developed by faculty.	Training sessions for staff; Zoom sessions for students on item-writing; Template for item-writing	1	ND	Students were satisfied with the assignment of writing questions	Student engagement was helpful	"An integrated competency-based assignment can be well-tailored to an enthusiastic project, not only to provide a fair assessment but also, to create a usable product. Students' engagement in the needs assessment, design, plan, implementation, and evaluation of the end product maximize the outputs to unexpected horizons"
Andreae et al.	Healthcare simulation to prepare for the COVID-19 pandemic	May	CME	Anesthesia physicians; n = 7	Anes-thesiology	USA	Academic hospital	Simulation (training for treating patients with COVID-19)	Use immersive training simulations to test algorithms and protocols and optimize management of suspected COVID 19 patients	Immersive in-situ training simulation with 4 scenarios related to COVID 19: cardiac arrest, emergency airway management, tele-instruction for remote guidance and supervision, and transporting an intubated patient. Scenarios required PPE use, procedures. One included a telemedicine link to an "expert" who was tasked with guiding team remotely.	(Details provided in companion paper below)	ND	QI;: Impact on organizational behavior, leading to changed scope of practice, altered resuscitation algorithms, awareness of resource crisis.	Simulations revealed gaps in policy, practice/behaviors, and preparedness	Teams were surprised by time necessary to safely intubate, identified barriers to communication created by PPE, adjusted difficult airway protocols and resuscitation algorithms.	"Simulation impacted organizational behavior, leading to changed scope of practice, altered resus algorithms, raised awareness of impending resource crisis"
Andreae et al.	Data and debriefing observations on healthcare simulation to prepare for the COVID-19 pandemic (companion paper to above)	July	CME	Anesthesia physicians; n = 7	Anes-thesiology	USA	Academic hospital	Simulation (training for treating patients with COVID-19)	Test protocols developed in tabletop exercises, augment the organizational response by improving interdisciplinary coordination, and triangulate simulation debriefings with participants.	Immersive in-situ training simulation with 4 scenarios related to COVID 19: cardiac arrest, emergency airway management, tele-instruction for remote guidance and supervision, and transporting an intubated patient. Detailed "expected action" steps (Table 3).	Detailed description of needed materials (e.g., manikin, height adjustable, gurney, crash cart, difficult airway kit, etc.) No details regarding time or cost.	2b; 4a	QI; Impact on organizational behavior, leading to changed scope of practice, altered resuscitation algorithms, awareness resource crisis.	Identified overarching themes from debriefings. The themes demonstrate learning and suggests ideas for practice change (e.g., Airway instrumentation and mask ventilation expose clinicians to virus aerosolization"). See table 2.	ND	ND
Ansari et al.	The effects of personal protective equipment on airway management: An in-situ simulation	July	Mixed	Trainees, attendings, staff; n = 34	Anes-thesiology	Europe	Academic hospital	Simulation (training for treating patients with COVID-19)	Evaluate airway management procedures using a skill specific checklist during a simulated difficult airway scenario. Evaluate the time to successful tracheal intubation.	In situ simulation with structured scenario with video review performance checklist, followed by debriefing, additional training on doffing PPE and the training on video laryngoscopy.	over 2 weeks, using high fidelity simulation equipment already available	2b	ND	12% failure rate in tracheal intubation and longer time for intubation as compared to previously published studies from the same department using a video laryngoscope	ND	Following structured training, procedural steps can be performed to an acceptable level of competence. Additional training with newly introduced devices (e.g., McGrath® video laryngoscope) is of paramount importance.

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Ashton et al.	Junior doctors: when fresh blood fast-tracks the fight against COVID-19	Sept-ember	GME	Residents; n = 578	Multi-disciplinary	Europe	Academic hospitals	Service	Highlight the efficiency millennial residents can bring at a time of crisis (by means of being more technologically savvy and their capacity in fast networking with their peers)	A Crisis Management Team (CMT) was established to identify staffing needs and dispatch resident volunteers. CMT had two arms - The Monitoring Team and Matching Teams. The monitoring team would assess the needs of departments. Needs were stratified, levels 1-5 to signify urgency of need. Level 4 and 5 needs triggered the matching team to carry out workforce recruitment.	Social networks; Novel web app to sort and organize volunteers that took 48 hours to develop	ND	Volunteers matched to need / dispatched to fill critical staffing gaps (impact on system)	1902 residents responded to the CMT call; 578 were actually dispatched; 230 in ICUs, 93 in Eds and 255 in inpatient wards	The CMT reflected the potential of millennial junior doctors / residents to take the lead in times of crisis.	The CMT provided a reliable and agile answer to hospital staffing needs, due to the familiarity of those involved with social networking and information communication technology (ICT) tools.
Astani et al.	Radiology Department and Residency Program Response and Adaption to COVID 19	July	GME	Residents; n = ~130	Radiology	Middle East	Academic hospitals	Clinical service reconfiguration, Pivot to online learning (synchronous, asynchronous)	Provide reliable interpretation of radiographic scans while addressing the patient surge; Ensure uninterrupted training of radiology residents	2 teams were created: one core radiograph interpretation team and one of redeployed residents assisting under the clinical supervision of internal medicine and infectious disease doctors. Lectures were moved online and presented live. Webinar and Q&A sessions were also set up online. Eventually case presentations, weekly journal clubs, and monthly grand rounds were also switched to a virtual format.	ND	1	Augmented staffing on other services	98% resident satisfaction regarding the novel online teaching activities	Virtual and online lectures cannot replace some necessary in-person training.	Residents cannot learn certain skills virtually (e.g., ultrasound scanning)
Ayoub et al.	Medical Student Mobilization During a Pandemic: The Ochsner Clinical School Response to COVID-19	July	UME	3rd & 4th Year Medical Students; n = 151	N/A	USA	Academic hospital	Service	Integrate volunteer medical students into projects addressing the needs of the Louisiana health system	6 projects emerged based on needs: COVID-19 Call Center, Obstetrics Call Center, PPE Initiative, COVID-19 Diagnostic RT-qPCR Laboratory Testing, MedVantage Clinic Telemedicine, and Family Communication Champion Project. Students supported triage efforts, addressed PPE shortages, assisted with diagnostic efforts, discussed care with families separated from hospitalized patients, and ensured access to health maintenance appointments for disadvantaged persons.	ND	2a, 2b	3,625 volunteer hours impacted community and healthcare	Students learned 1. relevant medical knowledge reviewing patient charts, 2. interprofessional collaboration in healthcare teams, 3. empathy and listening skills, 4. leadership skills. Call center wait times decreased from 3 hours to 0; 632 OB patients had questions answered; 379 chronically ill geriatric patients were reached via telemedicine; 15,000 COVID-19 samples were analyzed; a novel face shield was developed using 3D printing; and PPE was distributed to frontline health workers.	"...medical students can provide essential assistance to the medical workforce in the event of a major disaster or global crisis."	Medical students are ideal candidates for identifying and addressing gaps in healthcare. They have also shown their determination and resilience through service projects during the COVID-19 pandemic.
Babal et al.	First, Do No Harm: Lessons Learned From a Storytelling Event for Pediatric Residents During the COVID-19 Pandemic	May	GME	Residents; n = 37	Pediatrics	USA	University	Well-being / mental health / learner support	Determine if narrative storytelling can support resident growth and wellbeing in times of crisis	2-hour online storytelling event: Faculty storytellers attended a 1-hour workshop. 3 faculty members told stories, each lasting 8-10 mins about meaningful or challenging clinical experiences related to COVID-19. Storytelling was followed by facilitated discussion.	Blackboard videoconferencing platform; 3 faculty storytellers; Storytelling workshop; professional storyteller to give feedback; session facilitator.	2a	ND	Majority of residents reported hearing faculty tell stories was beneficial for their emotional growth (n = 13, 76.5%) and professional growth (n = 11, 64.7%) and they wanted more in the future (n = 12, 70.6%). Fewer said that it was cathartic n=9, 52.9%).	May be beneficial for some but may be distressing for others. Trauma-informed practice may be needed.	Storytelling about stressful events can be helpful but can be potentially triggering. Joyful stories may be welcomed.
Balakrishnan et al.	A novel "Google Classroom" based pathology education tool for trainees during COVID-19 pandemic: Impactful learning while social distancing	August	GME	Pathology trainees (residents or fellows)	Pathology	Inter-national	Collaboration of pathologists	Pivot to online learning (asynchronous) Assessment	Supplement learning (lost case exposure) by leveraging technology	An international collaboration of pathologists developed a "Breast Case Challenge". Teachers posted a new case weekly with a clinical vignette, a PPT, a set of microscope images and a series of questions. Learners post their differential diagnosis and request additional studies. Mid-week there is follow up discussion.	Online platform which is free. No other costs or resources discussed.	1	ND	Survey of participants highlighted open access to learning resources, opportunities for networking and collaboration, tolerance to others' opinions and a forum for consensus and common ground.	Interactive dialogue, learning from others and consensus building. Questions serve as a self-evaluation tool.	Online learning platforms are an effective way to develop learning in pathology during the COVID pandemic. Google classroom is a more professional alternative than Facebook's discussion forums.
Bandi et al.	Strategies to overcome limitations in Otolaryngology residency training during the COVID-19 pandemic	July	GME	Residents in Otolaryngology; n = 15	Oto-laryngology	Europe	Academic hospital	Clinical service reconfiguration, Pivot to online learning (synchronous)	Report strategies to overcome the educational constraints caused by COVID-19	Clinical teams were created to cover inpatient, outpatient and surgical services. Ensured not all residents in the same place at the same time to reduce exposures. Teaching activities were shifted online, including lectures, journal clubs and case conferences. Multi-disciplinary tumor boards were conducted virtually. Dissection labs were held with social distancing measures to mimic surgeries.	ND	1	ND	Most useful activities were dissection (n=8, 53.4% residents) and online journal clubs/webinars (n=7, 46.6% of residents). Suggestions included actively participating in tracheostomy procedures on COVID patients, attending lessons by senior consultants on ENT topics and promoting collegial discussion of inpatient cases.	Understanding what the residents perceived as useful training during the pandemic can guide future interventions	Residents perceived decreased surgical training and suggested dissection labs, live surgery videoconferencing and online didactics to supplement training.

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Bautista et al.	Development of an interprofessional rotation for pharmacy and medical students to perform telehealth outreach to vulnerable patients in the COVID-19 pandemic	August	UME	Pharmacy students; 3rd year medical students; n = 5	Inter-professional	USA	University	Telehealth	Teach students interprofessional and communication skills while having them provide outreach to vulnerable patients	6 sessions across 2 weeks; 1st = 2-hour induction. Each subsequent session had a 30-minute didactic "huddle" followed by a 2-hour outreach, where students collaboratively reviewed patient notes and performed follow up calls. Help was available from an offline preceptor if needed. Students presented patient encounters to preceptors.	Zoom; Electronic Health Record; Doximity application to call patients; 7 preceptors + 2 directors met on zoom 2x1hour; Staff scheduled follow up appointments.	1, 2b	ND	All students agreed that they achieved learning objectives; and rated pre and post encounter huddles, outreach, medicine reconciliation as good, very good, or excellent. Gained skills in telehealth.	Technology issues; low rates of patients answering calls; no pre-intervention survey	This interprofessional rotation was well received by students and addresses trends in healthcare delivery, specifically an increasing reliance on telehealth, distance learning, and need for IPE in the workplace.
Beer et al.	Megaflip, a Novel Approach to National Collaboration for Flipped Classroom Education	June	GME	Fellows in training from 16 neo-natology and pulmonary fellowship programs; n = 131	Pediatrics (Neonatal-Perinatal Medicine)	USA	National organization of neonatal-perinatal medicine program directors	Pivot to online learning (synchronous)	Provide high quality education to fellow trainees as recommended by the ACGME	Use of flipped classroom model for neonatal fellowship programs using national neonatology curriculum, materials and resources. Learners are assigned prework (short videos and readings). Classroom sessions focus on case-based application. “Megaflip” sessions are delivered via Zoom. A small group of facilitators (2−3) host the Megaflip and the participating programs provide a local facilitator to lead their own fellows in large group and breakout discussions.	ND	1	ND	A megaflip model of flipped classroom across fellowship programs in the USA was conducted for 2 sessions (131 fellows from 16 programs). Survey results highlighted the utility of megaflip and its impact on fellow education.	Coordination among national programs is possible and well received.	The Megaflip is feasible and useful. Plan to continue model beyond the pandemic given advantages of opportunity for multicenter collaboration, reduced burden on faculty facilitators, and expanding fellow exposure to center-specific innovations and practice patterns.
Bhashyam & Dyer	Virtual Boot Camp: Orthopaedic Intern Education in the Time of COVID-19 and Beyond	July	GME	1st year orthopedic residents	Orthopedic surgery	USA	Academic hospitals	Pivot to online learning (asynchronous)	Create an asynchronous learning platform allowing residents to develop basic orthopedic knowledge and skills	Month long virtual bootcamp for 1st year residents used asynchronous, modular instruction of knowledge and skills. Available at https://ortho.hms.harvard.edu/virtual-bootcamp. Topics organized into modular weekly format to facilitate focused skills development. 4 modules were basic skills/hand, sport, trauma, and arthroplasty. Lectures presented via Zoom. Skill modules completed remotely.	Breakdown of resources and costs presented in tables. On average, $1700 was required per intern, $1400 for startup and $300 over the subsequent sessions.	1	ND	100% of residents were satisfied by the course, the modular format, and the “take-home” kits. All residents reported “virtual” boot camp improved their orthopedic knowledge base and surgical skills. 92% of residents thought it improved their preparedness for the operating room. All residents thought that it should be a permanent part of resident education.	Limited evaluation of learners' knowledge improvement and hands on technical skills	A virtual boot camp for cognitive and technical skill learning for orthopedic residents is feasible and well received by learners.
Blankenburg et al.	Virtual Cafes: An Innovative Way for Rapidly Disseminating Educational Best Practices and Building Community During COVID-19	June	CME	Pediatric program directors; n=255	Pediatrics	USA	National organization of pediatric program directors	Well-being / mental health / learner support	Share educational innovations and best practices as well as build community and consensus	Daily, 1-hour, Zoom videoconferences "Virtual Cafes" hosted by the board. Sessions on COVID-related GME issues: short presentation of ideas, followed by open dialogue and information sharing verbally and through the chat function	zoom, program directors to plan sessions	2a	Increased engagement with the association of pediatric program directors and its members	"Members noted that these cafes resulted in significant changes in their approaches to educational, clinical, and administrative issues."	Carry on with sessions	"Virtual Cafes are a successful way to engage membership, build community, and quickly disseminate innovative educational practices"
Buckley	Faculty development in the COVID-19 pandemic: So close - yet so far	May	CME	N/A	N/A	Canada	Regionally dispersed faculty group	Faculty development	Develop a virtual platform for faculty development using social networking	A provincial virtual faculty development session was developed to bring four regionally dispersed faculty staff groups together to learn with and from each other. Regional leads and site administrators reached out to faculty. Experts were invited to help bridge knowledge gaps around virtual learning. Formal presentations were avoided to encourage spontaneous informal discussion. Continuity of connection was offered afterwards through email.	ND	1	ND	"Overall this form of 'connection' was highly valued. Connection allowed them to develop an informed and shared understanding of the changes to his or her role, as well as the reassurance and confidence to embrace newchallenges, such as teaching virtually and attending to student well-being."	Educational leaders and teachers within medicals schools have other responsibilities and are overstretched during the COVID-19 pandemic. Arranging for a co-facilitator to help keep track of comments and questions was helpful. Participants seemed quite open to share varied and even competing opinions. Faculty valued other forms of follow-up communication.	Virtual faculty development sessions appear promising, but still needs evaluation over time.
Buléon et al.	Protecting healthcare providers from COVID-19 through a large simulation training programme	August	CME	HCW; n=1143	Multi-professional	Europe	Academic hospital	Simulation (training for treating patients with COVID-19)	Develop simulations to prepare trainees for infection control procedures	6 procedural skills sim sessions in-situ for hand sanitizing, fitting N95 masks, donning, doffing, airway management. Each provider viewed tutorial, took turns preforming skill while others rated them using checklists, received immediate feedback, repeated until each provider passed.	Developed and trained over 10 days, no description of cost or specific materials	ND	QI; New/modified checklists and policies; Providers trained were 4x less likely to contract COVID	ND	Time constraints, small group and distancing limitations	Impossible to prepare for everything; will be a need for rapid, massive, and targeted adaptation to future health crises. Simulation is effective for training many people in new procedures. Training is critical to limit viral spread.

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Burns & Wenger	A remotely conducted paediatric bootcamp for fourth-year medical students	June	UME	4th year med students; n=6	Pediatrics	USA	University	Pivot to online learning (synchronous)	Provide a virtual "boot camp" to medical students preparing them for residency without in-person rotations	Remote pediatric bootcamp with didactics, flipped classroom, small group activities, role-plays and case discussions delivered via Zoom. SP exercises converted to case-based discussions. Procedural training supplemented by online videos and interactive modules.	Required 32 volunteer instructors for six students over 40 sessions.	1	ND	All but one session (using social media and technology in medicine) received an average rating of 4.5 or higher on a 5-point Likert scale.	Time to appropriately prepare for remote sessions, particularly with procedure and exam related activities, can enhance the experience (i.e. providing students with kits/materials to practice virtually with instructors). Practice sharing audio and visual material prior to sessions allows for less technical difficulty.	Most of the pre-existing bootcamp curriculum could be adapted to remote format readily. Even for traditionally clinical in-person experiences, planned learning activities can be converted to satisfactory/enjoyable remote learning sessions.
Carroll et al.	Re-ACT: Remote Advanced Communication Training in a Time of Crisis	August	CME	Physicians, PAs, NPs; n~700	Inter-professional and Multi-disciplinary	USA	Academic hospital	Simulation (training for treating patients with COVID-19) Pivot to online learning (synchronous)	Adapt to online format and provide communication training	Converted in person training to 1-hour virtual format offered 3-4 days a week with live patient-actors and opportunity for participants to practice serious illness communication skills with actors.	Used Zoom, live patient-actors (paid $30 / hour), volunteer facilitators. Costs estimated to be $1 per person compared to $500 when offered live. If facilitators paid, costs increase to $4 per person.	1; 2b	QI	Re-ACT participants felt less prepared from the training compared to those who did ACT, but did feel more prepared than before any training. Table 2 compares learning from in-person sessions versus Re-ACT on a variety of advanced communication skills.	Learning is negatively impacted, but gains are still seen compared to no intervention.	"Provided effective and well-received communication training during a time of crisis." Cost is significantly reduced and can reach more participants with the remote format, particularly if the training is championed by institutional leaders.
Chandra et al.	Zooming-out COVID-19: Virtual clinical experiences in an emergency medicine clerkship	June	UME	Medical students; n=67	Emergency Medicine	USA	University	Telehealth	Allow students to engage in patient care and practice communication skills by interacting with patients discharged from the hospital	Students video called 2 groups of discharged ED patients: those who were COVID + or those with general medical complaints. Students had a script and a checklist to guide them and were supervised remotely by a faculty preceptor.	Zoom teleconferencing app with HIPPA-compliant account; 1 faculty preceptor per student	1	Patients were grateful for follow up; faculty liked teaching	Students gave positive feedback – felt engaged and valued.	Not all patients answered calls – needed longer roster of patients for callbacks	"Students felt engaged and valued the help they provided to the ED during the pandemic... Patients were grateful for the follow-up."
Cheung et al.	Investigating effects of healthcare simulation on personal strengths and organizational impacts for healthcare workers during COVID-19 pandemic: A cross-sectional study	July	CME	Doctors, nurses, patient care assistants; n=1415	Inter-professional and Multi-disciplinary	Asia	Academic hospital	Simulation (training for treating patients with COVID-19)	Unify and standardize hospital-wide practice and procedures to minimize contamination by and exposure to COVID-19 during high risk procedures.	101 simulations were conducted either "in-situ" in the ED or ICU or "lab-based" for isolation and general wards. Specific personal strengths of HCW were explored (assertiveness, mental preparedness, internal locus of control and responsibility) between simulation settings.	none	1; 2a; 2b; 3; 4a	QI	Summarized in figure 1. Both in situ and lab simulations increased personal strength measures equally. Impact of intervention across all Kirkpatrick levels: Participants highly satisfied, improved knowledge and skills, changed behaviors, clinical outcomes, and organizational practices.	Effective strategies: 1. Doctor-nurse ratio ≤ 1:5 (nurses had greater training needs; prone to stress) 2. Prioritize training for high-risk areas 3. Use parallel modes of simulation (in-situ and lab-based simulation) 4. Offer quotas for observers to maximize training capacity 5. Align with most up-to-date guidelines of infection control	Workforce can adapt in times of crisis. Simulation has shown promising evidence for infection control, enhanced skills and knowledge acquisition and personal strengths, leading to satisfactory clinical and organizational outcomes.
Chow et al.	The Next Pandemic: Supporting COVID-19 Frontline Doctors Through Film Discussion	Sept-ember	Mixed	Residents, non-trainee medical officers; n=63	Pediatrics	Asia	Academic hospital	Well-being / mental health / learner support	Educate and provide support to front line doctors in training	Film screening (e.g., documentary about SARS pandemic) followed by discussion with facilitators, limited to 12 students. Students queried about impact of film in relation to current COVID-19 pandemic (e.g., How has COVID-19 impacted on your personal life? How do you feel about the publics' response?)	6 faculty members, 2 facilitators for each session, Netflix, projector, 1-hour discussion per session	1	ND	Session appreciated by participants. Participants reflected on a variety of areas including preparedness, blame, impact on HCW and the public.	ND	Medical humanities have a role in providing education and support for HCWs in a pandemic. Session generated reflective discussion and potentially personal growth.
Clemmons et al.	Building Up While Shutting Down: An Academic Health System Educational Response to the COVID-19 Pandemic	August	UME	Medical students; n=347	N/A	USA	University	Pivot to online learning (synchronous, asynchronous)	Provide training on the pandemic (i.e., alternative learning experiences) during the suspension of clinical activities to support safety	A pandemic course was created focused on basic, clinical and health systems science, public health, and health equity related to COVID-19. Students completed 3 learning events and associated study per day, including a variety of media (e.g., faculty recorded lectures, narrated PowerPoints, educational videos), reading materials, and select live sessions on Zoom. Exams were done online, flexible in time and location.	Rapid development over 2 weeks. No details but appears to use readily available resources.	1, 2a, 2b	ND	Exam 1 scores ranged from 79% - 100%. Exam 2 scores ranged from 84% - 100%. Students appreciated the monumental effort involved to create and curate educational content in such a short amount of time. High yield basic science information, and lectures related to the scientific underpinnings of the COVID-19 pandemic received the highest evaluations.	Difficult to create a curriculum with evolving and rapidly changing information.	This course integrated basic and clinical science with the larger context of health equity, physician mental health, and community response beyond the clinical environment. This offers an important opportunity to prepare well-rounded future physicians.
Co & Chu	Distant surgical teaching during COVID-19 - A pilot study on final year medical students	June	UME	Final (6^{th}) year medical students; n = 30	General Surgery	Asia	University	Pivot to online learning (synchronous)	Implement remote learning strategies to teach basic surgical skills (e.g., knot tying)	Students (who had previously undergone in-person surgical skills training) attended an identical web-based surgical skills training. Instructor utilized two cameras - one for close-up and another for video conferencing. Students had computer set up to optimize visualization of their hands for instructor assessment with feedback.	Camera, laptop, dedicated space for lab session, training session for faculty utilizing conferencing software and technologies to optimize visualization and assessment	1, 2b	ND	Most students indicated web-based surgical skill learning was clear and easy to follow with similar knowledge acquisition for instrumental knot tying. Comparative outcomes (in-person vs. web-based): Instrumental knot tying - 73.4% felt similar difficulty; Hand knot tying - 36.7% found web-based learning more difficult.	Positioning of close-up camera focused on instructors' hands can facilitate demonstration (making sure camera is behind instructor as to not create extra burden for students to mirror hand placement). Students in remote learning environments need to have safety issues of sharps disposal addressed	Web-based surgical training can allow for interactive sessions with immediate feedback for student acquisition of basic surgical skills.

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Coiado et al.	How COVID-19 Transformed Problem-Based Learning at Carle Illinois College of Medicine	August	UME	Medical students	N/A	USA	University	Pivot to online learning (synchronous)	Restructure problem-based learning small group session curriculum for remote learning environments	Online Zoom platform utilized for problem-based learning. All participants shared videos, facilitating case discussion. Various virtual whiteboards were used (e.g., Zoom, Google docs) to document key aspects of the case and discussion.	AV tech required to facilitate sharing of documents with small group via screen share.	2b	ND	Subjective comparative outcomes (in-person vs. online PBL sessions, no reported use of scales): Students generate and research learning issues in a similar degree. Student engagement is similar.	Online sessions take more time than in-person sessions, as time is needed to pause and allow adequate time for individual speakers. There is an increased risk of student distraction due to easy access of online sites. Remote structuring may lead to more passive participation.	Successful adaptive innovation from in-person to online PBL curriculum. Could be utilized as a supplement to in-person learning in the future (allowing guest speakers).
Collado-Boira et al.	The COVID-19 outbreak-An empirical phenomenological study on perceptions and psychosocial considerations surrounding the immediate incorporation of final-year Spanish nursing and medical students into the health system	June	UME	Final year medical and nursing students; n=62	Multi-professional	Europe	University	Clinical service reconfiguration	Address a critical healthcare provider shortage in Spain, to support a health system on the verge of collapse due to COVID-19, by authorizing early graduation and non-registered practice, in a controlled work situation supervised by experts	Early graduation and practice were explored using a phenomenological, qualitative approach, to understand the lived experience of final year nursing and medical students. Convenience sampling was used. A semi-structured interview was conducted. Data was analyzed to identify interrelated themes and insights.	ND	1; 2a	Helped fulfill critical staffing shortage	Students described reaction and attitudes, notably fears (concern of getting infected, health system disorganization, lack of PPE, feeling unprepared to cope with difficult situations (e.g., end-of-life care)).	Understanding experiences of novice health professionals responding to critical workforce shortages in a pandemic is critical for future contingency planning to prevent problems in the providers' performance.	Despite the threats posed by COVID-19, students were willing to accept the government appeal due to social commitment, vocation, and professional ethics. This study will help to detect student learning deficits, which will allow universities to better optimize the curriculum in order to ensure their success in future crises.
Conrad et al.	Preparing for the SARS-CoV-2 pandemic: creation and implementation of new recommendations	July	CME	Consultants, interns, and nurses	Anes-thesiology	Europe	Academic hospital	Simulation (training for treating patients with COVID-19)	Develop simulation-based training sessions for anesthesia procedures	Comprehensive in-situ training sessions and new posters (figure 1) were developed and deployed with new standardized operating procedures for induction / endotracheal intubation / difficult airways with appropriate PPE.	Requires high level of staffing and time.	4a	Policy change, kits, protocols; lots of QI	Transfer of new procedures into organizational practice; determined need for separate induction / extubation and intraoperative teams to minimize exposure; to date no COVID transmission has occurred.	Helpful to have relationship with their infection control department.	Performing extensive simulation trainings is beneficial. The success of implementation depends on staff acceptance.
Daly Guris et al.	Just-in-Time Simulation to Guide Workflow Design for Coronavirus Disease 2019 Difficult Airway Management	May	CME	ICU doctors, nurses, respiratory therapists; n=4	Multi-professional	USA	Academic hospital	Simulation (training for treating patients with COVID-19)	Design simulation training for treating patients with COVID-19	Tabletop and in situ simulations: exercises increased in complexity, progressing to intubation wearing PPE, with activation of the difficult airway team (Appendix A)	none	ND	QI: Identification of potential patient care and system failure points in managing the unanticipated difficult airway.	Key points for system improvement were identified through the difficult airway simulation debrief. Clinical management of an actual COVID-19 patient with difficult airway demonstrated very similar success and anticipated failure points.	See Table 1. Communication was difficult due to noise of PAPR. Led to creation of patient-specific airway contingency planning bundle.	"We suggest a framework of systems-based process improvements in preparing for situations where the risk of failure is incredibly high to both patients and clinicians alike."
Day et al.	Virtual Interviews for Surgical Training Program Applicants During COVID-19: Lessons Learned and Recommendations	August	GME	Fellows	Surgical oncology	USA	Academic hospital	Interviews (selection to residency)	Develop program to interview trainees virtually	Surgical fellowship interviews were conducted in an on-line environment with faculty and current fellows support and involvement. Pre-interview day modified from typical dinner / drinks. On interview day, applicants moved from room to room on Web X platform, while interviewers stayed in the same physical room.	Web X	1	ND	Pre-interview group activities: current fellows 8.33/10, applicants 8.86/10. Interviews: interviewers 8.3/10, applicants 9.2/10. No applicant preferred virtual interviews to in-person interviews, but several stated they would not have a preference given a choice."	2 interviewers interviewing together in the same room can present social distancing challenges; important to involve stakeholders	"Careful attention to the challenges and opportunities of virtual interviews, including those in the technology, process flow, interviewer and team safety communication, interpersonal, and social domains, can result in rapid implementation of a successful virtual interview experience"
Dennis et al.	Knowing Your Team: Rapid Assessment of Residents and Fellows for Effective Horizontal Care Delivery in Emergency Events	June	GME	Residents and fellows; n=1053	Multi-disciplinary	USA	National organization	Clinical service reconfiguration	Design a categorization schema (Table 1) of patient care skill sets to efficiently facilitate *horizontal care delivery* (a comprehensive, institution-wide approach to mobilize the existing trainee workforce to meet immediate needs)	Residents and fellows were broadly categorized by core specialty area and by clinical skill level to aid in horizontal deployment. This was implemented locally at Vanderbilt University Medical Center and disseminated nationally in the form of the COVID Staffing Project - a multi-institutional collaborative to implement the categorization schema across various GME supported programs.	Trainee Pandemic Role Allocation Tool (TPRAT) - Downloadable tool which automated the organization of trainee into COVID-19 clinical roles based on their specialty and year of training	ND	QI / creation of staffing call schedule. At least 2 other institutions adapted the original model. Several changes to TPRAT have been made based on received feedback.	This model for horizontal deployment of trainees during a variety of emergency situations was acceptable during the COVID-19 pandemic at 1 institution. With multi-institutional input, the instrument was refined and developed into a COVID-19 specific tool (the TPRAT) for categorizing trainee specialties, with broad interest nationally.	"The categorization scheme broadly classifies residents and fellows into only 4 categories and may not reflect the exact needs of a specific disaster response. For example, the relative lack of emphasis on surgical services during a COVID-19 pandemic response plan would not align with needs following a mass shooting, and thus each disaster may require customization."	Trainees should always be in the most relevant educational and clinical roles possible, with the goal of maximizing learning and contribution during a disasters. This classification scheme for residents and fellows, developed initially for one large institution, was disseminated nationally and further refined during the COVID-19 pandemic. The deployment tool appears feasible and widely acceptable and may be scalable to institutions of varying sizes.

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Dharamsi et al.	Enhancing departmental preparedness for COVID-19 using rapid-cycle in-situ simulation	June	CME	Care providers; n=36 participated, 20 observed	Emergency Medicine	Canada	Academic hospital	Simulation (training for treating patients with COVID-19)	Develop a rapid-cycle in-situ simulation program facilitating identification and resolution of systems-based safety threats	In-situ simulation involving a possible COVID-19 case in respiratory failure, using a mannequin modified to aerosolize phosphorescent secretions, followed by 15-min debriefing. One session / week conducted with staff on shift.	Modified mannequin, phosphorescent moulage, simulation training team (three physician simulationists, a simulation education specialist, nurse educators and managers)	1; 4a.	QI (identified safety threats and iterated solutions), departmental policy change	97% of participants agreed that the simulation was relevant to their practice, and 94% felt more prepared to care for a potential case of COVID-19. Safety threats addressed.	Repeat iterations allowed for quick addressing of issues with PPE and other logistical challenges of caring for COVID-19 patients.	"Rapid-cycle in-situ simulation program provides opportunities to identify and address issues in caring for patients with possible COVID-19 in time-sensitive fashion."
Díaz-Guio et al.	Cognitive load and performance of health care professionals in donning and doffing PPE before and after a simulation-based educational intervention and its implications during the COVID-19 pandemic for biosafety	June	CME	Physicians, nurses, respiratory therapists n=61	Multi-professional and Multi-disciplinary	South America	Academic hospital	Simulation (training for treating patients with COVID-19)	Create simulations for donning and doffing PPE aimed at minimizing provider cognitive load after training	A 2-scenario in-situ simulation for donning and doffing PPE in the ED and ICU was created. Assessment of cognitive load was conducted using a 9-point Paas scale, and a checklist was used to assess PPE use before and after the intervention.	ND	2b, 3	Reduction in cognitive load and errors	"In the post-test, 100% of participants were successful in donning the PPE and 94.8% in doffing; only 9.8% were contaminated. The mean of the cognitive load was low (4.1±1.4 points), and the performance was high (7.9±1.1)."	"…donning and doffing PPE is critical and may be changed significantly by active training with clinical simulation in terms of performance and decreased cognitive load."	"Donning and doffing of PPE generate high cognitive load, teams training in high fidelity clinical simulation minimizes the load and increases performance. We recommended assisted donning and doffing, strictly following the checklists."
Diaz & Dawson	Use of simulation to develop a COVID-19 resuscitation process in a pediatric emergency department	August	Mixed	Pediatric ED staff; n=66	Emergency Medicine	USA	Academic hospital	Simulation (training for treating patients with COVID-19)	Develop a COVID-19 resuscitation simulation to prepare pediatric ED staff	Immersive simulations conducted focused on the physical space, staffing and flow, personnel safety, patient safety, the value of clear closed loop communication and American Heart Association COVID-19 resuscitation guidelines. Deliberate practice with facilitated feedback and reflection on performance.	14 hours of training simulations	2a; 2b	System testing and process improvements	"The feedback is universal increased comfort with our new space, increased understanding of needed infection prevention and control, measures surrounding COVID-19 resuscitations, improved under- standing of AHA COVID-19 recommendations, and increased confidence in resuscitating a COVID-19 pediatric patient."	"Simulation-based education optimizes the efficiency of learning at the individual and team levels by guiding participants through goal-oriented reflections in safe, encouraging, collaborative environments. Simulation may help decrease cognitive load. Simulation may mitigate errors by increasing individual and team comfort, performance and confidence."	Simulation allowed us to understand barriers within our current space and helped us develop and refine a new process that would allow us to effectively resuscitate pediatric COVID-19 patients while minimizing personnel risks. And we used simulation to educate staff about our new space, processes, and workflows.
Domen et al.	The APPCN multisite didactic initiative: Development, benefits, and challenges	July	Mixed	Neuropsychology faculty, fellows, students; n=521-715	Neuro-psychology	Inter-national	National organization of postdoctoral programs in neuro-psychology	Pivot to online learning (synchronous, asynchronous)	Provide didactic activities to trainees of member programs potentially having difficulty providing normal training activities and facilitate a sense of community during a time of social isolation.	A multi-site didactic curriculum was developed and implemented. Synchronous sessions were delivered live on Zoom. A calendar of live events was created and posted. Materials and resources were placed in an online repository for asynchronous learning. A post implementation electronic survey was initiated to assess the program.	Zoom enterprise subscription necessary to accommodate large number of learners; Calendar on Microsoft Teams; Box used as repository for didactic materials	1; 2b	Anxiety and stress during the pandemic were assessed along with community sense by participating in the MDI	79% endorsed that participation in MDI activities was beneficial. Table 3 (increased knowledge, increased sense of community, reduced isolation and anxiety).	Barriers to participation included not having time, difficulty accessing didactic information, and not knowing about the MDI. Trainees at nonparticipating sites reported greater anxiety than trainees at participating sites.	A multi-site didactics initiative can be planned and implemented at short notice. Well received by trainees and gives a sense of community. Facilitates learning, particularly in smaller programs.
Dow et al.	GP Live'- recorded General Practice consultations as a learning tool for junior medical students faced with the COVID-19 pandemic restrictions	August	UME	1st year medical students; n=230	Internal medicine	Europe	University	Pivot to online learning (synchronous, asynchronous)	Deliver authentic GP consultations to medical students while there are restrictions on face-to-face contact	Real GP consultations recorded by GP with patient consent. Range of recordings selected for variety. Recording viewed by students in small group sessions (max 9) with GP tutor to facilitate discussion.	iPad + free standing microphone for recording, Panopto Video Platform, secure university server, team to review and make final selection of recordings, GP tutor per every 9 students	1; 2a; 2b	ND	93% either agree or strongly agree that is was a valuable learning experience. Student focus groups revealed changes in attitudes and learning - “applied learning; progression of skills; realistic medicine; approach to complexity and appreciation for GPs adaptability”	Issues with sound quality due to microphone positioning were main negative	Using technology can help us teach, particularly now during pandemic. Advise others to try recording GP consultations.
Dubé et al.	COVID-19 pandemic preparation: using simulation for systems-based learning to prepare the largest healthcare workforce and system in Canada	August	CME	Healthcare providers; n~30,000	Multi-professional and Multi-disciplinary	Canada	Academic hospital	Simulation (training for treating patients with COVID-19)	Use a centralized simulation response team to address simulation needs across a significant geographic area	Alberta Health Service's eSIM COVID-19 response team developed a robust simulation curriculum and operationalized a coordinated response to simulation needs. Curriculum included simulation scenarios, prebriefing scripts, debriefing tools, cognitive aids, “how-to” guides and shared webinars. Three methods were used surge planning and tabletop debriefing; process walkthrough and environmental scans; rapid cycle simulation and debriefing.	10 days to develop simulations. Team mobilized over 5 weeks, organized simulation request intake system, developed training materials; no description of cost	4a	AHS system policy/procedure change based on provincial outcomes	Well over 2500 systems issues have been proactively identified and mitigated through > 400 simulation sessions. Nine themes deemed highest frequency and highest impact noted across province - listed in table 3.	Centralized approach beneficial	"Not all health authorities have opportunities to coordinate or operationally support a centralized team; we recommend the explicit effort of simulation programs to align with other programs in meaningful ways to analyze and share emerging data in real-time to support validation for broader sharing and scalability when possible."

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Duggan et al.	Staying Afloat in the COVID-19 Storm: GERIAtrics Fellows Learning Online And Together (GERI-A-FLOAT)	July	GME	Geriatric fellows	Internal Medicine	USA	Collaboration of geriatric fellows	Pivot to online learning (synchronous)	Utilize a virtual platform to teach about geriatric medicine	"GERI-A-FLOAT is a weekly, 1-hour educational series utilizing a virtual platform (Zoom) to deepen knowledge of geriatric medicine and bring together fellows from across the country for networking." Uses a variety of instructional methods: flipped classroom, interactive lectures, workshops, and smaller breakout discussions.	ND	1; 2a	ND	"Although survey response rates were low…sessions were rated highly, and 100% of respondents noted intent to change resulting from the session"	Twitter ideal for widespread collaboration; weekly videoconferences facilitate inter-institutional collaborations; mastering Zoom is feasible; low administrative burden and high impact of crowdsourcing education; practical platform for virtual posters.	"GERI-A-FLOAT was well received by participants, expanding fellows' clinical exposure and learning while lifting some of the burden from educators to urgently design de novo curricula related to caring for vulnerable adults during the pandemic."
Durfee et al.	Medical Student Education Roadblock Due to COVID-19: Virtual Radiology Core Clerkship to the Rescue	July	UME	Clinical medical students; n=111	Radiology	USA	Academic hospitals	Pivot to online learning (synchronous)	Design a virtual radiology core clerkship to allow continued learning during the cessation of clinical activities	4-week virtual Radiology Core Clerkship based on Alliance of Medical Student Educators in Radiology (AMSER). Included 19 Aquifer Modules, didactics via Zoom, and two online exams. 12 virtual homerooms formed (8-10 students each) with one flipped classroom workshop per day and second session focused on unknown case conference.	Large number of dedicated faculty (facilitation of a total of 432 small group sessions + didactics). Administrative support for scheduling of multiple sessions and coordination.	1; 2b	ND	84% rated course as excellent. 95% rated structural organization excellent or good and felt the content enabled them to master core knowledge in radiology. Major strengths were the small group sessions, quality of teaching, and cohesive content with clinical relevance. Final Exam scores were similar to in-person clerkship.	Speaker notes for small group sessions allowed uniform coverage of content across many facilitators. Providing continuity by assigning consistent faculty/point people for small group sessions provides a sense of community for students. Shortening lectures to 1 hour may help facilitate student retention of learning material.	Successful endeavor, providing an opportunity for students to complete a graduation requirement and, per performance on final exam, achieved appropriate mastery of learning material when compared to previous results from in-person clerkships.
Elledge et al.	Maxillofacial education in the time of COVID-19: the West Midlands experience	July	GME	Maxillo-facial surgery trainees; n=15	Oral maxillo-facial surgery	Europe	Collaboration of maxillofacial surgeons	Pivot to online learning (synchronous)	Implement a robust online learning program with built in quality assurance from trainer and trainee feedback	Weekly webinars by Zoom on topics related to maxillofacial surgery. Polling by Kahoot or Socrative by Master Connect. Surveys and focus groups used for feedback	ND	1; 2b	ND	93% - 97% positive responses regarding content and trainer delivery. Self-reported learning improvement across all program content.	Key themes included pragmatics of delivering online education, issues surrounding trainer interactivity in the virtual world, and a desire for case-based content and pre-learning of information (the "flipped classroom").	A weekly webinar is well received and generated themes from focus groups that will inform future programs
Eusuf et al.	Maintaining education and professional development for anesthesia trainees during the COVID-19 pandemic: the Self-isolAting Virtual Education (SAVEd) project	August	GME	Anesthesia trainees	Anes-thesiology	Europe	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Ensure continued education of anesthesia trainees in self-isolation	The Self-isolAting Virtual Education (SAVEd) project was created by self-isolating anesthesia trainees. Consisted of 80 pre-recorded and 24 live tutorials on Zoom. Resources were promoted through e-mail, social media, and by sharing resources with other deaneries. Impact was assessed by usage statistics on social media.	None reported apart from live videoconferencing by zoom.	1; 2b	Usage statistics on social media and websites.	Median scores for quality of content, presentation of material and usefulness compared with traditional tutorials of 5, 5, and 5. MCQ scores were higher post-tutorial than pre-tutorial in sessions where they were administered.	Benefits include less time spent travelling and the ability to access learning more flexibly. Disadvantages included the loss of social contact between trainees and less interaction between attendees and facilitators.	Self-isolating trainees project for virtual education was well received and improved knowledge in anesthesia trainees
Evans et al.	Use of whole slide imaging (WSI) for distance teaching	July	GME	Pathology residents; n=15	Pathology	Inter-national	University	Pivot to online learning (synchronous, asynchronous)	Provide distance teaching in pathology and address practicalities of setting up remote teaching	Virtual teaching using a digitalized slide set, image repository sharing, and videoconferencing was conducted by pathologists in Canada for trainees in Jamaica. Each teaching session consists of 5-7 cases grouped by subspecialty. Residents download the slides and discuss with the teachers as a group; The impact was evaluated by survey.	Zoom, Google hangouts, Microsoft Teams. File sharing and pathpresenter (can limit file sizes).	1	ND	Teachers felt that teaching was not hampered by the 'virtual' engagement and supported the virtual teaching. Technical issues were dealt with iteratively. The residents were very supportive and enthusiastic in embracing this mode of teaching, though noted limitations (Table 1).	Technical issues surmounted by iteration and by choosing alternative devices/technology	Virtual digitalized learning using Whole slide imaging in pathology is here to stay.
Favier et al.	Percutaneous tracheostomy simulation training for ENT physicians in the treatment of COVID-19-positive patients	June	CME	ENT physicians n=14	Oto-laryngology (ENT)	Europe	Academic hospital	Simulation (training for treating patients with COVID-19)	Provide training for ENT physicians in the performance of percutaneous tracheostomy in COVID-19 patients to free up ICU providers	3-hour module (Figure 1), with several simulation scenarios of increasing difficulty. Consists of briefing video, familiarization with tracheostomy kits, practice on low-tech simulator, PPE donning, completion of high-fidelity mannequin scenarios, debriefing and PPE doffing	Uses a high-tech SimMan mannequin and a low-tech procedural simulator.	1; 2a; 2b	ND	Learning assessed by checklist, errors identified; Appendix 2 contains learner reaction, changes in confidence and learning outcomes by self-assessment and faculty assessor (with entrustment designations)	Found that anatomy in mannequins was poor substitute to real patient, so introduced low fidelity "pre-training step"; found that groups who experienced low-tech sim first had fewer procedural errors/complications.	The training developed in this paper "seems suited for training ENT physicians."
Flotte et al.	Accelerated Graduation and the Deployment of New Physicians During the COVID-19 Pandemic	June	UME	4th year medical students; n=57	N/A	USA	University	Clinical service re-configuration	Supplement the healthcare work force in the COVID-19 pandemic by allowing early graduation and limited-licensing to practice as physicians	A review board was convened to assess whether final year medical students had satisfied the program requirements and competencies needed to complete the MD qualification. Early graduation was conducted via an online platform. Students were offered limited-licensing as physicians for 90 days on a completely voluntary basis in order to assist in the COVID-19 response.	ND	1; 4b	ND	Thus far, very positive experiences have been reported back regarding the limited licensing of these early graduates. The assistance of these early graduates has allowed for the care of a high volume of patients with rapid turnover, despite the increased acuity. The graduates themselves have found the experience gratifying whilst gaining valuable perspectives on the effects of the pandemic of medical practice.	ND	"Successfully graduated 4th year students early and deployed these graduates to patient care teams to address the surge in COVID-19 patients. These newly graduated physicians were able to make immediate positive impact on patient care, whilst decreasing the workload for residents and faculty physicians."

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Gallardo et al.	Home Program for Acquisition and Maintenance of Microsurgical Skills During the Coronavirus Disease 2019 Outbreak	July	GME	Neuro-surgery residents; n=5	Neuro-surgery	South America	Academic hospital	Other; home-based learning	Introduce a model of training for acquiring and maintaining microsurgical skills at home	Training skill program for training at home using low cost affordable materials including a smart phone, a shoe box, and a set of surgical instruments. Training exercises performed once a day, 3 times a week, for 4 weeks with the dominant and non-dominant hand. Skills evaluation conducted via video.	Affordable materials, smart phone.	1; 2b	ND	Significant improvement in performance with the dominant and the non-dominant hand, pre-post. All participants were satisfied or very satisfied with the learning objectives, material availability, exercises performed, flexibility, and the training overall.	ND	A microsurgical training program at home using low cost materials is feasible and effective in improving skills and satisfaction.
Garg et al.	Rapid transition of a preclinical health systems science and social justice course to remote learning in the time of coronavirus	August	UME	1st year medical students; n =155	N/A	USA	University	Pivot to online learning (synchronous, asynchronous)	Transition a 3-week health systems science and social justice course online due to cessation of in-person teaching	Health systems science course consisting of asynchronous self-directed learning modules and synchronous, interactive didactic sessions. New content was developed to reflect systemic issues highlighted by the COVID-19 pandemic. Closed-book, short essay exam given online at end of course.	Technology team executed time-intensive technology testing, including meetings with each faculty member prior to sessions to troubleshoot accordingly. Technology availability had to be ensured for both faculty and students for successful implementation.	1; 2b	ND	Final exam essay performance similar to prior years. Mixed reviews of independent learning modules, request for more engagement with faculty. Satisfaction improved over prior years (3.6/5 rating).	Chat function allowed for the sharing of related references and knowledge between students, enhancing engagement with learning material. Students can be encouraged to work more with others. Topics of social justice require extra support for both students and faculty in order to fully explore in-depth and emotional topics in a safe learning environment.	New multimodal methods implemented for the education of students in topics of social justice for remote learning was successful and also was time efficient.
Geha & Dhaliwal	Pilot virtual clerkship curriculum during the COVID-19 pandemic: Podcasts, peers and problem-solving	May	UME	Clerkship medical students; n=6	Internal Medicine	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Convert in-person clerkship experiences to remote learning experiences mid-rotation	Twice-daily interactive remote sessions were implemented with pre-assigned medical podcasts and worksheets for students to complete. Students submitted diagnostic schema and assessments for 11 assigned cases, 2 of which required student collaboration. Oral presentations were submitted for 3 cases with feedback. 30-60 minute "rounds" were held each morning.	Increased faculty time to gain familiarity with technology and to set up learning communities	1; 2b	ND	Satisfaction high with drafting schemas (5.0), writing diagnostic assessments (4.83), oral presentations (4.83), and podcasts (5.0); case conferences were rated lower (4.0). Most students reported positive impressions of the virtual clerkship, including increased feedback from faculty on presentations, better co-learning among students, and satisfactory knowledge.	Increased faculty time will be needed in order to foster a remote learning community, requiring recruitment of additional faculty. Shared schedules, collaborations, and video participation were essential for community building.	Engagement of peers, patients, and teachers in a virtual learning environment can provide students with communication skill sets required of physicians.
Gomez et al.	Innovation Born in Isolation: Rapid Transformation of an In-Person Medical Student Radiology Elective to a Remote Learning Experience During the COVID-19 Pandemic	June	UME	2nd, 3rd and 4th year medical students; n=116	Radiology	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Adapt in-person diagnostic radiology elective to entirely online learning experience during pause in clinical rotations	3-week remote diagnostic radiology elective with synchronous and asynchronous didactics and interactive case review workshops using secure picture archiving communication system (PACS). Learner engagement promoted through Nearpod interactive polling, Microsoft Forms, quiz-bowls, Jeopardy sessions, journal club discussion board, required assignments and online quizzes for formative assessment. Open-book online summative assessment.	Zoom; Faculty tutorials on utilizing Zoom videoconferencing; Faculty training sessions for testing of software. VPNs, Pacsbin (HIPAA compliant collection of images), Nearpod platform, Microsoft Teams, Blackboard.	1; 2b	ND	100% passed the final exam. Positive reviews of online elective (strengths: Pacsbin workshops, interactive resident-led case sessions). Faculty comfortable with remote teaching and most agree or strongly agree that they have tools/resources necessary for conversion of lecture material to video format. Faculty pleased with flexibility of schedule and ability to work from home.	In-person didactics should be limited. Pre and post formative assessments for lecture material may help long-term retention of material. Enhanced utilization of audience response system, smaller class size, and access to computers with cameras may be helpful to promote a more positive learning environment.	Implementation of remote course shows that with the proper tools, interactive and engaging teaching is achievable even without in-person teaching.
Goncalves et al.	COVID-19: UCT-Africa Virtual ENT transcends academic silos through videoconferencing academic meetings and ward rounds	June	Mixed	Medical officers, registrars, fellows and consultants; n=175	Oto-laryngology	Africa	Collaboration of oto-laryngology (ENT) surgeons	Pivot to online learning (synchronous)	Cut across academic silos, promote institutional collaboration, and maintain educational goals	Academic presentations and academic ward rounds hosted on Zoom made open access to all ENT departments in Africa. Recorded versions of sessions also made available.	Zoom	1	ND	Positive learner reactions: 97% reported learning on virtual platform beneficial, 87% would like to contribute material, 67% felt virtual platforms could replace physical meetings, 97% agreed platform was sustainable post pandemic	ND	Ways in which scientific learning and networking occurs may change drastically in long term and there are opportunities for cross institutional collaboration.
Gulati et al.	Instagram for peer teaching: opportunity and challenge	August	UME	Medical students; n= >123	N/A	Europe	University	Assessment	Support students while clinical placement suspended	Two 4th year medical students created "Instagram Stories", a series of multiple-choice questions (MCQs) or daily quizzes on a variety of generalist topics posted to Instagram. Each MCQ consisted of a short clinical vignetter and 4 answer options with explanations provided. > 300 questions posted over 3 months.	Instagram	1	ND	Respondents found project relevant to learning: ‘helped to consolidate learning’, ‘question bank was extremely relevant and thought-provoking.’	Longer posts had substantially less engagement; the ‘quiz function’ was only available for 24 hours; and information on the platform may lack accuracy, particularly with a peer-to-peer approach. Incorporated ethnicity and health MCQs that were well received.	"Instagram is an underutilized platform for delivering medical education and is particularly well-suited for providing MCQs for revision purposes. The peer-to- peer approach allowed them to gain teaching experience early on in their career and made learning relevant"

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Gupta et al.	Innovative anatomy assessment methods in COVID-19 pandemic: Statistical observations and students' viewpoints	July	UME	1st year medical students; n=250	Anatomy	Asia	University	Assessment	Compare 3 different assessment methods, to create a standard operating procedure for gross anatomy assessment	Students given the option to take their assessment via Viz telephonic interview, WhatsApp video call, or Zoom. 10 questions from a common pool used by each examiner. Specimens and AV carefully arranged. Assessment took 15 minutes for each student.	Viz, WhatsApp, Zoom	2b	ND	The interview platform used by students for the anatomy examination had no significant impact on obtained scores. Students preferred Viz telephonic app to video based platforms.	Need a common set of questions to eliminate interviewer bias, choice of application was impacted by access to internet	Assessors and students both need to adapt to paradigm changes. Student feedback will tailor the assessment tool by refining validity, consistency, reliability and interaction dynamics of assessment designs.
Hannon et al.	An objective structured clinical examination: From examination room to Zoom breakout room	May	UME	Clerkship medical students; n=49	N/A	USA	Academic hospital	Assessment	Evaluate if virtual OSCEs could be effective	Remote OSCE administered on Zoom. Assessed history taking, communication skills, clinical reasoning, clinical testing and documentation. PE maneuvers were verbalized but could not be adequately assessed. 1 OSCE per day and 4-6 students per round. Students received training prior to the OSCE with regards to technology.	Zoom, Qualtrics, SPs; cost savings due to not using clinical skills center or staff	1	ND	Students felt the narrative physical examination flow was awkward and 53% of students thought the remote OSCE was not as good as in-person but adequate for assessing clinical skills. Students and SPs appreciated the OSCE.	Hard to assess the PE, transitioned from must pass to must complete	Virtual OSCEs were good at assessing hx, communication and clinical reasoning, but hard to assess PE.
Hodgson & Hagan	Medical education adaptations during a pandemic: Transitioning to virtual student support	April	UME	Medical students	N/A	Europe	University	Well-being / mental health / learner support	Provide pastoral care in a non-face-to face, socially distanced manner, to assist students struggling with social isolation / coping with uncertainty	Personal tutors providing pastoral care to reduce social isolation and anxiety. Tutors connected with students in their tutor group via Microsoft Teams on 1:1 video calls and via the group chat function.	Microsoft Teams, personal tutors, 4G smartphone or laptop, internet connectivity	1	ND	Well received by students and faculty; Video calls better received than audio; People enjoyed the group chat	Provided relief - seeing people valued; some students limited by poor internet connectivity or lack of access to computer/smartphone. Hardship funds available.	Predict increasing use of virtual student support.
Huang et al.	Primary Care Mock Codes During a Pandemic: Interprofessional Team-Based Emergency Education While Maintaining Social Distance	May	CME	Medical assistants, nurses, physicians, NPs, phlebotomists n=72	Pediatrics	USA	Academic hospital	Pivot to online learning (synchronous)	Educate staff about medical emergencies while practicing social distancing	Virtual interprofessional mock codes conducted. 1 facilitator and 5 participants per 35-minute session. Material emailed in advance. Team collaborates via videoconference to manage pediatric emergency (e.g., a seizure), assessing the child, reviewing protocols, and assigning team roles. Followed by debrief.	ND	1, 2b	ND	96.4% agreed met learning objectives, 97.3% liked the virtual learning opportunity, 97.3% reported two key learning points.	Smaller group training improves participation by all team members.	Simulated pediatric emergencies in a virtual format were feasible and met the intended learning objectives.
Huffman et al.	Fellows Front and Center: Tele-Training and Telehealth	May	GME	Fellows; n=101	Pediatrics	USA	Academic hospital	Telehealth	Train and supervise trainees using telehealth	Fellow conducted telehealth visits with faculty observing. Used pre-brief for coordination, as well as de-brief sessions post-encounter.	Telehealth platform	1	ND	Total number of patient contacts maintained. Pros: 1. more observational supervision 2. real time confidential feedback; 3 adaptability skills. Faculty thought there were disadvantages (e.g., lost autonomy, heightened scrutiny), fellows did not. Fellows found being able to see patient in their home environment advantageous.	Multiparty functionality on telehealth platform was an issue	Continue telehealth in clinical care and training
Iqbal et al.	Telegram as a Tool to Supplement Online Medical Education During COVID-19 Crisis	June	UME	Medical students; n=203	N/A	Middle East	University	Other	Explore the impact of Telegram, a cloud-based messaging and file sharing application, on medical student education	Telegram is a free, cloud-based messaging application capable of being used on both smartphones and desktops (www.telegram.com). It allows users to create groups and channels, facilitating the sharing of files of multiple formats, including PowerPoint presentations, audios/videos, PDFs, and Word documents.	Telegram application	1	ND	Benefits include ease of access to educational resources; unlimited sharing capacity (no limits on group size or file size); easy communication with colleagues and class leaders; engagement with teachers promotes wellbeing; security of messages.	Downsides: can be distracting, interface complex to use, information overload. Resource sharing was found to be valuable.	Telegram offers more functionality and fewer drawbacks than other Apps and allows users to take responsibility for their own learning.
Jack et al.	Live-Streaming Surgery for Medical Student Education - Educational Solutions in Neurosurgery During the COVID-19 Pandemic	July	Mixed	Clinical medical students and residents; n=6	Neuro-surgery	USA	Academic hospital	Pivot to online learning (synchronous)	Leverage technology to ensure ongoing surgical education when in-person activities are limited	Livestreaming of neurosurgical procedures conducted using secure Zoom. Multiple video channels used, including operation views, microscope views, and neuronavigational views. Audio was transmitted via Bluetooth headset (worn by primary neurosurgeon) or speaker (for access to entire OR team) for real-time 2-way communication between learners and surgical team.	Technologic resources include: Laptop for transmission of audio/video, HDMI splitter to receive multiple video inputs, integrated camera in overhead surgical light, GoPro, Bluetooth speaker or headset. Personnel to switch screen views, training in utilization/setup	1; 2b	ND	Survey respondents felt that the overall picture quality of live-streamed procedures was good (in-light camera) or exceptional (microscopic) with no significant delays that impacted their learning. They noted improved knowledge in neuroanatomy after viewing. Communication/interaction with surgical team was noted as exceptional	Quality of audio/video is dependent on internet speed and bandwidth for both host and viewer, advantage of direct ethernet connection. In-light camera more valuable as it was placed with appropriate level of zoom to display surgical field, in contrast to the GoPro Hero5 (limited zooming capability limits visualization). Excess cords to facilitate livestreaming may pose safety hazard.	A method of livestreaming OR cases via Zoom while allowing communication between viewers and surgeons can enhance the remote learning experience of both clinical medical students and residents.

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Jarry Trujillo et al.	Surgical training during COVID-19: a validated solution to keep on practicing	August	GME	Surgical trainees; n=24 surgical skills; n=610 COVID competencies	Multi-professional	South America	Academic hospital	Pivot to online learning (asynchronous)	Develop a validated technology-based methodology for remote skill training	A web-based mobile platform (LAAP) to train laparoscopic surgeons remotely: LAPP connects trainees to an online network of certified tutors. Trainees watch an instructional video, practice, then upload a video of exercise. Tutors provide personalized feedback. Content includes laparoscopy and other procedures, COVID-related skills (intubation, PPE, mechanical ventilation, prone positioning)	LAAP network was developed prior to pandemic and modified	2b	Health ministry has adapted the platform	Over 240 sessions assessed, and 711 feedbacks on surgical skills given. For COVID related competencies, >796 sessions assessed and >3700 feedbacks	The easy scalability means methodologies like this will soon become part of our lives. The system not only removes the need for on-site trainers but also provides much convenience and safety to both instructors and trainees.	This remote surgical teaching system can help residents keep on training during lockdown, supporting them with hundreds of expert feedbacks.
Jones et al.	Interprofessional education during the COVID-19 pandemic: finding the good in a bad situation	August	UME	Students of health professional programs; n=654	Inter-professional	USA	University	Pivot to online learning (synchronous, asynchronous)	Convert a large foundational interprofessional course to an online learning environment and evaluate impact on interprofessional competencies	25 online groups with 30 interprofessional students each + 1 facilitator enrolled into online sessions. Four discussion boards mirroring in-person content were created for each group with an additional COVID-19 discussion board for application of knowledge of interprofessional care to current scenarios. All except one discussion board (Team Final Presentation) were worked on by each individual asynchronously.	Online learning management system available for all students across different institutions. Discussion board platform and 12 facilitators to monitor online discussion.	1	ND	Majority (69.2%) indicated preference for in-person courses. Two formats roughly equivalent in content delivery, involvement, learning. Students felt slightly more connected in the online course. Positives: flexible schedule, self-pacing, time for reflection, engagement. Negatives: lack of face-to-face interaction, less connectivity, communication challenges, unclear expectations, lack of feedback	More time needs to be allocated to review pedagogy for online teaching, learning, and best practices. Enhanced communication of course requirements in a stressful time and also across a student body from various institutions was difficult.	Interprofessional learning with, from, and about health profession students can take place through an online format and students can meet core competencies of IPE in this format.
Joseph et al.	COVID-19 Pandemic-Medical Education Adaptations: the Power of Students, Staff and Technology	July	UME	Medical students; n=200	N/A	Europe	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Transition a predominantly in-person curriculum to online at one of the newest UK medical schools	Integrated, systems-based curriculum with early clinical contact delivered via multiple new modalities. Resources placed on learning management platform. Delivery included podcasts, webinars, narrated presentations, small group tutorials, asynchronous formative assessments, and synchronous large group feedback. Facilitated by collaboration on resources with other UK schools.	Canvas, Zoom, BigBlueButton, and Microsoft teams all available to staff members. Required adoption of unfamiliar technologies by faculty.	1	ND	Students prefer variety of teaching modalities, smaller interactive groups, shorter lessons (20-40 minutes).	Lab work and clinical skills teaching was not able to be effectively taught by online modality. Security of summative evaluations was challenging.	The power of technology has been fully embraced to continue providing medical education in the time of crisis. However, preclinical medicine cannot be satisfactorily delivered exclusively online in the long term.
Jumat et al.	From Trial to Implementation, Bringing Team-Based Learning Online-Duke-NUS Medical School's Response to the COVID-19 Pandemic	August	UME	Preclinical medical students n=82	N/A	Asia	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Move an entire curriculum comprised of modified TBL sessions to an online format	TBL activities were transitioned online in the Zoom platform. Students completed pre-session assignments and readiness assurance tests. Team sessions were conducted using chat box and shared online documents. In lieu of breakout rooms, a separate video conferencing session or instant messaging platform was employed based on team preferences to manage side conversations. Sessions close with large group discussion.	Robust administrative team (n =7) maintained online learning resources, granted appropriate access, conducted training sessions for platform use, and provided in-session technical support	1	ND	Students appreciated the online TBL format and found it easy to communicate with their peers.	Creating breakout rooms for 82 students in 13 teams in Zoom was cumbersome. Access to reliable internet network or internet-enabled devices was a major obstacle for all participants. Technological literacy ability was also a challenge, requiring support from a dedicated administrative team.	The preparedness of the educational leadership and dynamic work ethic of the administrative team allowed for the successful deployment of online TBL curriculum.
Juprasert et al.	Restructuring of a General Surgery Residency Program in an Epicenter of the Coronavirus Disease 2019 Pandemic: Lessons From New York City	July	GME	Surgical residents	General Surgery	USA	Academic hospital	Clinical service reconfiguration	Reassign general surgery residents and restructure surgical services to support pandemic efforts, maintain staffing for emergency surgical care, limit infection risk, and maintain surgical education	Surgery department restructured and residents redeployed to address clinical needs in 3 phases: 1) prioritize reserve pool and limit exposure; 2) condense surgical services and implement procedure team; 3) redeploy to support ICU expansion. Resident training / education transitioned to web-based lecture series. Residents mental health and well-being were attended to (e.g., CopeNYP and conferences with Psychiatry faculty to mitigate distress).	ND	ND	Enabled staffing of additional ICU beds, created surgery capacity (Figure 4)	Many changes to the structure of services were successful and enhanced critical care capacity. Formation of the procedural team was valuable to offload ICU work.	Flexible, real-time communication was necessary between program leadership, ICU directors, and the residents. It was also vital to empower those in charge of scheduling to make decisions in the best interest of the residents without going through the normal approval process. Prompt and clear dissemination of information was essential.	As surgical volume returns, will need to strike the right balance of surgical education and optimal patient care.
Kesselman et al.	Endovascular simulation as a supplemental training tool during the COVID-19 national emergency	August	GME	Interventional radiology trainees; n=6	Radiology	USA	Academic hospital	Simulation (training for treating patients with COVID-19)	Ensure endovascular procedural proficiency in context of reduced case load	Educational program consisting of didactic instruction (total 36 hours) and live procedural participation, supplemented by high fidelity endovascular simulations (~ 6 hours per trainee, limited to 3 participants at a time for social distancing).	Two VIST G5 endovascular simulation units with over 20 endovascular modules	1	ND	All respondents stated simulator use was helpful for their education	Simulators are expensive but worth the investment.	During national emergencies, compromises to interventional radiology education can be mitigated by use of novel educational tools such as high-fidelity endovascular simulators

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Khalil et al.	The sudden transition to synchronized online learning during the COVID-19 pandemic in Saudi Arabia: a qualitative study exploring medical students' perspectives	August	UME	Medical students; n = 60	N/A	Middle East	Academic hospital	Pivot to online learning (synchronous)	Explore medical student perceptions regarding the effectiveness of synchronized online learning	Virtual curriculum at Unaizah College of Medicine included lectures, case discussions, 4-box case analysis, clinical case discussions, online seminars, and dry labs (online laboratory demonstrations). This qualitative study used virtual focus groups and a discussion guide with 7 open-ended questions. Interviews were analyzed for thematic content.	ND	1	ND	Online learning may work better for content learning in some areas (like basic sciences) but less so for others (clinical skills). Recorded lectures allowed better understanding and mastery of content. Online sessions saved time and performance improved, associated with higher levels of contentment. Preferences for future: mixed (clinical and TBL skills felt to be better in person)	Technical insufficiency (poor internet connectivity and deficits in educators' basic computer skills)	Synchronized online classes were well-accepted by medical students, representing potential for the future of medical education. An organized and clear institution approach to online teaching and faculty mastery of technologic tools will facilitate adoption.
Khan & Kiani	Impact of multi-professional simulation-based training on perceptions of safety and preparedness among health workers caring for coronavirus disease 2019 patients in Pakistan	June	CME	Nurses, doctors, nursing assistants, ambulance drivers, sanitation, laundry; n=44	Multi-professional	Middle East	Academic hospital	Simulation (training for treating patients with COVID-19)	Improve health workers' perceived preparedness, safety, and willingness to care for COVID-19 through simulation	Simulation-based course including use of PPE, safety protocols, clinical procedures performed on patients by staff, sanitation procedures performed by sanitation staff, etc. Used mannequins, mock patients, and integrative classroom and practical sessions.	Mannequins, mock patients	2a	ND	Figure 1 shows changes in attitudes: Participants felt more prepared to handle tasks related to the care of COVID-19 patients and felt more strongly that those who did not complete the training were not prepared to care for COVID-19 patients. Reported less fear.	Debriefing sessions invaluable	"Multi-professional simulation-based training imparted confidence and sense of preparedness among HCW."
Krawiec & Myers	Remote Assessment of Video-Recorded Oral Presentations Centered on a Virtual Case-Based Module: A COVID-19 Feasibility Study	June	UME	3rd year medical students; n=12	Pediatrics	USA	Academic hospital	Assessment	Develop clinical skills in the absence of clinical contact using a videorecorded oral presentation assignment with formative assessment	Students videorecorded a $\leq$10-minute oral presentation of a patient they saw on their clerkship or a virtual online case. Assessed based on rubric on patient history, PE, diagnostic test results, summary statement, assessment and plan, clinical reasoning and synthesis of information, and general aspects (organization, speaking style)	Aquifer case files	2b	ND	Overall formative assessment scores of video-recorded oral presentations were 5 (mostly on target). Table 1 shows scores for individual components in the rubric.	Tool was not validated to use with virtual cases.	"This study demonstrated the possibility of remotely assessing oral presentation skills centered on virtual case-based modules using a patient presentation tool intended for non-virtual patients."
Kuo et al.	Efficacy of Vascular Virtual Medical Student Education During the COVID-19 Pandemic	Sept-ember	UME	3rd year medical students	Vascular surgery	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Create virtual electives for surgical subspecialties	Virtual Surgical Education Group (ViSEG) designed virtual electives in 8 surgical specialties, including vascular surgery. Week-long curriculum based on American College of Surgeons prerequisite competencies and USMLE content outline. 4 hours lectures daily, assigned readings of landmark vascular surgery publications, video instruction of PE and procedures. Proctored virtual skills lab offered suturing instruction with webcams for real time feedback.	Webcam, faculty mentor, skills lab materials	1; 2b	ND	Students indicate overall positive response to course and increased interest in pursuing vascular surgery as a career. Students showed improved performance after elective with significantly improved pre / post scores.	ND	Successful remote delivery of a vascular surgery curriculum to medical students can be accomplished and may serve as a vital adjunct to traditional clerkships.
Lakissian et al.	In-situ simulations for COVID-19: a safety II approach towards resilient performance	July	Mixed	attendings, residents, fellows, nurses, students, respiratory therapists n=131	Multi-disciplinary	Middle East	Academic hospital	Simulation (training for treating patients with COVID-19)	Improve the safety of patients and providers via simulation, to practice new care guidelines specific to COVID-affected patients	In-situ simulations of rapid sequence intubation and other respiratory interventions, PPE donning/doffing to prepare multidisciplinary teams and identify latent safety threats. Simulations consist of prebrief, simulation scenario and debrief, conducted with native teams.	Three different high-fidelity simulation mannequins available; no details of cost or duration of QI project as a whole. As of pub, 131 participants and 22 simulations run.	1; 2a; 2b, 4a	QI, identification of latent safety threats	Most participants strongly agree that the simulation improved their knowledge and confidence of both clinical and efficient teamwork skills (additional file 1). Safety issues identified and solutions (Table 1).	Deliberate practice of utmost importance for rare events. Shift from safety I (what went wrong and why) to safety II (what went right) employed to further improve systems. Aim is to create teams that are better able to respond, monitor, learn and anticipate.	"Guiding healthcare professionals in attaining desired levels of comfort and preparedness, individually and in a team setting, helps them maintain and perpetuate the efficient practices performed/acquired during simulation, thus allowing them to become active and proactive."
Laloo et al.	Virtual surgical education for core surgical trainees in the Yorkshire deanery during the COVID-19 pandemic	Sept-ember	GME	Surgical trainees; n=62	General Surgery	Europe	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Promote high quality surgical education and facilitate on-going learning	Online teaching program developed for core surgical trainees. Twice weekly teaching sessions (20 total) either delivered synchronously via Zoom with interaction or pre-recorded and uploaded onto Google Classroom and YouTube for asynchronous consumption. Teaching delivered by senior surgeons and consultants. Content in accordance with Joint Committee of Surgical Training curriculum and Membership of the Royal College of Surgeons examinations.	Zoom, YouTube, Google Classroom	1	ND	Figures 2-4: 79% rated the series highly, 86% rated the series as useful, 93% were satisfied with the platforms used. Weekly short sessions were preferred to monthly longer sessions.	Recording attendance may improve uptake. Shorter interactive sessions can promote attention and retention. Multimedia can enhance learning.	An online teaching program for core surgical trainees is feasible and well received.

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Lang et al.	POPCoRN One-Pagers: Educational Materials for Pediatric Providers Caring for Adults	May	CME	Pediatric providers	Pediatrics	USA	Multi-institutional collaboration	Faculty development	Provide educational materials to support pediatric providers caring for adults during the pandemic	Pediatric Overflow Planning - Contingency Response Network (POPCoRN), a multi-institutional collaboration, created an inventory of high-yield topics in the form of succinct, one-page, living documents. The one-pagers were developed by multiple individuals, then formatted for consistency, with final input from an adult hospitalist and pediatrician for content accuracy and clarity, respectively. Documents are housed on the POPCoRN website.	Committee for final overview, web repository	1	ND	Since the introduction to POPCoRN One-Pagers on 29th March 2020 there have been 54,841 views (which shows resource uptake). Excellent feedback has been received regarding the utility of these documents in a real-time setting.	ND	There has been excellent feedback about the utility of these 'one-pager' documents in the on-the-ground care of adults in previously pediatric predominant areas.
Lara et al.	Remote Assessment of Clinical Skills During COVID-19: A Virtual, High-Stakes, Summative Pediatric Objective Structured Clinical Examination	June	UME	Clerkship medical students; n=49	Pediatrics	USA	Academic hospital	Assessment	Develop a teleOSCE for a high-stakes summative assessment of clinical skills	TeleOSCE implemented on Zoom. All participants engaged remotely. Used established SP checklists, communication scoring tools, and faculty observation rubric. In virtual "hallway" students get a pre-brief and are given a "doorway folder". Students are then moved into the exam room with SP, faculty and administrator. Encounter lasts 22 minutes. They repeat the cycle for a total of 4 pediatric cases.	Zoom, SPs	2b	ND	No difference in mean scores or failure rate when compared to last three years of in-person OSCEs	Could run through half as many OSCEs in a day, compared to the live version.	Remote summative teleOSCEs are feasible with similar outcomes.
Lawrence et al.	Building Telemedicine Capacity for Trainees During the Novel Coronavirus Outbreak: a Case Study and Lessons Learned	July	GME	Residents; n=23	Internal Medicine	USA	Academic hospital	Assessment	Prepare residents to work in a telemedicine environment	5 OSCE cases adapted to a virtual visit telemedicine format. Each encounter took 10 minutes. Competencies assessed included acknowledging a medical error, recognizing and addressing patient emotions, and establishing trust. Trained SPs used a standardized evaluation tool that rated performance using a behaviorally anchored scale (not done, partially done, done). Faculty provided verbal feedback and completed an entrustment scale.	Open Notes mock electronic health record, virtual platform (unspecified), simulation center exam rooms with audio / video recording equipment and one-way mirrors for faculty observation	1, 2b	ND	Residents expressed enthusiasm for telemedicine training but had concerns about their preparedness for telemedicine practice and the need for further competency and curricular development. Differences were seen between the in person and telemedicine encounters.	Cases and scoring rubrics were not developed for telemedicine; Digital professionalism should be incorporated into pragmatic telemedicine training.	Programs interested in building capacity among residents to perform telemedicine, particularly during the COVID-19 pandemic, can make significant impact in their trainees' comfort and preparedness by addressing key issues in technical proficiency, history and exam skills, and communication
Lee I. et al.	Academic coaching of medical students during the COVID-19 pandemic	June	UME	Medical students	N/A	Asia	University	Well-being / mental health / learner support	Support students within an adapted, virtual education program	A virtual academic coaching program was created around the conceptual framework of the Master Adaptive Learner (MAL). The framework consists of 4 phases - planning, learning, assessing and adjusting. 2 academic coaches tracked and analyzed students' performance. Interventions addressed content matters, study habits or learning strategies. Regular 30-minute meetings were scheduled with coaches for reflection and feedback.	Core teaching faculty + 2 academic coaches	1	ND	"Students in the program favored the proactive support. Many acknowledged that individualized goal-directed study plans and follow-up meetings kept them accountable, reflective and motivated, and guarded against the use of ineffective learning strategies."	"At times, it was important for coaches to help students reprioritize, troubleshoot and re-work study plans, as well as encouraging a deliberate holistic approach that included self-care and the maintenance of mental wellness." "Regular and short-interval engagement with students during social isolation allows them to feel safe in reaching out for help and empowers them"	"This model of academic coaching informed by theory supports students and empowers them with the skills necessary for effective learning, adapting and thriving in a health care environment challenged by uncertainty and ambiguity."
Lee Y. et al.	Enforced format change to medical education webinar during the coronavirus disease 2019 pandemic	May	CME	Medical school faculty: n=210	N/A	Asia	University	Pivot to online learning (synchronous)	Continue faculty development offerings during pandemic to enhance teaching competencies	Regular faculty development seminars were held as interactive online webinars. Each session lasted 1 hr. with participants utilizing the chat feature.	ND	1	ND	Increase in attendance from face to face seminars. During first webinar: 78.5% reported technical difficulties with connection, 37% described multi-tasking, 87% strongly agreed with liking the format. Satisfaction went up with the 2nd webinar.	Technical problems (e.g., internet capacity and clarity) required troubleshooting	Webinar format for faculty development has been successfully launched with improved participation.
Lieberman et al.	Coping With COVID-19	Sept-ember	UME	Clinical medical students; n = 28	Pathology	USA	University	Pivot to online learning (synchronous, asynchronous)	Implement remote 2-week clinical pathology elective to ensure continued learning during the pause in face-to-face activities	2-week remote clinical pathology elective implemented. Focus was on teaching student's efficient selection and interpretation of laboratory tests. Zoom was utilized for some didactic content, small group sessions, "rounds," and "sign-out". Self-study resources were provided, and reflective writing assignments were implemented. Emerging clinical laboratory information on COVID-19 incorporated.	Secure Zoom for transmitting protected health information	1	ND	Average rating of the course Overall rating of course 4.45-4.57/5, good to excellent. Students reported the course helped them appreciate the significance of the subject matter. Strengths included digital resources, study time, integration with clinical work, and variety of presentations. Weaknesses included fatigue with teleconferencing and density of complex subject matter.	Serving students in different time zones requires minimization of activities at the extremes of workday. Teleconferencing fatigue is a concern. Increased breaks during activities may help.	Remote learning offers in-depth instruction in laboratory medicine, exposing students to the critical role of clinical laboratory in response to emerging infections and affords flexibility for educators to response to the continuing pandemic.

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LoSavio et al.	Rapid implementation of COVID-19 tracheostomy simulation training to increase surgeon safety and confidence	May	Mixed	Attendings, residents, operating room nurses; n=17	General Surgery	USA	Academic hospital	Simulation (training for treating patients with COVID-19)	Determine if simulation training for tracheostomy increases procedural confidence and proper use of PPE	A simulation program to teach faculty and residents a new tracheostomy protocol with proper use of enhanced PPE in patients with COVID-19. Specifically focuses on the use of CAPR devices (Controlled Air Purifying Respirators) in conjunction with sterile gowning technique.	5 days to develop, 2 days to teach; CAPR device, tracheostomy equipment, mannequin	2a; 2b	ND	Significant improvement in knowledge and confidence levels (Table 1). Participants reported the session to be very helpful and increased their comfort level in surgically treating COVID-19 patients.	Consider implementation of a mobile tracheostomy team and focus early simulation training on this team.	Rapidly implemented simulation training was demonstrated to successfully increase confidence levels among resident and attending surgeons. This protocol can serve as a blueprint for any medical center being faced with the scenario of potentially having to perform tracheostomy in COVID-19 patients.
Maeda et al.	Experience with online lectures about endoscopic sinus surgery using a video conferencing app	July	Mixed	Residents; n=35	Oto-laryngology (ENT)	Asia	Academic hospital	Pivot to online learning (synchronous)	Provide remote surgical education to residents and specialists	Interactive lectures delivered using Zoom, including videos for endoscopic surgery. Chat or hand-raising functions used for interaction.	Zoom	1	ND	91% response rate (Table 2). Learners appreciated bi directionality (i.e. engagement), though struggled with video streaming quality. The majority would like both online and face-to-face or online only sessions in the future.	Videos can be provided in advance to download to overcome connection problems; Recommend cameras on with virtual background for privacy	Feasible to deliver interactive lectures online using Zoom
Malhotra et al.	Conducting orthopedic practical examination during the Covid-19 pandemic	July	GME	Residents	Orthopedics	Asia	Academic hospital	Assessment	Conduct a zero patient contact exit exam	Cases (see example figure 3) were developed in a digital format by faculty (cases presented in PowerPoint with photographs, radiographic findings, etc.). Oral exam is conducted in-person with multiple examiners and faculty present, socially distanced, but no patients, Exam consists of 1 long case and 3 short cases.	Faculty / examiner time	1	ND	See table 2 and figure 5a. The mean score for overall satisfaction for each question in examiner group was 4.5 while that in examinee group was 4.1. The mean total score for the examiner and examinee group was 48 and 43.4 respectively.	A similar exam could be administered entirely via Zoom.	Orthopedic residency end-of-training examinations can be successfully conducted during the COVID pandemic.
Mastroianni et al.	Changing our training paradigms in general surgery residency during the covid-19 outbreak	August	GME	Residents, fellows; n=62	General Surgery	South America	Academic hospital	Clinical service reconfiguration; Pivot to online learning (synchronous, asynchronous) Well-being / mental health	Outline changes in the general surgery residency program, prioritizing learner safety while maintaining quality of supervised continuous medical teaching	Multiple interventions described with minimal detail: 1) Residents placed in teams working one week on, 2 weeks off to create a reserve workforce. Residents don't participate in COVID + surgeries. 2) Resident conducted (faculty supervised) didactics via Zoom. Simulation activities continued and resident research projects accelerated due to increased time. 3) Well-being support through direct contact with psychologist and faculty - resident mentorship pairings	ND	1	Reduced COVID infections amongst residents	92.5% of residents felt totally satisfied with the modification to surgical training as a result of COVID-19	Resident feedback regarding changes is important in identifying any developing psychological health concerns as a consequence of the global crisis	This model proved to be a useful strategy in a general surgery residency program at a university hospital to deal with the outbreak training limitations focusing on resident safety and welfare.
Matalon et al.	Trainee and Attending Perspectives on Remote Radiology Readouts in the Era of the COVID-19 Pandemic	July	GME	Residents, fellows; n=105	Radiology	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Implement remote radiology "read outs" to comply with social distancing	PACS workstations redistributed to empty offices and meeting rooms to facilitate remote radiology readouts. Videoconferencing and screensharing tools were used. 2 workflows: 1) synchronous review and discussion of trainee preliminary report via Microsoft Teams; 2) asynchronous review, attending edits trainee report and provides feedback later via email	HIPAA compliant Microsoft Teams, Primordial messenger, PACS stations	1	ND	Table 2 and 3a: "Early perceptions of remote readouts by radiology trainees and attendings was generally positive, specifically regarding the themes of social distancing, technology, and autonomy/competency, with negatively rated themes of education/feedback and atmosphere/professional relationships."	Synchronous review ideal for junior residents or complex cases. Asynchronous review ideal for senior residents and straightforward cases. Model may facilitate enhanced autonomy / graduated responsibility for senior residents. May enhance efficiency of senior residents when volume is high and case complexity low.	Remote supervision and feedback of trainee radiologists' reports is feasible, and the benefits outweigh the drawbacks.
McRoy et al.	Radiology Education in the Time of COVID-19: A Novel Distance Learning Workstation Experience for Residents	August	GME	PGY1 radiology residents; n=9	Radiology	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Simulate live radiology workstation teaching and ensure adequate call-preparation	Figure 1 provides overview: A radiographic case collection was created in Pacsbin, a HIPPA compliant app that allows anonymized images from PACS to be stored in the cloud. A senior resident manager selects daily cases and puts them on Google Classroom. A senior resident teacher generates a report. Learners independently interpret images and submit their assignment. Learners then engage with near-peer teachers in a readout via Zoom and obtain feedback.	Three programs used: Zoom, Google classroom, Pacsbin	1	ND	Figure 7 shows results. Learners felt more prepared for call, were interested in continuing the project post-pandemic and interested in expanding to radiographic subspecialties.	Pacsbin allows for dynamic engagement with images, unlike static image repositories. It also allows multiple educators to contribute files.	"This resident run platform promotes interpretive radiology skills through case review, provides a framework for self-motivated study, and encourages peer to peer learning, all via distance learning."
Mohd et al.	The Preparation, Delivery and Outcome of COVID-19 Pandemic Training Program among the Emergency Healthcare Frontliners (EHFs): The Malaysian Teaching Hospital Experience	June	Mixed	Medical officers, assistant medical officers, nurses; n=178	Emergency medicine	Asia	Academic hospital	Simulation (training for treating patients with COVID-19)	Develop training modules for emergency frontliners to care for COVID patients that are safe and prevent the spread of the disease	Immersive live simulations were developed. Pre-reading materials were provided, which included basic facts. A prebrief was conducted for each of 3 modules: donning-doffing PPE, airway management and cardiopulmonary resuscitation of suspected COVID-19 patients. Simulations proceeded according to a checklist and were followed up with a debrief.	3 weeks of training	1, 2a	QI	Minimal report with couple quotes that participants like the training and feel more confident.	"One of the greatest challenges during the preparation of training content was the lack of available robust scientific evidence."	Checklists are important adjuncts during resuscitation and airway management in time-constrained, resource-limited situations. Face-to-face training can still be conducted, provided strict adherence to safety principles.

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Mohos et al.	Doctor-patient communication training with simulated patient during the coronavirus pandemic	August	UME	Medical students; n = 86	N/A	Europe	University	Pivot to online learning (synchronous)	Provide online communication skills training	Communication skills sessions were held on Zoom with a SP. Each student records an interaction with a SP. They then meet in a small group of 5 students with a faculty facilitator. Videos are analyzed as a group. Student provides self-reflection and faculty / peers provide evaluation/feedback.	Zoom, SPs, family physician mentors (training for both).	1	ND	Majority of students felt sessions met the learning objectives, were useful, and instructors were prepared (4.45, 4.06, and 4.78 out of 5, respectively). Students satisfied with organization and technical management. Several highlighted the simulated patient as a rewarding component, allowing for constructive feedback and self-reflection.	Non-verbal communication is challenging in the virtual environment. Lack of infrastructure, appropriate training, and teaching attitudes were challenges.	The implementation of the online practice was successful. However, lack of personal contact is a negative. Therefore, online formats cannot be considered a complete replacement to personal communication training but can be a supplement.
Molina et al.	Virtual Interviews for the Complex General Surgical Oncology Fellowship: The Dana-Farber/Partners Experience	July	GME	Fellows; n=20	Surgical oncology	USA	Academic hospital	Interviews (selection to residency)	Develop a virtual fellowship interview process to simulate the in-person interview day	A virtual interview day was conducted using Zoom breakout rooms. Applicants began their interview day in the "main room" with a 30-minute overview by the fellowship director. Applicants and faculty were moved to a "hallway" and subsequently to breakout "interview" rooms. Applicants completed 5 fifteen-minute interviews. Between each interview they returned to wait in the "hallway". When not being interviewed, applicants could join a virtual tour with fellows. Faculty scored interviewees in Google.	Zoom, Google docs, administrator to move people into rooms per schedule	1	ND	Applicants reported an improved flow in 2020 compared to 2019. No significant differences in other reported indicators when compared to 2019. Faculty were impressed and reported an "excellent" overall impression.	Took away cost for program and applicants. No travel requirements, though downside is can't get to know location. 1 min warning before interviews concluded was awkward. Ability to maximize faculty members participation.	"The virtual interview served to match the in-person interview of the prior year, while maintaining the recommended objectives of social distancing."
Mouli et al.	Effectiveness of simulation-based teaching of ventilatory management among non-anesthesiology residents to manage COVID 19 pandemic - A Quasi experimental cross-sectional pilot study	May	GME	Residents; n=26	Multi-disciplinary	Asia	Academic hospital	Simulation (training for treating patients with COVID-19)	Ensure non-anesthesiology trainees knowledgeable and prepared for ventilatory management in COVID-19 patients	A 7-hour teaching module was developed to train non-anesthesiologist ventilatory management. 3 hours of lectures (ABG, basics of ventilation, ventilation strategies in COVID patients), 1 hour of audio-video sessions, 1 hour of demonstrations as well as hands-on training and 2 hours of assessment with direct observation and feedback by anesthesiology faculty. COVID pneumonia was modeled through high fidelity human patient simulator. Followed by debriefing.	Course ran over 4 days, human patient simulator	1; 2a; 2b	ND	Increased knowledge (pre-post). 88.4% met or exceeded expectations as per the training objectives. 11.6% were borderline or below expectation. Learner satisfaction (highly satisfied): 84, 96, 100% for 3 modules. 84.5% felt confident or very confident in interpreting ABG. 65.3% were confident maneuvering mechanical ventilation and 96.15% were very confident using PPE during intubation of COVID-19 patients.	ND	A planned teaching module in personal protection of health care workers and ventilation management helps to train non-anesthesiologists more effectively as a part of COVID-19 preparedness. Simulation with debriefing based training is the best alternative in the present pandemic and will also ensure the safety of HCPss.
Munshi et al.	An online clinical examination for fellowship certification during the COVID-19 pandemic	June	GME	Fellows; n=433	N/A	Middle East	National regulatory body (Saudi Commission for Health Specialties)	Assessment	Assess candidate knowledge using an online exam format for high-stakes certification / licensure	Saudi certification exam moved online. Exam blueprinted against learning outcomes. 4 virtual stations lasting 15 minutes each. Some scenarios had enhanced reality features (e.g., data, radiographic images, videos) built in. Proctors admitted examiners and candidates to each virtual station. Examiners moved stations and proctors and candidates remained to ensure exam security. Assessed with checklists	ExamHD, 72 proctors, 232 examiners	1	ND	"96% of examinees and 91% of examiners reported satisfaction with how the examination contents reflected real practice"	Need to do dry runs to test technical aspects; reduced costs / travel	Online examination solved a certification emergency. It appears online case vignette assessments are acceptable to examinees and examiners
Naidoo et al.	Confronting the challenges of anatomy education in a competency-based medical curriculum during normal and unprecedented times (COVID - 19 pandemic): Gagne, Peyton and Mento to the rescue	June	UME	1st year medical students; n=172	Anatomy	Middle East	University	Pivot to online learning (synchronous, asynchronous)	Apply pedagogical framework to allow anatomy education to continue in virtual environment	Applied a pedagogical framework for blended learning. Designed a social media application 'interactome' to allow different steps in blended learning process. Following a flipped classroom format - didactics and demonstration videos were provided asynchronously in advance on MS teams or YouTube, then learners came together in small groups for case discussions. A faculty instructor moderated discussion in Microsoft Teams and WhatsApp.	MS Teams, WhatsApp, YouTube. Extensive instructor training required. Reduced number of cadavers needed.	1; 2b	ND	Overall positive feedback from students. The framework led to a trend towards better performance in summative exams in this preliminary evaluation.	Instructors reluctant to adopt and modify their teaching approaches (created training for this). Group dynamics can become an issue if students become distracted - may need peer tutor in group. Approach may work better if also combined with radiology.	Able to teach anatomy during unprecedented times. Experienced reluctance from tutors to adapt to new delivery method (flipped classroom) but have designed further training to help combat this. Online learning may solve issue of a lack of cadavers in middle eastern countries.

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Newcomb et al.	Building Rapport and Earning the Surgical Patient's Trust in the Era of Social Distancing: Teaching Patient-Centered Communication During Video Conference Encounters to Medical Students	June	UME	Students, faculty, observers; n=11	General Surgery	USA	Academic hospital	Pivot to online learning (synchronous)	Design an effective online communication skills training for students entering surgical specialties	2-hour virtual class focused on telecommunication held on Zoom. Following a brief didactic component about building virtual rapport and trust, students and faculty discuss patient centered communication experiences. Students then participate in two 15-minute role plays (Table 1: a surgical clinic consult and disclosure of a surgical complication). Faculty and peer observers then provide feedback.	2-hour zoom session. 2 facilitators. 1 volunteer simulated patient with acting training. No info on prep time.	1; 2a	Generated telecommunication best practice suggestions from the debriefs	Overall positive feedback. Student confidence improved in all domains of video communication (Figure 1). Particularly liked the interactive aspects to retain focus and the real-time feedback from faculty with direct observation.	Increased focus is required to communicate empathy and concern on video call. Patient distress was more difficult to interpret. Decreased ability for eye contact and physical touch may be mitigated by use of real time feedback as a method of emotional support, similar to observation that increased vocalization by student interviewer demonstrated attention to and emotional involvement in a patient's story.	Telemedicine is a promising area for expansion and session received positive feedback. Aim to expand it over curriculum.
Niburski & Niburski	A corona virus tracker for clinicians and students: Assessing education during an evolving phenomenon	May	Mixed	Healthcare practitioners, general public; n=250	Inter-professional	Canada	University	Other, information curation	Create curated online resource about COVID so healthcare practitioners and public can access accurate information	A curated information resource was created: whohascoronavirus.com. The site contained daily briefings from the WHO displaying death rates, recovery rates, active cases, and total cases. Clinical information regarding treatment modalities, radiographic images, etc. was summarized from the Journal of the American Medical Association (JAMA).	ND	1; 2a	ND	Healthcare practitioners reported improvement in general knowledge (2.3 ± 0.4 to 4.4 ± 0.6, p<0.01), improvement in understanding of the epidemiological situation of the corona virus (1.8 ± 1.1 to 4.5 ± 0.3, p<0.01), improvement in clinical treatment (3.4 ± 0.4 to 4.0 ± 0.3, p<0.05)	When facts are appropriately sorted, managed and displayed, there is greater understanding by physicians and the public. Technologies need to be nimble to ensure unproven treatments don't get excessive "airtime".	This tracker helped provide accurate information in timely manner. During uncertainty, technologies have to be limber, worked with daily, and enable the highest level of accurate information.
O'Connell et al.	Effective Use of Virtual Gamification During COVID-19 to Deliver the OB-GYN Core Curriculum in an Emergency Medicine Resident Conference	June	GME	Residents; n=36	Emergency Medicine	USA	Academic hospital	Pivot to online learning (synchronous)	Employ virtual gamification to enhance resident learning	Novel virtual game modeled after the TV show “So You Think You Can Dance?” Starts with a warm-up (where all players engage individually) and several rounds of team play with rapid-fire OB-GYN questions and cases. 2 teams play in each Zoom breakout room with answers judged by faculty. Teams are gradually eliminated to a final face-off, where the audience decides the winner.	Zoom, Kahoot	1; 2b	ND	87% enjoyed the activity, 95% reported being engaged, 95% reported learning new knowledge.	Further time and facilitator training were needed. Challenging to communicate with facilitators once in breakout rooms.	Virtual gamification was effective and well received.
Parker et al.	Remote Anatomic Pathology Medical Student Education in Washington State	August	UME	3rd and 4th year medical students; n=70	Pathology	USA	University	Pivot to online learning (synchronous, asynchronous)	Provide remote anatomic pathology elective	2-week, interactive, online organ system-based anatomic pathology course: Activities are tailored to the no pathologist future clinician, emphasizing basic microscopy and pathology terminology. Lectures delivered via Zoom. Multiple strategies to increase engagement while distance learning employed, including flipped classroom, screen annotation, case-based discussions and slide presentations (via online digital platform PathPresenter.net).	Zoom, PowerPoint, PathPresenter, Canvas, Microsoft Teams. 2 months to develop course. 3 course faculty, TAs and Canvas administrators.	1; 2a; 2b	ND	Feedback overwhelmingly positive. Preliminary results suggest increase in pathology knowledge and elevated student opinions about pathology. 10-fold increase in students undertaking pathology placement (as opposed to face to face placement). 2 students now interested in career in pathology	Initial concerns that students may take passive approach. Addressed this by using case-based scenarios, annotate function on PathPresenter and flipped classroom model. Reliance on technological interactive tools to enhance synchronous learning: annotation function, webcam use, virtual slide sessions gave biggest impact.	Online learning has made pathology learning accessible for medical students. Lessons from this can be used to expand into 4-week course with laboratory-based elements. Can be used in future for other non-pandemic related barriers to learning.
Pasricha et al.	Remote corneal suturing wet lab: Microsurgical education during the COVID-19 pandemic	August	GME	Residents; n=10	General surgery	USA	Academic hospital	Pivot to online learning (synchronous)	Examine the feasibility and efficacy of a remote wet lab for microsurgical education	Randomized control trial of simulated corneal suturing task for penetrating keratoplasty with and without remote synchronous feedback. Residents sutured porcine corneas via Zoom using a smartphone connected to a microscope with or without remote ophthalmology attending feedback. 2 graders assessed the pig eye outcomes once complete.	Zoom, microscope	1, 2b	ND	Residents in both groups more comfortable with corneal suturing after the wet lab and found it effective. Objective corneal suture performance (suture length, tension, depth) was similar in both groups.	ND	Remote wet lab is feasible and effective for training residents in microsurgical techniques.
Patel et al.	Utility of a webinar to educate trainees on UK core surgical training (CST) selection – A cross sectional study and future implications amidst the COVID-19 pandemic	Sept-ember	GME	Residents and medical students; n=111	General surgery	Europe	Academic hospital	Interviews (selection to residency)	Develop a webinar to educate trainees on Core Surgical Training selection in the UK	A free online webinar was held on a single day by a 2nd year core surgical trainee. The webinar covered the structure of the CST selection interview, portfolio preparation and advice on how to answer clinical knowledge, management and leadership questions during interviews. Survey was sent in advance via Google forms to participants to assess their baseline knowledge about the CST selection process.	Zoom, Google forms	1	ND	"Over half of respondents (55.0%) preferred a webinar over a face- to-face tutorial, appreciating the flexibility, convenience and zero financial cost associated."	Webinar experience heavily influenced by internet capability	"Webinars have been underused in preparation for CST applications. Preparation for CST application may become increasingly reliant on online materials, which may result in an increased demand for high quality, engaging and informative webinars."

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Pennell et al.	Live-streamed ward rounds: a tool for clinical teaching during the COVID-19 pandemic	May	UME	medical students n=60	OB-GYN	Oceania	Academic hospital	Pivot to online learning (synchronous)	Maintain clinical clerkship model of OB-GYN education whilst medical students are excluded from the hospital	Phase 1: remote observation (assess and analyze) - student participates via video on a mobile phone, including discussion before and after a patient visit. Student is shown patient data and records on video platform. Phase 2: student preparation (evaluate and synthesize) - student takes notes during rounds and seeks missing medical information. Phase 3: remote case-based ward round presentation (construct and justify) - 3-40 students engage for 60-90 minutes via videoconferencing. Students present cases and an educator facilitates discussion.	Approval required from hospital executive. Consent taken for each patient. Skype for business used for student to attend virtually. Extra time taken on ward round by doctors. 60-90-minute virtual clinical round requires facilitator.	1	Series of recommendations for including virtual ward rounds in remote teaching (Table 3)	Feedback generally positive from 24 students. Development allowed continuation of placements despite restrictions, clinical case discussion round allowed for further reflection which is not normally possible onwards, allowed for larger number of students to be involved than on a normal ward round.	"The program may potentially slow downward rounds. There is risk of technological limitations. There is inability to observe or participate in physical examination. There is a loss of some of the valuable elements of the informal curriculum on ward round (e.g., exemplary professional values, behavior and collegiality via positive role modelling)."	Provided an opportunity for students to continue to develop their clerkship skills and was rapidly implemented. Can be applicable to all areas of medicine.
Prasad et al.	Online interprofessional simulation for undergraduate health professional students during the COVID-19 pandemic	Sept-ember	UME	4th year medical students, midwifery students; n=71	OB-GYN	Oceania	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Understand role of synchronous remote learning through simulation and impact on interprofessional interactions	ONE-sim interprofessional workshop covering maternal and neonatal emergencies, PPE and crisis resource management. Students given pre-reading and access to online videos on maternal emergencies prior to the session. Workshop structure: 1) Initial briefing (5 min), 2) Three Scenarios (20 min each), 3) Debrief (40 min). Workshop was led by a team of four (obstetrician, pediatrician, 2 midwives with extensive clinical and teaching experience), who simulated the emergency scenarios, which were live streamed to students via video conference.	Workshop led by team of 4. Zoom.	1	ND	"Students reacted positively to the online simulation and interacted collaboratively with each other during the video conference (Table 1)."	Live streaming the scenario helps it most closely simulate the face to face impromptu sessions and what emergencies look like in real life, but it is more resource and time intensive and less optimized than a prerecorded video. The authors ultimately decided to use prerecorded videos for future iterations.	IPE can be achieved in a useful and meaningful way using online platforms. May be useful ongoing post-pandemic. Needs further evaluation.
Prigoff et al.	Medical Student Assessment in the Time of COVID-19	Sept-ember	UME	Clerkship medical students; n=19	General Surgery	USA	Academic hospital	Assessment	Develop and online open book end of clerkship exam	Students took the clinical skills exam (CSE) open book, at home, and unproctored and the National Board of Medical Examiners (NBME) clinical subject or "shelf" exam at home proctored. Grading was adjusted by comparing the last 3 years of data.	ND	1, 2b	ND	"The COVID-interrupted group scored higher on CSE, NBME exam, and performance evaluations (CSE:75.2 vs 68.7, shelf:68.0 vs 64.0, performance evaluation: 2.96 vs 2.78). The % of students with honors was marginally higher in the COVID group (42% vs 32%). 7 students stated they would have preferred closed-book CSE, citing drawbacks such as modifying exam prep, being discouraged from thinking prior to searching online, second guessing answers."	ND	"During the initial outbreak of COVID-19, we found that an open book exam and a virtually proctored shelf exam was a reasonable option. However, to avoid adjustments and student dissatisfaction, we would recommend virtual proctoring if available."
Rasouli et al.	Virtual Spine: A Novel, International Teleconferencing Program Developed to Increase the Accessibility of Spine Education During the COVID-19 Pandemic	August	Mixed	Physicians, fellows, residents, medical students; n=995	Multi-disciplinary	Internati onal	Multi-institutional collaboration	Pivot to online learning (synchronous)	Address potential disparities in the access to spine education created by the COVID-19 pandemic across physicians and HCW in spine-related specialties across the globe.	Virtual Global Spine Conference (VGSC) had biweekly virtual meetings, hosted through the Zoom with various expert speakers (Orthopedic surgeons, neurosurgeons, neuroradiologists, etc.). All lectures were recorded and archived on YouTube and on the main conference website.	Zoom	1	ND	Since the launch of VGSC, more than 1000 surgeons, trainees, and other spine specialists have registered for the program. Surveys were sent to the participants early on with 168 responders - 92% viewed the content as highly valuable to their practice and 94% would continue participating in VGSC post COVID.	Many participants expressed their desire for virtual spine education to continue post COVID-19. Extra precautions are needed when dealing with virtual platforms because of potential cyber-security threats - 'Zoom bombing' as an example in this paper	Inequalities exist in the availability and access of these meetings to those who practice in countries outside the US. The early success and positive reception of the VGSC suggests this educational model can be emulated by other medical and surgical specialties to encourage national and international education and collaboration.
Rastegar Kazerooni et al.	Peer mentoring for medical students during the COVID-19 pandemic via a social media platform	April	UME	Medical students; n=381	ND	Middle East	University	Well-being / mental health / learner support	“Support students’ understanding of crisis management, self-mental care and other principal measures in order to strengthen the students' coping skills and mental preparedness”	Senior medical students instructed juniors to cope with anxiety through recommendation of stress managements techniques, exercise, maintaining social groups, time management and strategies to cope with shift to online learning under supervision of faculty through a social media platform	10 senior medical students with 40 hours of training each during previous 3 years. Faculty supervision	1	ND	71% junior students believed the platform had a significant impact	Senior students can provide useful and timely input and it helps them grow also	“Peer mentorship can teach medical students skills needed to be physicians”

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Recht et al.	Preserving Radiology Resident Education During the COVID-19 Pandemic: The Simulated Daily Readout	August	GME	Residents; n=32	Radiology	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Preserve radiology case volumes and variety for radiology residents via the creation of "simulated daily readout" (SDR).	Simulated" daily readouts (SDRs) were created to ensure readout experiences continued using a separate PACS filled with past radiology studies. The SDR was the primary focus of each rotation, as residents were not involved in 'live' cases - with aims to mimic a 'normal day' with an expectant proportion of normal and abnormal cases as determined by each subspecialty's consensus experience.	Initial design and build of the SDR environment took 7 information technology analysts 450 hours to complete. “20-30 hours” for faculty to develop cases, significant compute and IT resources	1	ND	Residents and teaching faculty felt strongly that the SDR initiative mitigated the COVID-19 negative impact on resident education. SDR mimics a resident's daily work on rotations and preserved resident education during COVID. The overall effectiveness of SDR was rated high to very high by the majority of residents and faculty alike, exceeding the resident expectations of this educational resource.	The most common shared concerns from both residents and faculty were the lack of patient history and access to prior imaging exams during SDR case dictation.	"The development of the SDR provided an effective method of preserving the educational value of the daily readout experience of radiology residents, despite severe decreases in imaging exam volume and case mix diversity during the COVID-19 pandemic.
Rose et al.	Physically distant, educationally connected: Interactive conferencing in the era of COVID-19	April	GME	Residents n=1080	Emergency Medicine	USA	National organization	Pivot to online learning (synchronous)	Mimic a traditional in-person conference experience.	Academic Life in Emergency Medicine (ALiEM) Connect was created to mirror conference attendance, by incorporating a livestream video of presentations on Zoom with concurrent backchannel (informal, non-public, secondary conversation) discussions via Slack. Platform was large enough to host >1000 learners from 64 different programs. Six nationally known speakers taught during the 2-hour event, 20 minutes were allotted to each speaker.	Zoom, Slack	1	ND	"Overall, resident feedback was overwhelmingly positive. In comparison with prior in-person conference experiences, 84% of residents felt that ALiEM Connect was the same or better in quality and 93% enjoyed the event overall."	Preliminary survey data suggest that most residents were unfamiliar with Slack and may have felt reserved about navigating the platform during discussion. From the ALiEM Connect team’s perspective, the live format required in-the-moment adaptability to unanticipated obstacles.	Although learners must remain physically distant during the COVID-19 pandemic, ALiEM Connect offered a model for massive, online, interactive conferencing that allowed for social connection and academic engagement amongst residents.
Rotoli et al.	Emergency Medicine Residency Curricular Innovations: Creating a Virtual Emergency Medicine Didactic Conference	May	GME	Residents; n=41	Emergency Medicine	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Adapt in-person EM education to an online learning platform and foster continued resident and faculty engagement.	EM curriculum with four didactic formats: 1) faculty-moderated virtual large group sessions, 2) faculty and chief resident-moderated virtual small-group sessions, 3) independent (asynchronous) learning activities, and 4) limited in-person critical procedure labs. Large-group sessions consisted of ~40 learners and ~2 faculty. Small-group format emphasized team learning, resident interaction, and connection. Independent learning activities emphasized flexibility, allowing learners to work at their own pace and focus on knowledge gaps.	ND	1	ND	95.6% of comments were positive: The initial Q&A session was critical to outline the process. Participants appreciated the investment in change and were forgiving of glitches in implementation. The debriefing sessions were helpful to reduce stress. Participants were interested in continuing virtual conference even when social distancing is no longer required. Residents felt faculty were accessible, invested, and engaged.	Aligning conference needs with the functionality and limitations of the virtual platform was imperative. All EM education cannot be taught online. Variable format was critical to maximize participant engagement while limiting the participant disconnect with online learning. Crucial to acknowledge the psychosocial impact of virtual learning and current pandemic by providing recurring updated pandemic content and debriefing time within conference.	"Expanding educational delivery beyond the physical classroom by shifting didactic conference to a virtual platform has diversified the way we teach. With early program leadership engagement, we developed innovative ways to virtually educate learners while acknowledging participant stress in the face of drastic change."
Roy et al.	A study on students' perceptions for online zoom-app based flipped class sessions on anatomy organized during the lockdown period of COVID-19 epoch	June	UME	Medical students; n=199	Anatomy	Asia	University	Pivot to online learning (synchronous, asynchronous)	Implement a flipped classroom model on Zoom to teach Anatomy	Ten gross Anatomy topics and 10 histology slides (total 15 sessions; one session for each gross anatomy topics and five sessions covering two slides for each day) were discussed in flipped class mode. For each session, the text materials were shared with students on WhatsApp two days before. Students generated a list of questions from these materials. On the third day, face-to-face interactive classes were undertaken using the Zoom platform."	WhatsApp, Zoom	1	ND	92% of students preferred sharing materials in advance. 2/3 desired asynchronous learning using YouTube videos. Internet connectivity was a major concern for 61%. Majority of the students felt overwhelmed with 6 day/week anatomy sessions. 77% did not want to continue with online sessions once face to face returned and 40% felt unable to keep up with the learning.	Challenges included lack of adequate preparation, infrastructural weakness, and lack of expertise of the participants. Concerns re: using the free version of zoom - are people joining who shouldn't be? Students wanted to use paid version to ensure security and for longer class length.	Most students did not want to continue with online education after the pandemic - likely due to poor connectivity and feeling overwhelmed by amount of sessions. The majority of students preferred in person learning, but also acknowledged that the switch to online teaching was somewhat rushed and future planning would help optimize it.
Sa-Couto & Nicolau	How to use tele simulation to reduce COVID-19 training challenges: A recipe with free online tools and a bit of imagination	June	UME	5th year medical students; n=8	N/A	Europe	University	Pivot to online learning (synchronous)	Use tele simulation to promote a meaningful distance learning experience	Course was developed using freely available tools and delivered through teleconferencing. Consisted of an introductory lecture, several group dynamics, and participation in three emergency scenarios (gastro-intestinal bleeding, anaphylactic shock, and opioid overdose). Scenarios typical take 15 min with 45 min for debriefing.	Zoom, an online simulation game (i.e. Full-Code App), a software simulating a vital sign monitor (vitalsignSIM),	1	ND	100% of learners felt it was a valuable learning experience and agreed it was comparable to face to face session. All students would like to continue teleconferencing sessions in the future, to compliment physical learning post the COVID pandemic.	Requires time and dedication. If not familiar with the program needs a few hours to get used to it. Session can be recreated with free resources available online. All wanted to see more tele simulation including as a complement to face-to-face activities post COVID.	"Tele simulation can be used to promote a meaningful, interactive simulation environment, even with limited physical resources. " "This strategy has high potential to be used in the transitional post-confinement period or as a future complement to physical settings. "
Sam et al.	High-stakes, remote-access, open-book examinations	May	UME	Final year medical students	N/A	Europe	Academic hospital	Assessment	Convert closed book exams to remote and open book	Open book exams (OBEs) were constructed from the United Kingdom Medical Schools Council bank of single best answer examination questions to assess the candidate’s ability to integrate clinical reasoning and decision-making skills. Psychometric analyses were conducted. Candidates could access the exams from anywhere.	ND	2b	ND	Median mark for the OBEs was identical to the median mark for the last 3 years of CBEs	ND	Concerns about the use of OBEs in high-stakes assessments may be unfounded. Remote OBEs present a viable alternative to traditional closed book exams if the questions appropriately assess the integration and synthesis of knowledge rather than factual recall.

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Samueli et al.	Remote pathology education during the COVID-19 era: Crisis converted to opportunity	August	UME	3rd and 4th year medical students; n=59	Pathology	Middle East	University	Pivot to online learning (synchronous, asynchronous)	Introduce surgical pathology to medical students and reinforce the pathological basis for disease	A remote pathology course was developed using whole slide images (WSI). Students were given remote access to university computers, with two freely available WSI viewers. Each topic was taught in a 4-part module: Self-assigned reading, lecture via Zoom, 5 question formative quizzes based on digital slides, and a frontal review of the slides via Zoom. 8 sessions offered over 2 weeks.	Zoom, "WSIs prepared using a Panoramic MIDI automated digital slide scanner (3DHistech)." CaseViewer 2.3 (3DHistech) and Aperio ImageScope 12.3.3 (Leica)."	1	ND	68% noted how interesting the course was, how much the course improved their understanding of diseases, and how strongly they would recommend the course." The online format seems to be preferable to students.	"Due to the need for fast curriculum development, case selection was based largely on availability. " Technical challenges in accessing the slides was the primary disadvantage of the class.	Developers were able to use the crisis to expose students to areas of pathology they normally aren't exposed to. The course was worthwhile and can be utilized in the future even in non-pandemic times.
Sandhu et al.	Virtual Radiation Oncology Clerkship During the COVID-19 Pandemic and Beyond	Sept-ember	UME	Medical students; n=26	Radiation oncology	USA	Academic hospital	Pivot to online learning (synchronous)	Develop and evaluate the impact of a virtual radiation oncology rotation.	2-week virtual radiation oncology clerkship available to both home and visiting medical students. The virtual curriculum consisted of synchronous resident and faculty-led didactics on Zoom using the chat and polling features; virtual clinic telehealth encounters facilitated through Epic Systems VidyoConnect; student talks, and supplemental sessions, such as quality assurance rounds and multidisciplinary tumor boards via WebEx.	Canvas, Zoom, Epic Systems and VidyoConnect, WebEx.	1, 2a	ND	Students found the clinic to be most valuable, followed by didactic lectures, journal club presentations, treatment planning sessions, and chart rounds. "All students agreed that the clerkship improved their understanding of radiation oncology and the role of a radiation oncologist." Most would recommend to their classmates.	Students requested didactics cover a broader range of disease sites, more virtual clinic experience, require cameras on to improve their attention, and more time for their end-of-clerkship talks, and attendance in chart rounds not to be mandatory because it was too fast paced and beyond their level of understanding.	"Our virtual clerkship was effective in increasing medical student interest in and knowledge about radiation oncology. These data will help optimize a new paradigm of virtual radiation oncology education for medical students during COVID-19 and beyond."
Shahrvini et al.	Pre-Clinical Remote Undergraduate Medical Education During the COVID-19 Pandemic: A Survey Study	June	UME	1st and 2nd year medical students; n=268	N/A	USA	University	Pivot to online learning (synchronous, asynchronous)	Transition pre-clerkship curriculum completely online	Preclinical curriculum entirely shifted to remote learning (Table 1). Organ system block lectures asynchronously viewed and final exams taken at home. Lab manuals posted for Anatomy and Histology and office hours provided. Clinical skills conducted remotely (minus the PE) with SPs. Problem based learning sessions given synchronously on Zoom. Clinical apprenticeships were cancelled.	n/a	1	ND	Most enjoyed the flexibility of the lectures being online. Most felt a profound impact of the loss of clinical exposure and stated that this reduced their motivation. 90% felt that lab-based learning was impacted - anatomy, pathology and ultrasound.	Students found the impact of losing clinic exposure was profound; they stated that these sessions were what motivated them during the more academic sessions. Most positive feedback was for the increased flexibility and the allowance of self-paced learning. Technical difficulties were a barrier to learning. Digital fatigue was high with some sessions lasting 3-4 hours. 50% of students wanted to continue with the pre-recorded videocasted lectures.	Remote learning had some negative impacts on pre-clinical learning, related to the loss of clinical experiences, loss of practical hands on experience in laboratory courses, and disconnectedness negatively impacting mental health. Positive aspects included more flexibility, opportunities to explore different learning resources, and time to focus on wellness.
Sharara-Chami et al.	In Situ Simulation: An Essential Tool for Safe Preparedness for the COVID-19 Pandemic	Sept-ember	Mixed	Residents, nurses, attendings; n = 106	Multi-professional	Middle East	Academic hospital	Simulation (training for treating patients with COVID-19)	Ensure HCW are trained and prepared to tackle the challenges of the COVID-19 pandemic	In situ 15-minute simulation followed by a debriefing at the bedside. Goals of applying standard precautions of donning/doffing, recognizing person of interest early, collaborating with infection prevention and control infrastructure, performing a primary assessment, starting immediate treatment, alerting hospital of suspected COVID-19, obtaining adequate samples and diagnostics, and triaging. Sim scenarios were adapted from Laerdal Medical titled Infection Prevention and Control: Severe Acute Respiratory Infection due to COVID-19.	2 weeks, using simulation equipment	2a; 2b	QI: Identification of threats with recommended solutions.	STAT scores to assess technical and behavioral skills: 16.3 out of 30 for basic skills, 23.3 out of 56 for airway and breathing, 14 out of 50 for circulation, and 39 out of 52 for human factors. SET-M scores for change in attitudes with 95-98% strongly agreeing on effectiveness of prebriefing, scenario, and debriefing.	"We were able to identify latent threats related to the system: fog in goggles if N-95 masks are not tightly sealed preventing good vision, time needed for the anesthesia team to arrive and for PPE donning and doffing, and coping with staff shortage, e.g., one registered nurse at the bedside in the COVID unit and others." Team performance improved with repeated simulations.	"We recommend intensive in situ simulation interventions targeting multidisciplinary teams in the new spaces, assessing the knowledge and identifying gaps that need to be addressed as well as latent threats that could be recognized through simulation before translating into actual patient care."
Shi et al.	A simulation training course for family medicine residents in China managing COVID-19	June	GME	Residents; n = 25	Family Medicine	Asia	Academic hospital	Simulation (training for treating patients with COVID-19)	Create a model to allow family medicine residents to experience a scenario of COVID-19, allowing them to learn and practice their knowledge and maximize capacities to respond, facilitating their ability to eventually make appropriate decisions.	Simulation developed over 1 month, delivered to 25 residents in groups of 5, which consisted of: pre-simulation survey, a 10-minute presentation to introduce the process of simulation and how to perform the task including what roles each participant would assume, the simulation itself, a debriefing, and a post-simulation survey. Pre-reading and presentations review on week prior to simulation.	1 month to develop simulation. Simulation center and equipment at the university hospital.	1; 2b	ND	Tables 1-3: All participants were satisfied and receptive to the learning experience. Pre-test and post-test results in the following categories: identification/ diagnosis (pre-test 19, post-test 24), infection prevention/ treatment (pre-test 55, post-test 58) and assessment of the referral/patient transportation (pre-test 12, post-test 14). P< 0.05 for all categories in two-tailed t-test.	Some of the clinical information could rapidly become obsolete.	The present study offers an alternative training opportunity for junior doctors to manage potential COVID-19 risks.
Singh et al.	Using Simulation to Assess Cardiology Fellow Performance of Transthoracic Echocardiography: Lessons for Training in the COVID-19 Pandemic	August	GME	Cardiology fellows; n=23	Cardiology	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Design a simulation-based training and assessment in echocardiography as a useful adjunct to education when procedural volumes are low	Simulation-based scanning tasks using the 3D Systems Ultrasound Mentor simulation program and mannequin were created. Tasks were designed by the Advanced Echocardiography Training Director. A preset checklist of basic competencies expected for each task was developed. Fellows scanned and were given immediate feedback based on their performance.	3D Ultrasound simulator and mannequin	2b	ND	Training level and number of scans performed did not translate to significant differences in TTE scanning skill when assessed via simulation. Simulation-based training was sensitive to skill differences between expert sonographers and trainees and provided an opportunity for efficient, targeted, and direct feedback.	None	Simulation for TTE education should be considered as a curricular complement for cardiology fellowships. Simulation-based tasks can be modified and repeated over the course of training to document longitudinal progress objectively.

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Singhi et al.	Medical Hematology/Oncology Fellows' Perceptions of Online Medical Education During the COVID-19 Pandemic	Sept-ember	GME	Hematology / Oncology fellows; n=42	Hematology / Oncology	USA	Academic hospital	Pivot to online learning (synchronous)	Transition to virtual instruction for didactics and continue with medical education	The academic program was transitioned to a fully virtual environment using the video conferencing WebEx software. Faculty deliver lectures live and use interactive features such as the chat box and virtual whiteboard.	WebEx	1	ND	Majority of fellows felt comfortable with the transition to an online learning. 1/3 reported that they were less focused, and nearly a 1/4 felt that they had learned less than during an in-person experience. Majority reported a change in social and interpersonal interactions. About 1/2 reported that it was easy/very easy to balance online attendance with personal or family commitments.	Review of the open-ended responses demonstrated that several respondents desired the use of an anonymous polling feature to encourage active participation during interactive review sessions.	Overall, most fellows felt comfortable with a transition to an online-only didactic curriculum. A pure-online educational approach has not yet been favored over the traditional in-person educational environment.
Sockalingam et al.	Responding to Health Care Professionals' Mental Health Needs During COVID-19 Through the Rapid Implementation of Project ECHO	July	CME	Healthcare professionals; n=426	Multi-professional	Canada	University partnership with community mental health centers	Well-being / mental health / learner support	Deliver support, resources, and mental health training to encourage and promote self-care for healthcare providers through virtual programming	Oregon Extension for Community Healthcare Outcomes (ECHO) Network tele mentoring program for rural frontline clinicians was adapted to support HCW caring for patients with COVID-19. Curriculum consisted of two 1-hour sessions per week that included: introductions, a mindfulness exercise, COVID-19 question and answer, a didactic presentation based on the curriculum topic, case based discussion to illustrate stress management skills, and a closing section based on health humanities education (e.g., poem or art) to stimulate reflection. Sessions were structured to balance information sharing and the development of skills to manage one's own mental health and well-being.	Utilized an existing hub and spoke resource for building mental health capacity in under resourced settings	1, 2b	ND	Session satisfaction (3.91-4.26 / 5) and self-efficacy (69.1-70.2 / 100) in healthcare providers (Table 1)	Rapid implementation was feasible based on pre-existing structure / network	"HCPs can experience significant psychological distress while delivering care during COVID-19... Virtually delivered tele-education programs, such as Project ECHO, can be rapidly implemented to provide HCP support and training on self-care using existing implementation frameworks and iterative curriculum design methods."
Steehler et al.	Implementation and Evaluation of a Virtual Elective in Otolaryngology in the Time of COVID-19	July	UME	3rd year medical students; n=12	Oto-laryngology (ENT)	USA	University	Pivot to online learning (synchronous, asynchronous)	Develop a virtual otolaryngology medical student elective to teach the basic tenets of otolaryngology and increasing exposure to the specialty."	"1-week virtual otolaryngology curriculum" conducted via home conferencing software. Program consisted of "lectures, case-based learning, and walk-throughs of surgical videos" Didactic sessions with faculty and residents via Zoom. ENT videos covering basic anatomy and exam techniques provided. Pre-readings prior to each session. 2 hours of morning lecture, 2 hours of afternoon lecture. Students also attend department grand rounds.	Faculty, residents and senior medical students came together 4 weeks prior to elective. Zoom	1, 2a, 2b	ND	Pre-post results demonstrated learning. 92% of students reported increased understanding. Scores on summative assessments were significantly higher (P <.001). 92% of students reported either 'increased'' or ''greatly increased'' interest in otolaryngology post course. Students appreciated course organization, formative assessments, and case-based learning"	Limitations included that the course was developed rapidly and couldn't be piloted, which resulted in technical difficulties, and the assessment was also not comprehensive.	"Our experience suggests that virtual curricula can be utilized to enhance surgical education of medical students even after the resumption of clinical duties, especially for surgical specialties that would otherwise receive little attention."
Steeves-Reece et al.	Rapid Deployment of a Statewide COVID-19 ECHO Program for Frontline Clinicians: Early Results and Lessons Learned	May	CME	Physicians, NPs, PAs; n=737	Family Medicine	USA	State Chief Medical Officer	Well-being / mental health / learner support	Provide tele mentoring to rural and urban clinicians to connect and share emerging information on COVID-19	Oregon Extension for Community Healthcare Outcomes (ECHO) Network tele mentoring program for rural frontline clinicians: 4 sessions set up once weekly for all comers. Featured a community presenter sharing their on-the-ground experience regarding best practices and lessons learned. Forum to connect ideas, share stories, experiences, and suggestions, as well as questions in the chat.	1 week to set up, 4 weekly sessions, online.	1	ND	94% of participants rated sessions as good, very good, or excellent.	Previously established network (systems and relationships: support system, including a project manager, IT support, and a registration/communication platform) were paramount to develop a program rapidly.	Public health emergencies require rapid delivery of high-quality information to HCPss, including those in rural communities. Project ECHO effectively met the urgent needs and reached a large proportion of the state.
Sud et al.	Undergraduate ophthalmology teaching in COVID-19 times: Students' perspective and feedback	July	UME	Medical students	Ophthal-mology	Asia	Academic hospital	Pivot to online learning (asynchronous)	Shift to online teaching of ophthalmology	Lectures converted into a virtual learning environment. PowerPoint presentations were uploaded to the shared area online and annotated with salient points. A WhatsApp group was created to allow sharing of relevant videos and reading material, to allow students to ask questions. MCQs administered.	Education management system (EMS) on the college website, PowerPoint lecture slides, WhatsApp group, Zoom.	1	ND	Most students felt this method was a suitable alternative for teaching. 18% felt that the MCQs helped them in self-assessment. The main disadvantages were that this mode of teaching was not as interactive as classroom lectures (60%), and clarifications could not be addressed instantly (29%).	ND	This platform is not a replacement for clinical and face to face teachings but is a method of continuing education during the times of the pandemic.
Suppan et al.	Effect of an E-Learning Module on Personal Protective Equipment Proficiency by Prehospital Personnel: Web-Based, Randomized Controlled Trial. Journal of Medical Internet Research	August	CME	EMTs and emergency physicians; n=176	Emergency medicine	Europe	Academic hospital	Simulation (training for treating patients with COVID-19)	Improve PPE selection through a gamified E-learning module	A gamified e-learning module with 19 sections and 7 embedded video sequences was developed. Within the module, trigger mechanisms are used to check that the user had accessed and completed all required steps before being allowed to proceed to the following section. Two quizzes were created, with 10 MCQs each.	Online platform	1, 2a, 2b	ND	Though baseline proportion of adequate PPE choice was high (75%, IQR 50%-75%), the donning sequence was in most cases incorrect. After either intervention, adequate choice of PPE increased significantly in both groups (P<.001). Confidence in the ability to use PPE was maintained in the e-learning group (P=.27) but significantly decreased in the control group.	Participants were dissatisfied with the e-learning format. There was no added value for gamified e-module, possible due to the characteristics of the population, high baseline knowledge, lack of power, the negative effect of pre-test (serving as a primer), some surprising no significant difference in overall satisfaction with gamified e-module.	"Among prehospital personnel with an already high knowledge and experience regarding PPE use, both web-based study paths increased the rate of adequate choice of PPE. There was no major added value of the gamified e-learning module apart from preserving participants' confidence in their ability to use PPE."

Author	Title	Month	Level	Learners	Specialty (or N/A)	Region	Organization responsible	Focus of development	Stated purpose of deployment	Brief summary of development or intervention	Resources (details of cost / time / resources)	Kirk-patrick Outcome	Other Outcomes (QI, impact, policy change, checklist, etc.)	Summary of Results (main details)	Lessons Learnt by development as stated by authors (barriers, challenges)	Summary of conclusion
Tang, Chen et al.	Maintaining Training with Self-Ultrasound During COVID-19	July	GME	Radiology residents	Radiology	Asia	Academic hospital	Other	Maintain ultrasound training of radiology trainees	Self-ultrasound was introduced to maintain ultrasound training, using ultrasound machines already available in the radiology department. A list of feasible self-ultrasound parts was determined.	Ultrasound machine	2b	ND	"Current residents had lower ultrasound scores across all three components at baseline... Scores of current residents improved by mid posting (to 3.1/5.0, 3.1/5.0, and 3.2/5.0 respectively compared to the previous group's mid posting scores of 3.0/5.0,3.1/5.0, and 3.7/5.0) and showed no statistical difference from the previous batch ($p > 0.06$).	Residents got to feel the patient experience, but not much significant pathology seen.	"Self-ultrasound sessions can be used to maintain ultrasound training during periods requiring reduced human interaction."
Tang, New et al.	Zooming for cells: Tele-education of histopathology residents during the COVID-19 pandemic	August	GME	Histopathology residents, medical officers, fellows	Pathology	Asia	Academic hospital	Pivot to online learning (synchronous)	Develop virtual histopathology teaching sessions during the pandemic and assess its suitability as a replacement	Virtual (1-2 hour) histopathology teaching sessions enabled interactive, 'real-time' review of images with learners. A microscopy camera was attached to a single-header microscope, connected to an internet-enabled laptop which allowed images to be projected on the screen which was then 'screen-shared' on Zoom.	Zoom	1	ND	93% of respondents (11 respondents to the survey) were satisfied with using Zoom, with 18% showing high satisfaction. Participants commented that this system was a good replacement for the more traditional means of teaching.	Pros - set up allowed greater attendance, especially from those posted to different hospitals. Cons - technical / hardware issues; poor internet connection, poor image resolution and voice quality, lag in audio and image, and potential issues regarding data security / information governance	Beyond COVID-19, there are advantages to this novel method of teaching histopathology, including allowing residents who are posted away from teaching hospitals to participate in virtual sessions and to involve other expert educators from other parts of the world.
Thum DiCesare et al.	Democratizing Access to Neurosurgical Medical Education: National Efforts in a Medical Student Training Camp During COVID-19	August	UME	Medical students; n=305	Neuro-surgery	USA	Multi-institutional collaboration	Pivot to online learning (synchronous)	Developed the first live, cross-institutional virtual training camp to deliver standardized neurosurgical educational content to medical students during the pandemic	8 neurosurgery residencies participated in a 1-day virtual neurosurgery training camp. They used Zoom for breakout rooms for mentorship sessions. They covered professional, academic, and technical aspects of neurosurgery.	Increased potential participant numbers with reduced cost.	1, 2a	ND	"Of the respondents, 65.0% reported improved neurosurgical knowledge, 79.8% reported decreased anxiety about sub internships and interviews, 82.5% reported increased enthusiasm about neurosurgery, and 100% desired a future annual virtual training camp because of the increased accessibility and decreased cost."	Strengths included the variety of speakers, the ability to casually interact with attendings and residents from numerous programs, the efficiency of the event to deliver a large and varied amount of content, and the ease of transition between sessions. Areas to improve included lengthening the event, having more directed didactic sessions, and providing more advice on how to be an outstanding sub intern or interviewee.	"This virtual structure improved resource usage and scalability compared with in-person training, maintained social distancing, and democratized access to standardized, specialized content not often available through traditional medical curricula. Even as a supplement to in-person events, the virtual training model could be implemented by national medical societies, which might significantly increase medical students' preparedness for, and education in, neurosurgery and other subspecialties."
Tsang et al.	From bedside to website: A neurological clinical teaching experience	July	UME	Medical students	Neurology	Asia	University	Telehealth	Provide students with learning opportunities from real patient scenarios	Students took a complete history via Zoom on a patient, a tutor helped them perform a "physical exam", and then discussion of investigation and management took place.	Zoom	1	ND	"Students' feedback has been positive, and most found website teaching comparable to or better than bedside teaching in fulfilling learning outcomes, except for PE skills"	Able to do enough examination to facilitate discussion. 'Annotate' and 'Remote control' in conjunction with split screen enabled session to be very interactive	"Telehealth clerking is an addition to the existing curriculum and website teaching may continue to have a role after the pandemic, as telemedicine consultation become an essential skill for the next generation of practitioners."
Verma et al.	Online Teaching During COVID-19: Perception of Medical Undergraduate Students	June	UME	4th year medical students; n=200	N/A	Asia	University	Pivot to online learning (synchronous)	Implementation of an online teaching program to continue medical education despite the pandemic.	Google Meet was used to deliver 60-minute daily lectures online rather than face to face as previously done.	Google meet	1	ND	Almost all of the students found the online sessions to be relevant and tailored to learning needs (n = 127 (99%)). Seventy-five (57%) students felt these classes safe, comfortable and enjoyable. Still many of them (120 (92%)) felt these classes as good utilization of time and reading on those topics decreased their stress about COVID-19." "Sixty-two (47%) students want online classes to be made part of their curriculum after COVID."	Feedback identified issues such as teachers not being technology friendly, a lack of interactive teaching, and easy distraction and technical issues. Thought to be time efficient.	"Although classical "classroom teaching" is not possible to replicate through online teaching, still it is a cheap and feasible method which helps to gain knowledge, maintaining routine and improving morale of teachers and students."
Vining et al.	Virtual Surgical Fellowship Recruitment During COVID-19 and Its Implications for Resident/Fellow Recruitment in the Future	April	GME	Residents; n=20	Surgical Oncology	USA	Academic hospital	Interviews (selection to residency)	Outline the successful implementation of and processes behind a virtual interview day for fellowship recruitment	Zoom used for virtual interviews. Applicants could go to an optional prep session with the program director and staff, day lasted 4 houses.	Zoom	1	ND	"Seventy-five percent (12/16) of applicants and all faculty respondents (12/12) stated the interview process was 'very seamless' or 'seamless'. Overall, the majority of applicants expressed a preference for live interviews (11/16; 68.8%). Half of the faculty interviewers (6/12; 50.0%) preferred live interviews; one-third (4/12; 33.3%) favored video interviews."	Cost and time savings	"Current circumstances related to the COVID-19 pandemic require fellowship programs to adapt and conduct virtual interviews"

Author	Title	Month	Level	Learners	Specialty (or N/A)	Region	Organization responsible	Focus of development	Stated purpose of deployment	Brief summary of development or intervention	Resources (details of cost / time / resources)	Kirk-patrick Outcome	Other Outcomes (QI, impact, policy change, checklist, etc.)	Summary of Results (main details)	Lessons Learnt by development as stated by authors (barriers, challenges)	Summary of conclusion
Wenhui, et al.	Whole-Process Emergency Training of Personal Protective Equipment Helps Healthcare Workers Against COVID-19	June	CME	Healthcare workers; n = 263	Multi-professional	Asia	Academic hospital	Simulation (training for treating patients with COVID-19)	Develop an emergency training program of PPE for general HCW who may be under the threat COVID-19 and evaluate the effect of the program.	Authors devised a training session for HCW. The training process was divided into three sections: (1) lecture and demonstration; (2) simulation exercise; (3) test and evaluation. In the lecture, the skills were demonstrated, and participants practiced. In the simulation section, the participants were assessed on ability to carry out tasks in the simulation. In the test section, trainees had to complete the simulation in pairs.	PPE for practice	2b	ND	Post-test scores were significantly improved when compared with the pre-test scores. Among all PPE, N95 respirator and protective cover all needed training most. Meanwhile, ‘‘proficiency level’’ and ‘‘mutual check & help’’ also needed to be strengthened as independent scoring points.	HCWs prefer surgical masks in daily work which are more comfortable and breathable. N95 and PPE easy to lose points because seldom used in ordinary times and both the donning and doffing (especially) are complicated.	This training program significantly improved the performances of participants. It may therefore be applied for general HCWs on a larger scale
Wenlock, et al.	Low-fidelity simulation of medical emergency and cardiac arrest responses in a suspected COVID-19 patient - an interim report	July	GME	Resident physicians and nurses; n = 56	Multi-professional	Europe	Academic hospital	Simulation (training for treating patients with COVID-19)	Pilot a low-fidelity COVID-19 simulation to improve our understanding of the role simulation can play, offer a safe training environment, identify problems with current protocols while providing workable solutions	The team organized two in-situ simulation scenarios: 1) a presumed decompensated heart failure who also has COVID-19 symptoms, and becomes unresponsive at the start of the case; 2) an acutely unwell patient who deteriorates into cardiac arrest mid-simulation and is a PUI for COVID-19; two facilitators: 1) run the scenario, 2) observe and provide feedback. The simulations were often observed by non-participating members of the ward team to maximize interprofessional learning.	Hospital simulation center equipment and four full-time teachers and five training assistants.	2a	QI / policy change: added a fifth member to COVID response team (runner)	Staff reported being significantly less prepared to respond to an emergency in a patient with COVID-19. The simulations significantly improved participants’ confidence in responding to emergencies in patients with suspected COVID-19. Numerous challenges were identified along the themes of equipment, personnel, communication and procedures.	Participants requested more simulations of the same type on a regular basis to improve skills, and to run simulations that involved different skillsets such as setting up CPAP. Participants noted that four people in the room were too few (compressions, defibrillation, procedures, team lead, airway, and room runner needs), which led to development of a fifth person to be runner.	Low-fidelity simulation can provide relevant and timely information on how prepared health systems and their workforce are to respond to emergencies.
Wlodarczyk, et al.	Development and emergency implementation of an online surgical education curriculum for a General Surgery program during a global pandemic: The University of Southern California experience	Sept-ember	GME	Residents; n=35	General Surgery	USA	Academic hospital	Pivot to online learning (synchronous, asynchronous)	Present a novel online curriculum for incorporation into traditional surgical educational programs to facilitate knowledge retention through the incorporation of a multimodal educational platform.	A multimodal curriculum was developed and implemented. Zoom was used as the foundation of the interactive e-curriculum. Residents participated in 1-2 online activities. The content was created to stimulate both passive and active learning in a flipped classroom setting. Educational activities included - (1) Faculty lectures, (2) Resident topic discussion, (3) Journal club, and (4) Question review sessions. All sessions were recorded and accompanying presentation materials were made available to all residents.	Zoom	1	ND	71.9% of residents and 16.6% of faculty reported improved resident participation while none reported decreased levels of participation ($p < 0.001$). 87.1% of residents and 66.7% of faculty preferred the online curriculum... Completed...practice questions per resident increased."	Faculty and residents voiced their preference for the online educational model. The ability to attend from various locations and record for future viewing was highlighted. There was a discordance regarding participant engagement thought to be due to resident discomfort asking questions and presenting viewpoints online and faculty inability to assess audience engagement.	The "online educational curriculum demonstrates success and can serve as a model for online restructuring of resident education."
Xu, et al.	Virtual grand rounds as a novel means for applicants and programs to connect in the era of COVID-19	Sept-ember	UME	Medical students; n=18	Urology	USA	Academic hospital	Interviews (selection to residency), Pivot to online learning (synchronous)	Investigate the feasibility and utility of video conferencing technology as an opportunity for applicants to interact with faculty from outside programs	Applicants were randomized to 6 urology programs to give a virtual grand round talk. "Presentations were recorded and analyzed to determine audience engagement. Students were surveyed regarding perceived utility of virtual grand rounds. Faculty were surveyed to determine system usability….and ability to evaluate the applicant."	Zoom, Web	1	ND	100% student satisfaction rate with virtual grand rounds. A majority felt this was a useful way to learn about outside programs. Nearly half of faculty felt confident in their ability to evaluate the applicant	Not a standardized process	"Virtual grand rounds can be a useful means for medical students to express interest in programs as well as an additional marker for faculty to evaluate applicants"
Zhang, et al.	The evaluation of online course of Traditional Chinese Medicine for MBBS international students during the COVID-19 epidemic period.	June	UME	Medical students; n=84	N/A	Asia	University	Pivot to online learning (synchronous, asynchronous)	Investigate students’ perception of an online traditional Chinese medicine course, and assess online learning efficacy	Two online learning platforms, ZJU and Dingtalk, were used to teach a traditional Chinese medicine course synchronously and asynchronously. The course covered 32 lectures in eight weeks. Students consulted instructional materials, submitted assignments, and took exams.	Online learning platforms ZJU and Dingtalk	1, 2a	ND	Participants preferred face-to-face learning (54.17%). Students felt the course brought benefits (mean 3.88, SD 0.87), and they were satisfied with the course content (mean 3.83, SD 0.95). Students’ TCM related knowledge and behaviors were significantly improved (all $P < 0.001$). Students’ awareness of the necessity of TCM education and their feeling of difficulty in learning TCM were strengthened.	Students reported enjoyed the ability to control the online lectures and to complete things asynchronously at their convenience. However, transition to remote learning requires time to adapt. Students felt less engaged/more distracted. The loss of hands-on activities and need for self-discipline on the part of the student also represent challenges.	"Online learning is a good alternative for TCM course of MBBS international students when classroom learning is suspended, whereas it cannot replace the need for onsite and face-to-face learning."

UME = undergraduate medical education, GME = graduate medical education, CME = continuing medical education, Mixed = some combination of UME, GME, CME, HCW = health care workers, TOT = trainers of trainees, WHO = World Health Organization, ND = not described, N/A = not applicable, CMT = crisis management team, PPE = personal protective equipment, Q&A = question and answer, RT-qPCR = quantitative reverse transcription polymerase chain reaction, ICT = information communication technology, ACGME = Accreditation Council for Graduate Medical Education, ENT = ear-nose-throat, IPE = interprofessional education, Re-ACT = Remote Advanced Communication Training, NP = nurse practitioners, PA = physician assistants, SP = standardized or simulated patient, ED = emergency department, ICU = intensive care unit, SARS = Severe acute respiratory syndrome, HIPPA = Health Insurance Portability and Accountability Act, ACT = Advanced Communication Training, QI = quality indicators, PBL = problem based learning, PAPR = powered air-purifying respirator, APPCN = Association of Postdoctoral Programs in Clinical Neuropsychology, TPRAT = Trainee Pandemic Role Allocation Tool, MDI = multisite didactic initiative, AHA = American Heart Association, GERI-A-FLOAT = GERIAtrics Fellows Learning Online And Together, SAVEd = Self-isolAting Virtual Education, GP = General Practice, AMSER = Alliance of Medical Student Educators in Radiology, MCQ = multiple choice questions, WSI = whole slide imaging, MD = doctorate of medicine, PACS = secure picture archiving communication system, OSCE = objective structured clinical examination, AV = audio visual, VPN = virtual private network, LAPP = web-mobile-based platform to train laparoscopic surgeons remotely, TBL = team based learning, POPCoRN = Pediatric Overflow Planning - Contingency Response Network, ViSEG = Virtual Surgical Education Group, USMLE = United States Medical Licensing Examination, MAL = Master Adaptive Learner, CAPR = Controlled Air Purifying Respirators, ABG = arterial blood gases, OB-GYN = obstetrics and gynecology, JAMA = Journal of the American Medical Association, CST = core surgical training, CSE = clinical skills exam, NBME = National Board of Medical Examiners, VGSC = Virtual Global Spine Conference, SDR = "simulated daily readout, EM = emergency medicine, AliEM = Academic Life in Emergency Medicine, OBE = open book exam, WSI = whole slide images, STAT = Simulation Team Assessment Tool, SET-M = Simulation Effectiveness Tool, CBE = closed book exam, ECHO = Extension for Community Healthcare Outcomes, CPD = continuing professional development, TTE = Transthoracic Echocardiography, HCP = health care professional, EMS = Education management system, TCM = Traditional Chinese Medicine, MBBS = Medical Bachelor, Bachelor of Surgery

Figure 1: PRISMA flow diagram for included studies

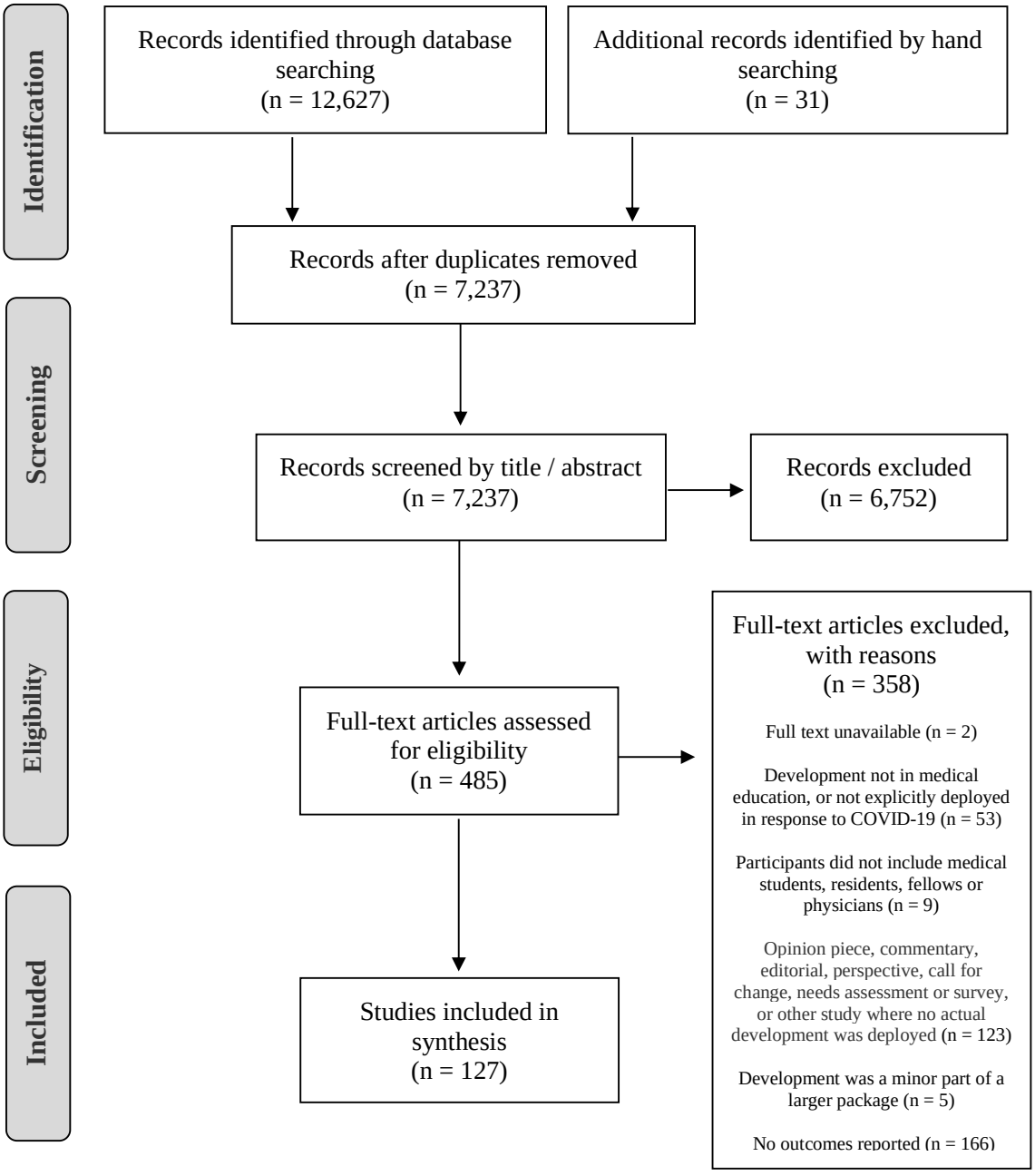
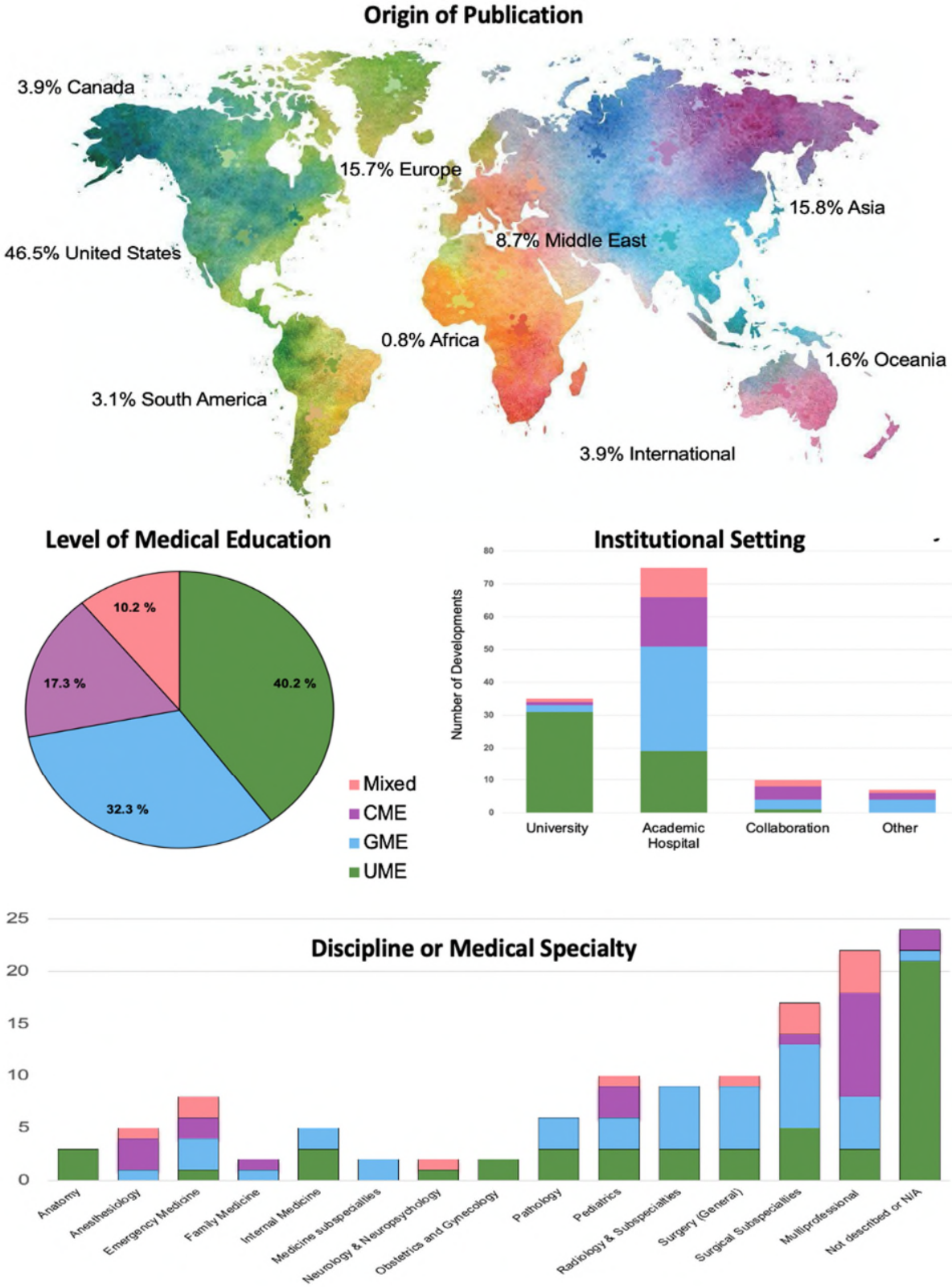


Figure 2: Infographic summarizing key findings



Focus of Development

45.7% Pivot to online learning

18.9% Simulation

8.7% Assessment

7.1%. Other or Multiple

6.3% Wellbeing / learner support

3.9% Telehealth

3.1% Service reconfiguration

3.1% Interviews and selection

1.6% Service

1.6% Faculty development

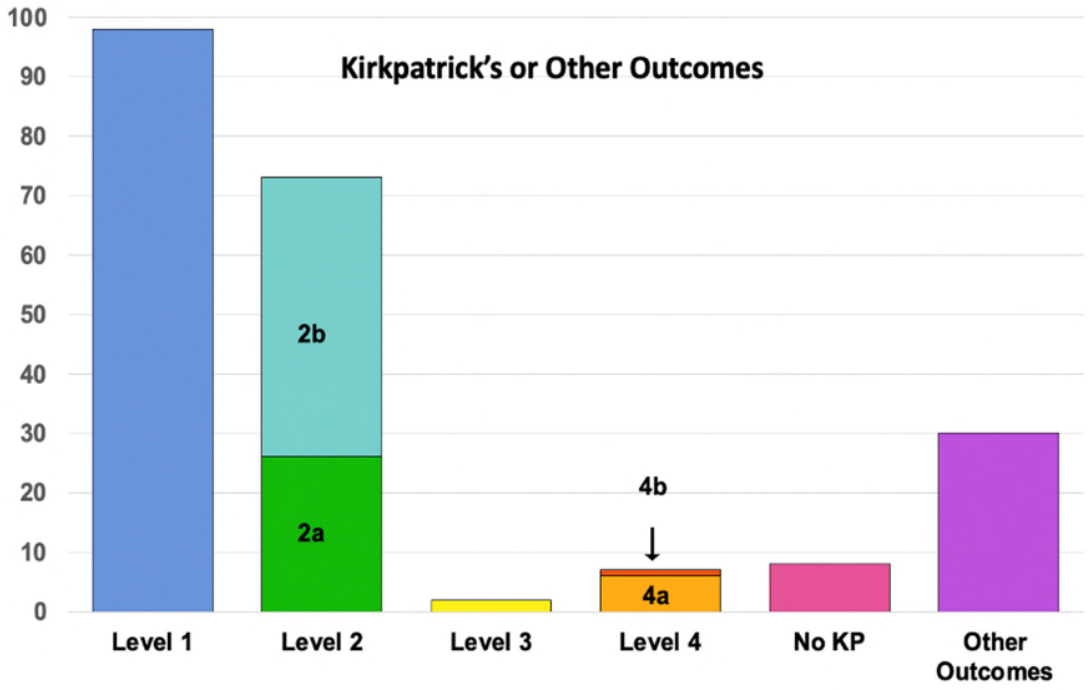


Table 2: Origin of included studies

Origin	Level of medical education				Total
	UME	GME	CME	Mixed	
United States	26	22	8	3	**59 (46.5%)**
Canada	0	0	4	1	**5 (3.9%)**
South America	0	3	1	0	**4 (3.1%)**
Europe	8	7	4	1	**20 (15.7%)**
Middle East	6	2	1	2	**11 (8.7%)**
Africa	0	0	0	1	**1 (0.8%)**
Asia	9	5	3	3	**20 (15.8%)**
Oceania	2	0	0	0	**2 (1.6%)**
International	0	2	1	2	**5 (3.9%)**
Totals:	**51 (40.2%)**	**41 (32.3%)**	**22 (17.3%)**	**13 (10.2%)**	**127 (100%)**

UME = undergraduate medical education, GME = graduate medical education, CME = continuing medical education, Mixed = some combination of UME, GME, CME

Table 3: Institutional Setting

Who is responsible for educational delivery?	Level of medical education				
	UME	**GME**	**CME**	**Mixed**	**Total**
University	31	2	1	1	35 (27.5%)
Academic Hospital	19	32	15	9	75 (59.1%)
Collaboration	1	3	4	2	10 (7.9%)
Other (e.g. national organization)	0	4	2	1	7 (5.5%)
Totals:	**51 (40.2%)**	**41 (32.3%)**	**22 (17.3%)**	**13 (10.2%)**	**127 (100%)**

UME = undergraduate medical education, GME = graduate medical education, CME = continuing medical education, Mixed = some combination of UME, GME, CME

Table 4: Discipline or medical specialty

Specialty	UME	GME	CME	Mixed	Total
Anatomy	3	0	0	0	3
Anesthesiology	0	1	3	1	5
Emergency Medicine	1	3	2	2	8
Family Medicine	0	1	1	0	2
Internal Medicine	3	2	0	0	5
Medicine subspecialties	0	2	0	0	2
Neurology & Neuropsychology	1	0	0	1	2
Obstetrics and Gynecology	2	0	0	0	2
Pathology	3	3	0	0	6
Pediatrics	3	3	3	1	10
Radiology & Subspecialties	3	6	0	0	9
Surgery (General)	3	6	0	1	10
Surgical Subspecialties	5	8	1	3	17
Multi-professional or multi-disciplinary	3	5	10	4	22
Not described or not applicable	21	1	2	0	24
				Total	127

Table 5: Focus of development

Focus	UME	GME	CME	Mixed	Total
Pivot to online learning (synchronous, asynchronous)	31	20	2	5	58 (45.7%)
Simulation (training for treating patients with COVID-19)	0	4	14	6	24 (18.9%)
Assessment	8	3	0	0	11 (8.7%)
Other or multiple areas of focus	2	5	1	1	9 (7.1%)
Well-being / mental health / learner support	3	1	3	1	8 (6.3%)
Telehealth	4	1	0	0	5 (3.9%)
Clinical service reconfiguration or early graduation to support the response to COVID-19	2	2	0	0	4 (3.1%)
Interviews (admission to medical school, selection to residency)	0	4	0	0	4 (3.1%)
Service provision	1	1	0	0	2 (1.6%)
Faculty or professional development	0	0	2	0	2 (1.6%)
Total	**51**	**41**	**22**	**13**	**127 (100%)**

Table 6: Kirkpatrick's or other outcomes

	Number of Studies
Kirkpatrick Level 1: Reaction or Satisfaction	98
Kirkpatrick Level 2a: Change in Attitudes	26
Kirkpatrick Level 2b: Change in Knowledge or Skills	47
Kirkpatrick Level 3: Change in Behavior	2
Kirkpatrick Level 4a: Change in Organizational Practice	6
Kirkpatrick Level 4b: Change in Clinical Outcomes	1
Kirkpatrick Not described	8
Other Outcomes (e.g., quality improvement, policy change, etc.)	30

Note: several studies addressed multiple Kirkpatrick levels or had multiple outcomes

Appendix 1: Search strategy

PubMed

(covid-19[tw] OR COVID19[tw] OR COVID-19[nm] OR SARS-CoV-2[tw] OR SARS-CoV2[tw] OR severe acute respiratory syndrome coronavirus 2[nm] OR severe acute respiratory syndrome coronavirus 2[tw] OR 2019-nCoV[tw] OR 2019nCoV[tw] OR coronavirus[tw] OR coronavirus[mh] OR pandemic[tw]) AND ("Internship and Residency"[Mesh] OR "Students, Medical"[Mesh] OR "Education, Medical"[Mesh] OR "Schools, Medical"[Mesh] OR Intern[tiab] OR interns[tiab] OR "House officer"[tw] OR "house officers"[tw] OR Resident[ti] OR residents[ti] OR residency[ti] OR "medical education"[tw] OR fellow[tiab] OR fellows[tiab] OR "junior doctor"[tw] OR "junior doctors"[tw] OR "post-graduate"[tw] OR postgraduate[tw] OR "foundation year"[tw] OR "foundation program"[tw] OR "medical student"[tw] OR "medical students"[tw] OR "Curriculum"[mesh] OR curricul*[tiab] OR "medical school"[tw] OR "medical schools"[tw] OR "medical training"[tw] OR "undergraduate"[tw] OR "graduate"[tw] OR Learn*[tw] OR training[tw] OR trainer[tw] OR trainee*[tw] OR instructor*[tw] OR instructional[tw] OR educat*[tw] OR classroom*[tw] OR simulat*[tw] OR virtual[tw] OR ZOOM[tw]) AND ("2020/05/01"[Date - Publication] : "3000"[Date - Publication])

Embase

('covid 19':ti,ab OR covid19:ti,ab OR 'covid 19':tn OR 'sars cov 2':ti,ab OR 'sars cov2':ti,ab OR 'severe acute respiratory syndrome coronavirus 2':tn OR 'severe acute respiratory syndrome coronavirus 2':ti,ab OR '2019 ncov':ti,ab OR 2019ncov:ti,ab OR coronavirus:ti,ab OR 'coronavirinae'/exp OR pandemic:ti,ab) AND ('medical education'/exp OR 'health student'/exp OR 'medical school'/exp OR intern:ti,ab OR interns:ti,ab OR 'house officer':ti,ab OR 'house officers':ti,ab OR resident:ti OR residents:ti OR residency:ti OR 'medical education':ti,ab OR fellow:ti,ab OR fellows:ti,ab OR 'junior doctor':ti,ab OR 'junior doctors':ti,ab OR 'post graduate':ti,ab OR postgraduate:ti,ab OR 'foundation year':ti,ab OR 'foundation program':ti,ab OR 'medical student':ti,ab OR 'medical students':ti,ab OR 'curriculum'/exp OR 'curriculum development'/exp OR curricul*:ti,ab OR 'medical school':ti,ab OR 'medical schools':ti,ab OR 'medical training':ti,ab OR undergraduate:ti,ab OR graduate:ti,ab OR learn*:ti,ab OR training:ti,ab OR trainer:ti,ab OR trainee*:ti,ab OR instructor*:ti,ab OR instructional:ti,ab OR educat*:ti,ab OR classroom*:ti,ab OR virtual:ti,ab OR zoom:ti,ab) AND [2020-2021]/py

CINAHL

((MH "Coronavirus+") OR (MH "Coronavirus Infections+")) OR TI (covid-19 OR COVID19 OR MW COVID-19 OR SARS-CoV-2 OR SARS-CoV2 OR MW "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR 2019-nCoV OR 2019nCoV OR coronavirus OR pandemic) OR AB (covid-19 OR COVID19 OR MW COVID-19 OR SARS-CoV-2 OR SARS-CoV2 OR MW "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR 2019-nCoV OR 2019nCoV OR coronavirus OR pandemic)

AND

TI (Intern OR interns OR "House officer" OR "house officers" OR OR "medical education" OR fellow OR fellows OR "junior doctor" OR "junior doctors" OR post-graduate OR postgraduate OR "foundation year" OR "foundation program" OR "medical student" OR "medical students" OR curricul* OR "medical school" OR "medical schools" OR "medical training" OR undergraduate OR graduate OR Learn* OR training OR trainer OR trainee* OR instructor* OR instructional OR educat* OR classroom* OR simulat* OR virtual OR ZOOM) OR AB (Intern OR interns OR "House officer" OR "house officers" OR OR "medical education" OR fellow OR fellows OR "junior doctor" OR "junior doctors" OR post-graduate OR postgraduate OR "foundation year" OR "foundation program" OR "medical student" OR "medical students" OR curricul* OR "medical school" OR "medical schools" OR "medical training" OR undergraduate OR graduate OR Learn* OR training OR trainer OR trainee* OR instructor* OR instructional OR educat* OR classroom* OR simulat* OR virtual OR ZOOM) OR TI (Resident OR residents OR residency) OR ((MH "Education, Health Sciences+") OR (MH "Schools, Medical+") OR (MH "Students, Health Occupations+") OR (MH "Curriculum+"))

PsycInfo

((DE "Coronavirus" OR DE "Middle East Respiratory Syndrome" OR DE "Severe Acute Respiratory Syndrome")) OR TI (covid-19 OR COVID19 OR MW COVID-19 OR SARS-CoV-2 OR SARS-CoV2 OR MW "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR 2019-nCoV OR 2019nCoV OR coronavirus OR pandemic) OR AB (covid-19 OR COVID19 OR MW COVID-19 OR SARS-CoV-2 OR SARS-CoV2 OR MW "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR 2019-nCoV OR 2019nCoV OR coronavirus OR pandemic)

AND

TI (Intern OR interns OR "House officer" OR "house officers" OR OR "medical education" OR fellow OR fellows OR "junior doctor" OR "junior doctors" OR post-graduate OR postgraduate OR "foundation year" OR "foundation program" OR "medical student" OR "medical students" OR curricul* OR "medical school" OR "medical schools" OR "medical training" OR undergraduate OR graduate OR Learn* OR training OR trainer OR trainee* OR instructor* OR instructional OR educat* OR classroom* OR simulat* OR virtual OR ZOOM) OR AB (Intern OR interns OR "House officer" OR "house officers" OR OR "medical education" OR fellow OR fellows OR "junior doctor" OR "junior doctors" OR post-graduate OR postgraduate OR "foundation year" OR "foundation program" OR "medical student" OR "medical students" OR curricul* OR "medical school" OR "medical schools" OR "medical training" OR undergraduate OR graduate OR Learn* OR training OR trainer OR trainee* OR instructor* OR instructional OR educat* OR classroom* OR simulat* OR virtual OR ZOOM) OR TI (Resident OR residents OR residency) OR ((DE "Medical Education" OR DE "Medical Internship" OR DE "Medical Residency" OR DE "Psychiatric Training") OR (DE "Medical Students") OR (DE "Curriculum" OR DE "Curriculum Development"))

Appendix 2: Full text screening form

Does this paper describe developments or interventions in medical education explicitly deployed in response to COVID-19?

- ☐ Yes (include)
- ☐ No (exclude)

Do the participants include medical students, residents, fellows or physicians? (The study may include other health professions in addition.)

- ☐ Yes (include)
- ☐ No (exclude)

The paper is an opinion piece, commentary, editorial, perspective, call for change, needs assessment, or other study where no actual development was deployed (e.g., an evaluation of the impact of COVID on training where an intervention is not described; an evaluation of "e-learning" across multiple institutions where the e-learning developments are not described).

- ☐ Yes (exclude)
- ☐ No (include)

This study describes a development that is a minor part of a larger package of planned measures (e.g., an entire university, including the medical school, pivoted to online education).

- ☐ Yes (exclude)
- ☐ No (include)

This study describes outcomes, either Kirkpatrick's outcomes (level 1 reaction, satisfaction; level 2a change in attitudes, level 2b change in knowledge or skills; level 3 change in behavior; level 4a change in organizational practice, level 4b change in clinical outcomes) OR other outcomes (e.g., quality improvement effect, policy change, etc).

- ☐ Yes (include)
- ☐ No (exclude)

Population – this study pertains to:

- ☐ UME
- ☐ GME
- ☐ CME

Focus - this study pertains to:

- ☐ Assessment
- ☐ Telehealth
- ☐ Well-being / mental health / learner support
- ☐ Faculty Development
- ☐ Clinical service reconfiguration or early graduation to support the response to COVID-19
- ☐ Interviews (admission to medical school, selection to residency, faculty selection)
- ☐ Training for treating patients with COVID-19 (e.g., simulations)
- ☐ Pivot to online learning (synchronous, asynchronous)
- ☐ Service provision
- ☐ Other