Developments in medical education in response to the COVID-19 pandemic: A rapid BEME systematic review: BEME Guide No. 63

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Abstract

Background

The novel coronavirus disease (COVID-19) was declared a pandemic in March 2020. This rapid systematic review synthesised published reports of medical educational developments in response to the pandemic, considering descriptions of interventions, evaluation data and lessons learned.

Methods

The authors systematically searched four online databases and hand searched MedEdPublish up to May 24, 2020. Two authors independently screened titles, abstracts and full texts, performed data extraction and assessed risk of bias for included articles. Discrepancies were resolved by a third author. A descriptive synthesis and outcomes were reported.

Results

Forty-nine articles were included. The majority were from North America, Asia and Europe. Sixteen studies described Kirkpatrick's outcomes, with one study describing levels 1-3. A few papers were of exceptional quality, though the risk of bias framework generally revealed capricious reporting of underpinning theory, resources, setting, educational methods, and content. Key developments were 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. Training for treating patients with COVID-19, service reconfiguration, assessment, well-being, faculty development, and admissions were all addressed, with the latter categories receiving the least attention.

Conclusions

This review highlights several areas of educational response in the immediate aftermath of the COVID-19 pandemic and identifies a few articles of exceptional quality that can serve as models for future developments and educational reporting. There was often a lack of practical detail to support the educational community in enactment of novel interventions, as well as limited evaluation data. However, the range of options deployed offers much guidance for the medical education community moving forward and there was an indication that outcome data and greater detail will be reported in the future.

Practice Points

- Remote synchronous and asynchronous educational developments were rapidly deployed and will likely persist beyond the pandemic. Learner engagement, structure and organization are key.
- Maintaining clinical exposure is important for learners impacted by COVID-19 and can be achieved using telehealth, PPE, physical distancing.
- Quality and detail of reporting educational developments must improve to promote replication in different contexts.

Background

The novel coronavirus disease (COVID-19) is a highly contagious viral illness caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). COVID-19 was first reported in Wuhan, Hubei Province, China in December 2019. Within weeks of its emergence, it had spread to several countries. In January 2020, the World Health Organisation (WHO) declared the outbreak a Public Health Emergency of International Concern. By March 2020, COVID-19 had evolved into a pandemic (Bedford et al. 2020). According to the dashboard of the Center for Systems Science and Engineering at Johns Hopkins University (JHU 2020), Baltimore, USA, the disease has now been reported in 188 countries, affecting over 15,000,000 people worldwide, resulting in over 600,000 deaths.

The impact of COVID-19 on healthcare systems and medical education has been unprecedented. Huge numbers of campuses have gone into lockdown. The need to physically distance and conserve personal protective equipment (PPE) has resulted in the suspension of in-person learning in classrooms, and even the workplace. The effects of COVID-19 have been felt across the medical education continuum, necessitating a myriad of changes. The educational community has rapidly adjusted their approach to meet these challenges, and a number of educational developments to support learning and educational progress have been reported.

Journals have expedited peer review to ensure COVID related innovations and adaptations reach educators in a timely manner. This has resulted in a large number of articles of varying quality

being published in a very short timeframe. Busy educators trying to adapt their practices to the continually evolving pandemic need an up-to-date collated resource that discusses and evaluates these developments.

Dedeilia et al. (2020) previously conducted a systematic review of educational developments in response to COVID-19. At the time of their review, they noted a 'scarcity of available sources' and thus decided to include letters to the editor, commentaries, editorials and perspectives. Their search ended April 18, 2020 and there has been a significant increase in the quantity and quality of articles since that time.

The aim of the current systematic review is to identify the evidence concerning teaching, assessment or other educational developments in response to the COVID-19 pandemic within medical education. Our review will address three main questions:

- What developments or changes in medical education have been deployed? (i.e., description or 'what was done' (Cooke et al. 2008))
- What is the impact of these developments or changes? (i.e., evaluation or 'did it work?')
- What lessons to be applied in the future have been learned by the teams who deployed these developments or changes? (i.e., implications or 'what's next?')

Methods

This review was conducted as a 'rapid' review, meaning that the timeframe from inception to completion was < 4 weeks. It is vital to note that the speed with which the review was conducted in no way impacted the methodological rigour of the approach. We embraced systematicity throughout, from the search strategy to the synthesis (Gordon et al. 2019a). We aligned with both positivism (applying the principles of systematic reviewing) and constructivism (utilizing qualitative synthesis methods). A study protocol (Gordon et al. 2020) was completed a priori and uploaded into the study repository on the Best Evidence in Medical Education (BEME) website. We reported our findings in alignment with 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).

Search strategy

We conducted an electronic search of four databases (MEDLINE, EMBASE, CINAHL and PsychINFO). We selected these 4 databases as they contain almost all the journals that publish on medical education and they are most commonly used in BEME reviews. We utilized 22 search terms and their Boolean combinations. The search was piloted on May 18, 2020 to check the appropriateness of the search strategy. This led to the addition of further terms, as the search was producing too many potential papers (roughly 1 paper meeting the inclusion criteria for every 10 titles) suggesting the search was too narrow. The final search was performed on May 24, 2020 using the following terms: (coronavirus OR covid19 OR covid-19 OR SARS-Cov-2 OR 2019-nCoV) AND (Medical education OR undergraduate medical OR medical student OR medical school OR training OR continuing medical education OR postgraduate medical

education OR assessment OR teaching OR evaluation OR interview OR recruitment OR distance learning OR examinations OR OSCE OR PPE OR clinical skills). To identify additional relevant articles, we conducted a hand search of MedEdPublish. Due to the short timeframe between the advent of COVID-19 and this review being performed, forwards and backwards citation searching was not performed as this was not considered likely to identify any further relevant papers.

Inclusion and exclusion criteria

The following inclusion criteria were used:

- Studies describing developments in medical education explicitly deployed in response to COVID-19.
- Studies in undergraduate, graduate or continuing medical education.
- Studies published after December 1, 2019, when COVID-19 was first identified.
- Studies in any language.

The following exclusion criteria were applied:

- Opinion pieces, commentaries, editorials, perspectives, calls for change, needs assessments and other studies where no actual development had been deployed.
- Studies that have Health Care Professionals but no medical students, residents, fellows, or physicians.
- Studies that describe the development as a minor part of a larger package of planned measures.

The original protocol stipulated that Kirkpatrick's outcomes needed to be reported for inclusion (Kirkpatrick and Kirkpatrick 2016). However, during the pilot phase, we identified several interventions of interest that had been executed, but not evaluated due to insufficient time prior to publication Consequently, we decided to amend the protocol and include such studies.

The titles and abstracts of all papers identified through the search were reviewed independently by two authors against the above inclusion and exclusion criteria. Inter-rater reliability was calculated using Cohen's Kappa. The full papers of all studies included after abstract screening were retrieved and again reviewed against our inclusion and exclusion criteria by two authors. Disputes at either stage were resolved through discussion, including a third author where necessary, until consensus was reached.

Data extraction

Based on BEME Guidance (Hammick et al. 2010), we devised and piloted a data extraction form to be completed online within Google Sheets to allow synchronous review and sharing of extracted data.

Data extracted included:

- Paper identifiers (author(s), date)
- Context (geographic location, local COVID-19 specific details, education level, institutional setting, number of learners)

- Description of intervention (focus of development, purpose of deployment, brief summary of development, further description of development)
- Intervention outcome (Kirkpatrick outcome, summary of results, plans for future study)
- Risk of bias (underpinning bias, resource bias, setting bias, content bias, development limitations)
- Other details (key points for discussion, lessons learnt, summary of conclusions, appropriateness of conclusion, any other comments by extractor)

Two studies were extracted by all authors independently and a meeting was held to ensure appropriateness of the extraction forms and shared understanding of terms to enhance inter-rater reliability. Extraction was then completed by two authors independently and disputes were resolved by involving a third author (MG) and discussing until a full consensus was reached at regular research team meetings.

Quality assessment

While many methods have been utilised to assess quality and judge risk of bias in medical education reviews, no consensus method exists (Buckley et al., 2009, CASP 2014, Gordon et al. 2018). The review team postulated, in line with previous BEME reviews, that this is partly related to the complexity of educational developments and therefore requires an approach that can address and account for this complexity. Thus, we considered two distinct quality elements: 1) the risk of bias or quality of the study design when outcomes were reported (similar to the Cochrane tradition) *and* 2) the risk of bias or quality of reporting for the educational

development itself (as previously used by Gordon et al. (2019b) and Gordon et al. (2018), originally modified from Reed et al. (2005)). The latter is critically important, because only when the development is robustly described, can educators or researchers hope to replicate the results in other contexts.

For the first element, if sufficient data on study design and outcomes were provided, we used the risk of bias tool (i.e., Higgins criteria) for randomized-control trials (Sterne et al. 2019) and the ROBINS-I tool (Risk Of Bias In Non-randomized Studies of Interventions) for non-randomised trials (Sterne et al. 2016) in line with current Cochrane handbook advice. If no such details were given, the quality of the study design and outcomes were not assessed. For the second element, we considered whether the authors explicitly reported on five key areas related to the educational development. A visual ranking system (Gordon & Gibbs 2014) was used to report risk of bias for these five areas (e.g., underpinning bias, resource bias, setting bias, educational bias, and content bias). Items were judged to be of high quality and low risk of bias (green), unclear quality and risk (yellow) or high risk and low quality related to lack of reporting (red). This ranking system is shown in Table 1.

Thresholds for judgements were discussed during piloting of the data extraction form. All judgements were made independently by two authors and disagreements were resolved through discussion or involvement of a single third author (MG). No weighting or overall rank is given, as no item is more important than another. Rather the judgement in each area is presented so readers can assess areas of stronger and weaker reporting.

Of note, for both elements, poor reporting does not necessarily mean the educational development is of poor quality, but it increases the risk that such poor quality may exist, hence the use of the terminology 'risk of bias' in reporting. Importantly, poor reporting limits utility for readers, as they will struggle to determine if the educational development is transferable to their context.

[INSERT TABLE 1 NEAR HERE]

Synthesis of evidence

A descriptive synthesis of included studies was completed utilizing data from the extraction form to summarize 'what was done'. This summary described the timing of publication, the setting (undergraduate, postgraduate, mixed), the geographical location and COVID-19 specific contextual factors, the type and number of participants, the focus of the educational developments and the purpose of the deployments. Outcomes (when available) were classified in accordance with Kirkpatrick's model of evaluation to determine 'did it work' (Kirkpatrick and Kirkpatrick 2016). Quality assessment for the five areas were reported. We planned for meta-analysis; however, suitably homogenous outcome data was not found. We close with lessons learned (i.e., 'what's next') as stated in the primary papers by the authors.

Results

The search was performed on 24th May 2020. A total of 7448 titles were found, with a further 28 identified through hand searching MedEdPublish. After deduplication, 6215 remained. Through title and abstract screening, 6004 studies were excluded. A total of 213 studies were considered

for full text screening and 164 were excluded. Inter-rater reliability at the screening phase was κ=0.933 (95% CI 0.927 to 0.94), representing almost perfect alignment. The primary reasons for exclusion were as follows: the article represented an editorial or opinion piece without deployment of a change (90), the article described a theoretical development or idea with no actual intervention (71), and the article was restricted to other health care professionals and did not include medics (3). Forty-nine studies were included in the final analysis. The flow diagram for included studies is shown in Figure 1 (PRISMA 2015).

[INSERT FIGURE 1 NEAR HERE]

Publications

The four earliest studies that were included in the review were published in March, 22 studies were published in April, and 23 studies were published in May. Of the 49 publications, 15 were published in a new virtual issue of *Medical Education* entitled "Adaptations", designed to rapidly share insights and innovations from health professions educators in response to COVID-19 (Eva & Anderson 2020).

Classification of studies

Table 2 presents the number of studies in terms of geographical location, the level of medical education and the institutional setting.

[INSERT TABLE 2 NEAR HERE]

Geographical location and local COVID-19 specific details

Twenty-three studies (47%) were conducted in North America, including fourteen studies in the United States, eight studies in Canada and one study in Mexico. A further twelve studies (25%) were conducted in Asia, ten studies (20%) in Europe, two studies (4%) in Africa, and one study (2%) in South America. Only one study (2%) was international.

In Canada, local COVID-19 restrictions limited group gatherings (Keegan et al. 2020) and learners were withdrawn from clinical placements (Haines et al. 2020, Johnston et al. 2020, Boodman et al. 2020). In the United States, the Centre for Disease Control and Prevention recommended implementation of physical distancing and cancellation of all gatherings of more than 10 people (Murdock et al. 2020, Almarzooq et al. 2020). Face-to-face didactic education was suspended first (Calhoun et al. 2020, Hannon et al. 2020) and then, the Association of American Medical Colleges recommended suspension of all direct patient contact responsibilities for medical students (Soled et al. 2020). Some hospitals were at capacity, requiring redeployments of the workforce (Balanchivadze & Donthireddy 2020) and cancellation of elective surgical procedures (Chick et al. 2020, Roy & Cecchini 2020). In Asia, studies reported government enforced lockdowns and restrictive measures, including the closure of medical campuses (Srinivasan 2020, Singh et al. 2020, Veasuvalingam & Goodson 2020). Studies in Singapore reported the escalation of the national pandemic alert to Disease Outbreak Response System Condition (DORSCON)-Orange resulting in quarantining, temperature screenings and visitor restrictions at hospitals (Kanneganti et al. 2020, Samarasekera et al. 2020, Boursicot et al. 2020). In Europe, countries implemented national restrictions on non-essential activities, invoked lockdowns and moved all educational activities online (Finn et al. 2020,

Moszkowicz et al. 2020, Torres et al. 2020). Some governments (e.g., Italy and Denmark) responded to the pandemic by boosting the workforce through expedited graduation or temporary voluntary employment of medical students (Lapolla & Mingoli 2020, Rasmussen et al. 2020). In Central America, South America and Africa, studies described the suspension of face-to-face education and the move to online teaching (Parisi et al. 2020, Fernandez-Altuna et al. 2020, Gaber et al. 2020).

Level of medical education, institutional setting and number of participants involved

Twenty-four studies (49%) described developments and changes in undergraduate medical education (UME) programs in response to the COVID-19 pandemic. Eighteen studies (37%) reported developments in postgraduate education programs, including within graduate medical education (GME) or continuing medical education (CME). Six studies (12%) described mixed learners. One study (2%) did not describe the learner level. Twenty-five studies (51%) were conducted in universities, twenty-one studies (43%) in hospital settings, and three (6%) were unspecified or multi-site.

Seven studies (Boodman et al. 2020, Murdock et al. 2020, Rose et al. 2020, Fernandez-Altuna et al. 2020, Samarasekera et al. 2020, Lapolla & Mingoli 2020, Keegan et al. 2020) describe educational interventions with large participant groups of over 1000. Thirteen studies (Blake et al. 2020, Cleland et al. 2020, Gaber et al. 2020, Haines et al. 2020, Hannon et al. 2020, Soled et al. 2020, Singh et al. 2020, Kanneganti et al. 2020, Choi et al. 2020, Rasmussen et al. 2020, Boursicot et al. 2020, Calhoun et al. 2020, Kang et al. 2020) describe interventions with participant groups between 26-1000 (min = 32, max = 906, median = 108). Nine studies (Burns

& Wenger 2020) (Roy and Cecchini, 2020) (Srinivasan 2020) (Hofmann et al. 2020) (Buonsenso et al. 2020) (Johnston et al. 2020) (Balanchivadze & Donthireddy 2020) (Christensen et al. 2020) (Almarzooq et al. 2020) describe interventions with participant groups between 1-25 (min = 1, max = 25, median = 14). The remaining twenty studies did not specify the number of participants involved in the educational intervention described. The Blake et al. (2020) study not only reported on 55 participants in the initial study, but also reported on early dissemination metrics, noting that the intervention was accessed by 17,633 users globally within one week of the digital launch.

Educational outcomes

While not all studies used the term "Kirkpatrick's outcomes," sixteen studies reported them and one study described multiple levels. Thirteen studies described level 1 (i.e., reaction), four studies (8%) described level 2 (i.e., learning) and one study (2%) described level 3 (i.e., behavioural change). Thirty-three studies (67%) did not report any Kirkpatrick's outcomes, however, seven of these articles explicitly stated a plan for future evaluation of educational effectiveness. One study described three levels of Kirkpatrick's outcomes (Blake et al. 2020). They utilized 'agile methodology', a robust three-step process for rapid program development and were able to conduct a comprehensive program evaluation within three weeks of the outbreak in the United Kingdom. Impressively, eighty-two percent of users (n=55) in the pilot study reported applying the information (i.e., changing behaviour) in their work or home lives after engaging with the digital resource.

Quality assessment / risk of bias

Quality of the study design when outcomes were reported

There was one Randomised controlled trial (Christensen et al. 2020). This was judged for methodological quality using the Cochrane Higgins criteria (Sterne et al. 2019). Randomisation, allocation concealment, incomplete outcome reporting, selective reporting and other sources were all of low risk of bias with high quality reporting. As this was an open label trial, detection bias was high risk. There were no other trials reported. The majority of papers (67%) did not offer interventional outcome data and those that did can best be described as 'educational case studies' rather than other study designs. As such, ROBINS-I evaluation was not undertaken to assess quality of these studies.

Quality of reporting for the educational development

The risk of bias framework for the reporting quality of the developments was applied. There was only one study considered at low risk of bias and high quality in all five domains (Blake et al. 2020). There were a further six studies that whilst not having full reporting of detail, did report in all areas with varying amounts of detail (Brown et al. 2020, Buronsenso 2020, Choi et al. 2020, Johnston et al. 2020, Murdock et al. 2020, Samarasekera et al. 2020). There were six studies that did not report on any of the five domains that were judged at high risk of bias and low quality for all (Ahmed et al. 2020, Boodman et al. 2020, Burns and Wenger 2020, Haines et al. 2020, Keegan et al. 2020, Lubarsky 2020). Within each study and within each domain, the distribution of reporting was capricious with no particular area systematically reported in a different manner

to others. Table 3 illustrates the individual ratings for each area for all the studies and will support the reader in considering which primary studies may offer reporting for future replication of developments.

Given the heterogeneity of reporting within the majority of studies, it is hard to comment on any patterns or correlation. However, it is worth noting that the one paper judged at low risk of bias was well-reported and well-designed in all areas, at all stages, with details provided on its design, as well as outcomes at several levels of Kirkpatrick's hierarchy (Blake et al. 2020). Conversely, for the six studies judged at high risk of bias, the quality was pervasively poor, with missing information in all extracted areas and no details of any educational outcomes. What is not clear, is if these studies simply represent poor reporting or poor-quality educational research. Fortunately, these papers make up a minority (12%) of the studies included. Full details of the quality assessments and other characteristics of included studies are described in Table 3 and a visual representation of key results is presented in an infographic (Figure 2).

[INSERT TABLE 3 NEAR HERE]

Summary of educational developments

Forty-nine educational developments were described. Of these, 40 utilised online learning approaches in whole or in part. Thirty-three papers described adaptations to existing educational programmes, and sixteen described new educational offerings. The focus of the developments were broadly categorised as follows:

- Pivoting to online education delivery (53%)
- Training for treating patients with COVID-19 (16%)

- Clinical service reconfigurations to support response to COVID-19 (12%)
- Assessment (12%)
- Faculty development (6%)
- Learner support, mental health and wellbeing (4%)
- Selection and admissions (4%)

A small proportion of papers (6%) addressed multiple of these categories.

Pivoting education delivery

Twenty-six papers described delivering existing educational programmes through online platforms in response to local restrictions imposed including limitations on gatherings and physical distancing. Of these, thirteen were targeted at undergraduate medical students, ten at postgraduate medical trainees, two at both undergraduate and postgraduate, and one did not describe their population.

These papers have been sub-categorised into three groups based on their context and focus:

A. Using video conferencing to deliver the same teaching approaches for non-clinical learning (e.g. seminars, simulated sessions, team-based learning).
B. Replacing clinical placement based learning with other teaching methods online.
C. Supporting continued experiential learning/clinical contact without physical presence in clinical workplaces (e.g. supervised phone or video consultations).

A. Same teaching approaches, online

Fifteen papers described replacing face-to-face teaching in the classroom with online learning using similar educational approaches (Durrani 2020, Gaber et al. 2020, Srinivasan 2020, Torres et al. 2020, Singh et al. 2020, Sudhir et al. 2020, Taylor et al. 2020, Veasuvalingam & Goodson 2020, Fernandez-Altuna et al. 2020, Parisi et al. 2020, Khan 2020, Rose et al. 2020, Agarwal et al. 2020, Almarzooq et al. 2020, Balanchivadze & Donthireddy 2020). Twelve of these employed synchronous learning on video conferencing platforms. These included delivering seminars (Srinivasan 2020, Singh et al. 2020, Rose et al. 2020, Agarwal et al. 2020, Almarzooq et al. 2020, Balanchivadze & Donthireddy 2020), debates (Durrani 2020), team-based learning (Gaber et al. 2020), simulation sessions (Torres et al. 2020), and clinical skills sessions (Khan 2020, Sudhir et al. 2020, Parisi et al. 2020,). The authors of studies that utilized synchronous learning formats often talked about the importance of learner engagement. In the studies that utilized a seminar or debate format, learner engagement was promoted using online chat features, electronic 'hand-raising' for questions, and online polling. In the one paper that discussed team-based learning, engagement was promoted using breakout rooms to host groups of 25 students completing the team readiness assessment test. In the simulation and clinical skills sessions, engagement was facilitated through skill building interactions, and instructor, standardized patient or peer feedback. Three papers used a combination of synchronous and asynchronous teaching approaches, although details of the balance were not reported. The synchronous components of these were similar to those described above. The asynchronous components involved making recordings of previous lectures available and making additional learning resources available through curation or de novo creation (Taylor et al. 2020, Veasuvalingam & Goodson 2020). In the papers that used asynchronous approaches, emphasis was placed on the

need for organization and structure to support learning in the virtual environment. No developments reported exclusively asynchronous learning, and the overwhelming emphasis was on synchronous remote learning. One paper described moving a whole curriculum online for a university in Mexico of 8,000 students, 18,000 residents, and 5,000 faculty (Fernandez-Altuna et al. 2020). They adopted a new digital distance learning platform for online delivery of virtual classrooms and academic consultancies and supporting work from home.

B. Replacing clinical placement based learning

Seven papers described replacing or supplementing clinical placement based learning with other teaching approaches (Burns & Wenger 2020, Lubarsky 2020, Moszkowicz et al. 2020, Kanneganti et al. 2020, Chick et al. 2020, Calhoun et al. 2020, Roy and Cecchini 2020). Authors noted that while these interventions were important for continued learning they could not replace certain face-to-face activities (e.g., time in the operating room (Chick et al. 2020). Two papers described replacing clinical placements in surgery with a mix of online synchronous and asynchronous teaching using a combination of videoconferencing, flipped classrooms with question and answer time, video review of surgical procedures, and surgical simulators (Chick et al. 2020, Kanneganti et al. 2020). One paper outlined videoconferencing of anatomy content for surgery students, though the exact nature of the intervention (i.e., if there were dissections) was unclear (Moszkowicz et al. 2020). One paper described an entirely virtual clinical elective using a combination of synchronous seminars, small group discussions, and role-plays (Burns & Wenger 2020). Four papers described replacing or supplementing clinical placements with asynchronous learning opportunities. These included practice questions (Chick et al. 2020), independent projects (Lubarsky 2020), interpretation of example slides for postgraduate

pathology trainees (Roy & Cecchini 2020), procedural videos (Kanneganti et al. 2020), and videoconferencing and e-learning modules (Kanneganti et al. 2020). One paper described a redesigned undergraduate curriculum to accommodate for a shortened academic year (assuming learners will be able to return to clinical placements). They reduced the duration of all placements by a third and supplemented selected placements with online virtual placements (Calhoun et al. 2020).

C. Supporting continued clinical contact

Four papers described supporting some form of continued clinical contact using approaches to mitigate risk for learners missing out on in-person patient care opportunities (Johnston et al. 2020, Chick et al. 2020, Oldenburg & Marsch 2020, Hoffman 2020). Activities included supervised telephone or video consultations for undergraduate medical students (Johnston et al. 2020) or postgraduate trainees (Chick et al. 2020, Oldenburg & Marsch 2020), with feedback from the supervisor either offline or with the patient present, and virtual ward rounds for undergraduate medical students using an iPad on wheels (Hoffman 2020) to see, hear and interact with COVID-19 patients and their physicians. Clearly, these studies are not workplace-based in the traditional sense, but they do use authentic patient interactions separate from other forms of learning.

Assessment

Seven papers described adaptations to assessment processes (Eltayar et al. 2020, Hannon et al. 2020, Boursicot et al. 2020, Ahmed et al. 2020, Lapolla & Mingoli 2020, Samarasekera et al. 2020, Veasuvalinga & Goodson 2020). Three of these described adaptations to assessing clinical

skills through objective structured clinical examinations (OSCEs) in the context of physical distancing. All three were for undergraduate medical students. Two redesigned the logistics in order to persevere with face-to-face OSCEs (Boursicot et al. 2020, Samarasekera et al. 2020). By using PPE, expanding the number of sites for testing, cohorting learners, and removing real patients from the assessments, the authors were able to successfully implement the exams. The third delivered an online OSCE using Zoom, replacing physical examination with a narration of what they would do (Hannon et al. 2020). The authors concluded that remote OSCEs were not as effective as in-person for assessing clinical skills. Three papers described written assessments (Samarasekera et al. 2020, Lapolla & Mingoli 2020, Veasuvalinga & Goodson 2020). The first split the candidates from one site to six smaller sites in order to enable in-person examinations with physical distancing. The second cancelled their national licensing exam in order to support early graduation of final year medical students (Lapolla and Mingoli 2020). The third transitioned to formative on-line quizzes and short tests with feedback to enhance and promote remote learning (Veasuvalinga and Goodson 2020). The other two papers described assessment item writing workshops that were both delivered online using Zoom instead of face-to-face (Eltayar et al. 2020, Ahmed et al. 2020).

Training for treating patients with COVID-19

Eight papers described new educational interventions designed for doctors (including postgraduate trainees) that were treating patients with confirmed or suspected COVID-19 (Boodman et al. 2020, Hanel et al. 2020, Merali et al. 2020, Buonsenso et al. 2020, Choi et al. 2020, Gardiner et al. 2020, Kang et al. 2020, Christensen et al. 2020). These papers varied in their focus: either on particular groups of providers or on particular procedures. Four papers

described training in safe endotracheal intubation for COVID-19 positive patients or persons under investigation (Hanel et al. 2020, Choi et al. 2020, Gardiner et al. 2020, Kang et al. 2020). One paper described the use of ultraviolet fluorescent powder during simulated intubation in order to demonstrate aerosol generation during this procedure (Gardiner et al. 2020). One paper described a 10-week online course in internal medicine for doctors redeployed from sub-speciality services (Merali et al. 2020). Another paper described training in lung ultrasound for obstetrics and gynaecology consultants with existing ultrasound expertise to facilitate the care of pregnant patients with COVID-19 (Buonsenso 2020). Three papers described in situ simulation programmes to train doctors in new protocols for intubation in the emergency department (Hanel et al. 2020), in obstetric emergencies (Kang et al. 2020), and in the intensive care unit (Choi et al. 2020). One paper described an approach to training medical students and junior doctors in donning and doffing personal protective equipment (PPE) (Christensen et al. 2020). These authors conducted a randomised control trial comparing in-person instructor led training with remote video-based instruction. Finally, one paper described the development of a newsletter to disseminate evidence-based responses to clinical questions raised by doctors treating COVID-19 patients (Boodman et al. 2020).

Clinical service reconfiguration

Six papers described retraining or redeploying learners to support the response to increased clinical service pressures. These included the accelerated graduation of medical students (Lapolla & Mingoli 2020), redeployment of postgraduate clinical trainees (from haematology and oncology to general medicine) to support care of COVID-19 patients (Balanchivadze and Donthireddy 2020), and reconfiguration of routine speciality care in order to avoid trainee viral

exposure (Agarwal et al. 2020). Three papers described using medical students to support clinical care, including launching medical student response teams to support physicians and public health agencies (Haines et al. 2020, Soled et al. 2020) and training medical students to work as ventilator or nursing assistants (Rasmussen et al. 2020).

Faculty development

Three papers described faculty development programmes (Cleland et al. 2020, Finn et al. 2020, Keegan et al. 2020). Two focused on supporting medical educators involved in adapting programmes in response to COVID-19. These included the curation of a set of resources (Keegan et al. 2020) and the delivery of an online webinar aimed at sharing best practice (Cleland et al. 2020). One paper described the development of a twitter community of practice for medical education researchers (Finn et al. 2020).

Learner support, mental health and wellbeing

Two papers described interventions targeted at supporting learners' wellbeing (Brown et al. 2020, Blake et al. 2020). The first used Barnet et al.'s (2014) seven-step framework to implement an online community for doctoral students in medical education in order to mitigate against social isolation (Brown et al. 2020). The second described the development of a digital package to support health professions workers' and students' mental health and wellbeing (Blake et al. 2020).

Selection and admissions

Two papers described revised admissions procedures for medical school (Ungtrakul et al. 2020, Samarasekera et al. 2020). The first describes replacing face-to-face multiple mini interview

(MMI) with an online version using a video conferencing platform that required omission of their teamwork scenario (Ungtrakul et al. 2020). The second changed the content of their admissions interviews and held them via Zoom instead (Samarasekera et al. 2020). They also adjusted their Focused Skills Assessment (which assesses non-cognitive skills) from 5 stations to 2, eliminating the teamwork scenario and focusing instead on a portfolio station and a new scenario-based station similar to a Situational Judgement Test.

Conclusions of study authors

This section is a summary of the lessons learned and conclusions by the primary study authors, rather than the review authors views. Most authors described the introduced changes in positive terms, using statements such as 'overwhelmingly positive,' 'very positive', 'high quality', 'highly satisfied' in 7 studies (Ahmed et al. 2020, Almarzooq et al. 2020, Blake et al. 2020, Eltayar et al. 2020, Finn et al. 2020, Khan 2020, Rose et al.2020), 'positive' or 'valuable' or 'useful' in 4 studies (Choi et al. 2020, Gaber et al. 2020, Lubarsky 2020, Taylor et al. 2020), 'successful' or 'sufficient' or 'equivalent' in 7 studies (Buonsenso et al. 2020, Burns and Wenger 2020, Christensen et al. 2020, Hanel et al. 2020, Rasmussen et al. 2020, Torres et al. 2020, Ungtrakul et al. 2020). No study was reported by the authors as wholly unsuccessful or unfeasible, however, some developments were noted to be less desirable than in-person activities, most notably among activities replacing clinical placements (Chick et al. 2020). In two studies the authors reported that students preferred the teaching and assessment method pre-COVID, namely in an online instruction using Google Classroom with a mix of lectures, practical demonstrations and case discussions (Singh et al. 2020) and an online OSCE (Hannon et al. 2020).

Positive aspects of remote learning highlighted by authors included enhanced effectiveness, flexibility, efficiency, engagement, communication and community (Almarzooq et al. 2020, Blake et al. 2020, Durrani 2020, Keegan et al. 2020, Rose et al. 2020). Videoconferencing tools were generally noted to be easy for facilitators and students to use in a personalized and intuitive manner due to their user-friendly interfaces (Sudhir et al. 2020), however, some encountered challenges with novel technologies and struggled with issues related to WiFi access and bandwidth (Chick et al. 2020). A few papers did discuss problems and challenges that could prove helpful to groups attempting to build on these experiences: faculty and learners need to be oriented to video-conferencing platforms (e.g., mute microphones in large group but not small group meetings, utilize the chat or hand raising function to speak or participate); restructuring is time intensive and requires communication, teamwork and the collective support of all members of the staff (Veasuvalingam & Goodson 2020); not all simulations can be replaced virtually or online, so pre-briefing and preparation are critical to success (Sudhir et al. 2020); remote platforms may support technical skill development, but they may not support non-verbal communication or physical exam skill development (Eltayar et al. 2020, Hannon et al. 2020).

Many study authors noted that these activities were developed, analysed, and published within a very short period and emphasized the potential of setting the stage for subsequent investigation and studies as time allowed. They noted that many of these developments (e.g., increased online learning, precepting clinical care via telehealth) were likely here to stay. Seven studies highlighted the sustainability of interventions beyond the pandemic (Boodman et al. 2020, Kanneganti et al. 2020, Keegan et al. 2020, Oldenburg & Marsch 2020, Srinivasan 2020, Ungtrakul et al.2020, Srinivasan 2020, Veasuvalingam & Goodson 2020), with the last

study stating that 'the shift online is transformational' and 'though not all will be different, this turning point has increased faith in technology sparking a change in behaviour away from traditional approaches.'

Discussion

Summary of Results

The forty-nine included papers describe a variety of ways to pivot education to virtual spaces which was previously classroom or patient-based. Whilst these developments were forced into fruition by the COVID-19 pandemic, the likelihood is that many will persist for the foreseeable future. In this first wave of papers, several developments were described that support online learning across the continuum with important implications for practice: Educators using video conferencing to deliver instruction synchronously should attend to learner engagement (akin to active learning strategies in the classroom). As noted by Ahmed et al. (2020), promoting engagement requires both raising awareness of the importance of engagement and filling educator's toolboxes with adaptations to existing teaching strategies 'rephrased in light of the virtual platform.' Educators using remote platforms for asynchronous instruction need to create organization and structure to support learning. Short-term supplementation of clinical placement-based learning is clearly feasible, as is continued experiential learning without physical presence, such as engagement of learners in telehealth. Means of maintaining meaningful clinical contact are to date underexplored, particularly amongst undergraduates.

This review revealed a fundamental paradox. Whereas service and workplace-based learning have previously been closely integrated, these have now become more discreet, and the purpose

and associated risks more explicit for each. Service delivery itself has been transformed by the COVID-19 pandemic. While much of patient care remains in person, a significant portion has shifting to a virtual environment. In order to enable future sustainability of service, we need to enable on-going patient-based training for learners with an appropriate balance of telehealth and in-person activities. A few studies in this review focused on the incorporation of trainees into telehealth appointments (Johnston et al. 2020, Chick et al. 2020, Oldenburg & Marsch 2020), yet more studies of this type are urgently needed given the rather seismic shift in clinical care. Most undergraduate papers focused on removing medical students from the clinical context to minimise risk. This cannot be a long-term strategy. Three papers described medical student contributions to service delivery (Haines et al. 2020, Soled et al. 2020, Rasmussen et al. 2020). A few postgraduate papers highlighted ways in which physical (face-to-face) patient contact could be maintained while mitigating risk using PPE and physical distancing (Hanel et al. 2020, Choi et al. 2020, Kang et al. 2020). Future undergraduate developments might draw on lessons learned from these studies to ensure that medical students can continue to engage in safe, in-person clinical learning.

Based on this review, it appears that assessment developments and adjustments were quite different across undergraduate and postgraduate sectors, likely reflecting the discreet progression of undergraduates prior to licensing and independent clinical practice. Undergraduate programmes have had to rapidly adapt their assessment processes, or progress students without summative assessment (Lapolla & Mingoli 2020) in order to license new graduates. Postgraduate assessment has tended to be postponed and / or regulations adjusted to reflect COVID-related delays. Since in-person (e.g., physically present) assessments may not be able to resume soon,

further studies that address assessment, particularly those further exploring remote OSCE examinations would and formative (low-stakes) and summative (high stakes) assessment in un-proctored or remote proctored contexts are urgently needed. This is particularly critical in the United States and other places where national bodies (e.g., the National Board of Medical Examiners) have implemented significant assessment changes (e.g., suspension of the United States Medical Licensing Examination Step 2 Clinical Skills exam; move to remote proctored, summative clinical subject exams at the end of clerkships.)

Quality and completeness of the evidence base

Despite the hurdles that included the very short time since the advent of COVID-19, a few papers were very well done and represented excellent scholarship, with high quality reporting of developments, impressive evaluation of impact or in one case, both (Blake et al. 2020). Blake et al. (2020) developed a digital learning package with the purpose of mitigating the impacts of COVID-19 on mental health by protecting and promoting the psychological wellbeing of healthcare workers during and after the outbreak. The digital package was notable for its usability, practicality, and effectiveness at meeting providers well-being needs, while being delivered at an acceptable cost. The authors followed a rigorous three-step iterative design process in developing the package that can serve as a model for rapid development and deployment of an educational intervention. Another paper (Christensen et al. 2020) conducted a randomized control trial of PPE donning and doffing comparing live instructor-led training with video-based instruction. The results led to the conclusion of equivocal educational effectiveness, with the implication that PPE training can be safely conducted virtually, a critically important finding for training and safety of the healthcare workforce. When evaluated using Kirkpatrick's

outcomes scale, these two studies reached Levels 1-3 (Blake et al. 2020) and Level 2 (Christensen et al. 2020) and were considered to have no or relatively low risk of bias.

The majority of papers, however, focussed on sharing experiences, rather than robust evaluation or research enquiry. As with all educational research, it is hard to decide whether this reflects primary educational and research weaknesses or reporting issues. Such research weaknesses could be understandable given the rapid developments when it comes to outcome evaluation but are harder to justify when considering the reporting of developments. Any high-quality development should clearly define the underpinning theoretical frameworks, articulate the resources needed for the development, define the setting, describe the educational methods, and the content of the development to promote replicability across different contexts. It is therefore disappointing and highlights a clear gap in the evidence base, that many did not present this.

This observed educational quality has implications for the continuation and extension of these developments, which may well persist beyond the end of the pandemic as independent or as hybrid innovations (i.e., integrated with traditional educational experiences). The rapid nature of the developments likely contributed to the relative absence of significant conclusions /discussion about long-term effects and again represents a current gap in the evidence base for educators and other stakeholders. Clearly, as evidenced by Blake et al. (2020) and Christensen et al. (2020), both quality scholarship and reporting thereof is possible, and authors should look to their work as models for future work.

Comparison with existing literature

This is a new and rapidly evolving situation that has resulted in very rapid deployment of educational developments. Much of the literature (per our criteria) is reflected in this review. One previous systematic review has been published on medical education developments during COVID-19 (Dedeilia et al. 2020). That review was performed on articles published before 18th April 2020. Due to differing methodologies and the rapid expansion of the evidence base, only three of the included articles in our review were included in their review (i.e. Chick et al. 2020, Moszkowic et al. 2020, Soled et al. 2020). Of note, we specifically excluded letters to the editor, commentaries, editorials, and perspectives, which comprised the bulk of their review. They concluded that their review 'summarized the available literature on the issue, which mostly consist(ed) of anecdotal communications without empirical evidence, due to the short time window and unexpectedness of the COVID-19 pandemic'. Clearly the evidence base has somewhat improved since their review, and there are examples of quality scholarship (e.g., Blake et al. 2020).

Strengths and limitations

The strengths of this rapid review include an 'a priori protocol', reporting using a STORIES approach (Gordon and Gibbs, 2014), a comprehensive search strategy developed through piloting, risk of bias assessment including an easy visual tool for representation, and timeliness of the review to inform other educators in the pandemic. We aimed to ensure rigor was not sacrificed by the rapidness of the review, yet there were limitations. Our selection of 4 electronic databases was less than other reviews may select, but in line with other reviews within BEME. Future reviews may include a wider selection. Whilst we hand searched MedEdPublish, we did

not hand search all non-indexed medical education journals. Our study selection and extraction was all done in duplicate but by multiple author pairs to allow a rapid turnaround. This reduced the scope for measures of inter-rater reliability and potentially increased the risk of inconsistent judgements during data extraction. Future reviews must consider this issue. Finally, we refined our inclusion and exclusion criteria to ensure the practicality and feasibility of a rapid review, focusing on studies describing developments that had already been deployed, as well as on studies involving medics (i.e., physicians or physicians in training). Important innovations may have been missed in opinion pieces or editorials. Literature focused on other health professions certainly warrants its own review in the future. As we are still early in the pandemic, the literature base is rapidly evolving. By the time this article is published, several additional reviews will likely already be warranted.

Concerning the literature base, we noted a tendency of groups to largely report successful developments. This likely reflects the increased willingness of groups to report and editors to publish successful (vs. unsuccessful) developments. We strongly recommend more balanced reporting and publication, as there is much to learn from failures.

The risk of bias related reporting the development details is very telling within this review. This does not in any way disadvantage papers for not presenting outcomes, but rather is guided by the principle that when reporting a development in education, sufficient detail must be given to allow readers to judge the quality of an intervention themselves, compare with other developments and possibly replicate. Reporting was lacking in all key areas, with the majority of studies in all categories rated as high risk, meaning no material of any form was given to judge these key areas. Whilst some studies were capricious, providing details in some key areas that

can still offer value to readers, it is limiting to this rapidly evolving field to not have details of underpinning theory, resources needed, content used, the settings for deployment or teaching methods employed. Robust reporting does not confer any added cost to the authors or ethical considerations and can add much for educators and researchers trying to advance the field. The barriers to including such content are not clear, and this limits the strength of the evidence overall.

Recommendations for future research and practice

This review provides some helpful direction for future publications. Based on this review, we have identified ample description of shifts to on-line platforms to deliver existing content (e.g. using on-line seminar instead of classroom delivery). There is, however, less detailed literature around supporting traditional and new clinical workspace-based learning, particular for undergraduate learners. We argue that this is where a focus for future research should lie. This review has synthesised postgraduate and undergraduate literature and there may be some helpful insights to inform undergraduate patient-based learning in the future.

There are some obvious gaps identified in this review. Gaps in assessment were noted above. Admission and selection to medical school are not yet well explored, and studies on selection into postgraduate training are entirely lacking. Further research is urgently needed to examine these important fields, particularly in relation to retaining equity and diversity principles in a virtual environment. Similarly, despite literature describing a range of innovative ways to deliver teaching, there is relatively little existing literature focusing on faculty development or support. The identified literature did not make visible any fundamental opportunities or theories for

change within medical education. This review focuses on a relatively short time frame of publication and future publications may explore in more detail potential opportunities for change and innovation produced by this global crisis.

There are also some more generic and methodological points to be made regarding the evidence base within this review. Our review has sought to gather useful data on developments that could guide future educators, yet in this area, many papers were lacking. We would invite authors, peer reviewers and editors to consider the importance of such reporting in future studies to answer vital and simple questions – 'what?', 'so what?', 'now what?' This can support dissemination and replication, and further research, building on methods and ensuring iterative evolution within the field.

Conclusions

This review highlights a number of areas of change in the immediate aftermath of the educational response to the COVID-19 pandemic. A rapid shift to synchronous and asynchronous remote learning occurred that will likely persist beyond the pandemic, and attention must be paid to learner engagement, structure and organization in the future. Early developments supported alternatives to clinical placements or continued clinical exposure using telehealth, PPE, and physical distancing. A few articles of exceptional quality, most notably a digital learning package to support well-bring (Blake et al. 2020) were identified that can serve as models to guide future educational developments and reporting. Gaps in the literature were identified with additional studies needed in the areas of assessment, admissions and selection to post-graduate training, and faculty development. While there was often a lack of practical detail

to support the educational community in enactment of novel interventions and limited evaluation data, the range of options deployed offers much guidance for the medical education community. There were indications that outcome data and additional details will be reported and therefore an update review may be warranted in the near future.

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References

Agarwal S, Sabadia S, Abou-Fayssal N, Kurzweil A, Balcer LJ, Galetta SL. 2020. Training in neurology: flexibility and adaptability of a neurology training program at the epicenter of COVID-19. Neurology. 94(24):e2608-14.

Ahmed S, Shehata M, Hassanien M. 2020. Emerging faculty needs for enhancing student engagement on a virtual platform. MedEdPublish. 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/2965

Almarzooq Z, Lopes M, Kochar A. 2020. Virtual learning during the COVID-19 pandemic: a disruptive technology in graduate medical education. J Am Coll Cardiol. 75(20).

Balanchivadze N, Donthireddy V. 2020. Hematology/oncology fellowship emergency restructuring in response to the COVID-19 pandemic—Henry Ford Hospital, Michigan. JCO Oncol Pract. [accessed 2020 June 25]. https://ascopubs.org/doi/full/10.1200/OP.20.00261

Barnett S, Jones SC, Caton T, Iverson D, Bennett S, Robinson L. 2014. Implementing a virtual community of practice for family physician training: a mixed-methods case study. J Med Internet Res. 16(3):e83.

Bedford J, Enria D, Giesecke J, Heymann DL, Ihekweazu C, Kobinger G, Lane HC, Memish Z, Oh MD, Sall AA, et al. 2020. WHO strategic and technical advisory group for infectious hazards. COVID-19: towards controlling of a pandemic. Lancet. 395(10229):1015-8.

Blake H, Bermingham F, Johnson G, Tabner A. 2020. Mitigating the psychological impact of COVID-19 on healthcare workers: a digital learning package. Int J Environ Res Public Health. 17(9): 2997.

Boodman C, Lee S, Bullard J. 2020. Idle medical students review emerging COVID-19 research. Med Educ Online. 25(1):1770562.

Boursicot K, Kemp S, Ong TH, Wijaya L, Goh SH, Freeman K, Curran I. 2020. Conducting a high-stakes OSCE in a COVID-19 environment. MedEdPublish. 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/2939

Brown ME, Archer RL, Finn GM. 2020. A virtual postgraduate community of practice. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/medu.14214

Buckley S, Coleman J, Davison I, Khan KS, Zamora J, Malick S, et al. 2009. The educational effects of portfolios on undergraduate student learning: a Best Evidence Medical Education (BEME) systematic review. BEME guide no. 11. Med Teach. 31(4):282–98.

Buonsenso D, Moro F, Inchingolo R, Smargiassi A, Demi L, Soldati G, Moroni R, Lanzone A, Scambia G, Testa AC. 2020. Effectiveness of a 'fast lung ultrasound teaching program' for gynecologists/obstetricians dealing with pregnant women with suspicion of COVID-19 infection. Ultrasound Obst Gyn. [accessed 2020 June 25]. https://obgyn.onlinelibrary.wiley.com/doi/abs/10.1002/uog.22066

Burns R, Wenger J. 2020. A remotely conducted paediatric bootcamp for fourth-year medical students. Med Educ. 54:668-9.

Calhoun KE, Yale LA, Whipple ME, Allen SM, Wood DE, Tatum RP. 2020. The impact of COVID-19 on medical student surgical education: implementing extreme pandemic response

measures in a widely distributed surgical clerkship experience. Am J Surg. [accessed 2020 June 25]. https://www.americanjournalofsurgery.com/article/S0002-9610(20)30229-4/pdf

Chick RC, Clifton GT, Peace KM, Propper BW, Hale DF, Alseidi AA, Vreeland TJ. 2020. Using technology to maintain the education of residents during the COVID-19 pandemic. J Surg Educ. 77(4). [accessed 2020 June 25]. https://www.sciencedirect.com/science/article/pii/S1931720420300842

Choi GYS, Wan WTP, Chan AKM, Tong SK, Poon ST, Joynt GM. 2020. Preparedness for COVID-19: in situ simulation to enhance infection control systems in the intensive care unit. Br J Anaesth. [accessed 2020 June 25]. https://bjanaesthesia.org/article/S0007-0912(20)30202-6/pdf

Christensen L, Rasmussen CS, Benfield T, Franc JM. 2020. A randomized trial of instructor-led training versus video lesson in training health care providers in proper donning and doffing of personal protective equipment. Disaster Med Public. 1–15. [accessed 2020 June 25]. https://www.cambridge.org/core/journals/disaster-medicine-and-public-health-preparedness/article/randomized-trial-of-instructorled-training-versus-video-lesson-in-training-health-care-providers-in-proper-donning-and-doffing-of-personal-protective-equipment/CF08F4727DA9D536883ECBFD04BC2570

Cleland J, McKimm J, Fuller R, Taylor D, Janczukowicz J, Gibbs T. 2020. Adapting to the impact of COVID-19: Sharing stories, sharing practice. Med Teach. 1–4. [accessed 2020 June 25]. https://www.tandfonline.com/doi/full/10.1080/0142159X.2020.1757635

Cook DA, Bordage G, Schmidt HG. 2008. Description, justification and clarification: a framework for classifying the purposes of research in medical education. Med Educ. 42(2):128-133.

Critical Appraisal Skills Programme. 2014. CASP Qualitative Checklist. [accessed 2020 July 17]. https://casp-uk.net/wp-content/uploads/2018/01/CASP-Systematic-Review-Checklist_2018.pdf

Dedeilia A, Sotiropoulos MG, Hanrahan JG, Janga D, Dedeilia P, Sideris M. 2020. Medical and surgical education challenges and innovations in the COVID-19 era: a systematic review. In Vivo. 34(3 Suppl):1603-11.

Durrani M. 2020. Debate style lecturing to engage and enrich resident education virtually. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/medu.14217

Eltayar AN, Eldesoky NI, Khalifa H, Rashed S. 2020. Online faculty development using cognitive apprenticeship in response to COVID 19. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/medu.14190

Eva KW, Anderson MB, 2020. Medical education adaptations: really good stuff for educational transition during a pandemic. Med Educ. 54(6):494.

Fernandez-Altuna M, Gutierrez Rayon D, Ramirez Resendiz M, Cruz Mendez P, Tovar Lopez KA. 2020. Experience of the biggest med school in Mexico during the COVID-19 pandemic. MedEdPublish, 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/3088

Finn GM, Brown MEL, Laughey W, Dueñas A. 2020. #pandemicpedagogy: using twitter for knowledge exchange. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/medu.14242

Gaber DA, Shehata MH, Amin HA. 2020. Online team-based learning sessions as interactive methodologies during the pandemic. Med Educ. 54(7):666–7. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/medu.14198

Gardiner C, Veall J, Lockhart S. 2020. The use of UV fluorescent powder for COVID -19 airway management simulation training. Anaesth. 75(7):964–5. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/anae.15089

Gordon M, Daniel M, Patricio M. 2019. What do we mean by 'systematic' in health education systematic reviews and why it matters! Med Teach. 41(8):956-7.

Gordon M, Farnan J, Grafton-Clarke C, Ahmed R, Gurbutt D, McLachlan J, Daniel M. 2019. Non-technical skills assessments in undergraduate medical education: A focused BEME systematic review: BEME Guide No. 54. Med Teach. 41(7):732-45.

Gordon M, Gibbs T. 2014. STORIES statement: Publication standards for healthcare education evidence synthesis. BMC Med. 12(1):143.

Gordon M, Hill E, Stojan J, Daniel M. 2018. Educational interventions to Improve Handover in Health Care: An Updated Systematic Review. Acad Med. 93(8):1234-44

Gordon M, Patricio M, Horne L, Muston A, Alston S, Pammi M, Thammasitboon S, Park S, Pawlikowska T, Rees E, et al. 2020. Protocol: Rapid review of developments in medical education in response to the COVID-19 pandemic: A BEME systematic review. Dundee, UK: [accessed 2020 June 25]. https://bemecollaboration.org/Reviews+In+Progress/Rapid+review+of+developments+in+medical+education+in+response+to+the+COVID+19+pandemic/

Haines MJ, CM Yu A, Ching G, Kestler M. 2020. Integrating COVID-19 volunteer response into the year 3 MD curriculum. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/abs/10.1111/medu.14254

Hammick M, Dornan T, Steinert Y. 2010. Conducting a best evidence systematic review. Part 1: from idea to data coding. BEME Guide No. 13. Med Teach. 32(1):3-15.

Hanel E, Bilic M, Hassall K, Hastings M, Jazuli F, Ha M, Trotter B, Fraser C, Rutledge G. 2020. Virtual application of in situ simulation during a pandemic. CJEM. 1–4. [accessed 2020 June 25]. https://www.cambridge.org/core/journals/canadian-journal-of-emergency-

medicine/article/virtual-application-of-in-situ-simulation-during-a-pandemic/668BA5EEAAF128CC100BDD5A88DD77D8

Hannon P, Lappe K, Griffin C, Roussel D, Colbert-Getz J. 2020. An objective structured clinical examination: from examination room to Zoom breakout room. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/medu.14241

Hofmann H, Harding C, Youm J, Wiechmann W. 2020. Virtual bedside teaching rounds with patients with COVID-19. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/abs/10.1111/medu.14223

Johns Hopkins University. 2020. COVID-19 dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. Baltimore, Maryland: [accessed 2020 June 25]. https://coronavirus.jhu.edu/map.html

Johnston A, Barrick K, Jivraj F, Ram R. 2020. 'The Virtual Check-In': A tool to facilitate virtual patient interaction for early clinical learners in a longitudinal integrated clerkship. MedEdPublish. 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/3125

Kang Y, Deng L, Zhang D, Wang Y, Wang G, Mei L, Zhou G, Shu H. 2020. A practice of anesthesia scenario design for emergency cesarean section in patients with COVID-19 infection based on the role of standard patient. Biosci Trends. [accessed 2020 June 25]. https://www.jstage.jst.go.jp/article/bst/advpub/0/advpub_2020.03066/_article/-char/ja/

Kanneganti A, Sia CH, Ashokka B, Ooi SBS. 2020. Continuing medical education during a pandemic: an academic institution's experience. Postgrad Med J. [accessed 2020 June 25]. https://pmj.bmj.com/content/early/2020/05/28/postgradmedj-2020-137840

Keegan DA, Chan M, Chan T. 2020. Helping medical educators world-wide pivot their curricula online: PivotMedEd.com. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/abs/10.1111/medu.14220

Khan H. 2020. An adaptation of Peyton's 4-stage approach to deliver clinical skills teaching remotely. MedEdPublish, 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/3031

Kirkpatrick JD, Kirkpatrick WL. 2016. Four levels of training evaluation. East Peoria (IL). Versa Press, Inc.

Lapolla P, Mingoli A. 2020. COVID-19 changes medical education in Italy: will other countries follow? Postgrad Med J. [accessed 2020 June 25]. https://pmj.bmj.com/content/postgradmedj/early/2020/05/13/postgradmedj-2020-137876.full.pdf

Lubarsky S. 2020. Movie night! An entertaining online educational method for introducing students to common presentations in neurology. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/medu.14218

Merali Z, Carayannopoulos KL, Lai A. 2020. All hands on deck: creation of an online internal medicine redeployment curriculum. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1111/medu.14213

Moszkowicz D, Duboc H, Dubertret C, Roux D, Bretagnol F. 2020. Daily medical education for confined students during COVID-19 pandemic: a simple videoconference solution. Clin Anat. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/full/10.1002/ca.23601

Murdock HM, Penner JC, Le S, Nematollahi S. 2020. Virtual morning report during COVID-19: a novel model for case-based teaching conferences. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/abs/10.1111/medu.14226

Oldenburg R, Marsch A. 2020. Optimizing teledermatology visits for dermatology resident education during the COVID-19 pandemic. J Am Acad Dermatol. [accessed 2020 June 25]. https://www.jaad.org/article/S0190-9622(20)30520-X/pdf

Parisi MCR, Frutuoso L, Benevides SSN, Barreira NHM, Silva JLG, Pereir MC, Cecilio-Fernandes D. 2020. The challenges and benefits of online teaching about diabetes during the COVID-19 pandemic. Diabetes Metab Syndr. 14(4):575–6. [accessed 2020 June 25]. https://www.sciencedirect.com/science/article/pii/S1871402120301089?via%3Dihub

PRISMA. (2015) Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). [accessed 2020 June 25]. http://prisma-statement.org/

Rasmussen S, Sperling P, Poulsen MS, Emmersen J, Andersen S. 2020. Medical students for health-care staff shortages during the COVID-19 pandemic. The Lancet. 395(10234):e79–80.

Reed D, Price E, Windish D, Wright S, Gozu A, Hsu E, et al. 2005. Challenges in systematic reviews of educational intervention studies. Ann Intern Med. 142(12):1080-99.

Rose C, Mott S, Alvarez A, Lin M. 2020. Physically distant, educationally connected: interactive conferencing in the era of COVID-19. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/pdf/10.1111/medu.14192

Roy SF, Cecchini MJ. 2020. Implementing a structured digital-based online pathology curriculum for trainees at the time of COVID-19. J Clin Path. [accessed 2020 June 25]. https://jcp.bmj.com/content/early/2020/05/04/jclinpath-2020-206682

Samarasekera DD, Goh DLM, Yeo SP, Ngiam NSP, Aw MM, Lim MM, Pillai S, Lee SS, Mahadevan M, Kow A, et al. 2020. Response and lessons learnt managing the COVID-19 crisis by School of Medicine, National University of Singapore. MedEdPublish, 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/3034

Singh K, Srivastav S, BhardwaJ A, Dixit A, Misra S. 2020. Medical education during the COVID-19 pandemic: A single institution experience. Indian Pediatr. [accessed 2020 June 25]. https://pubmed.ncbi.nlm.nih.gov/32366728/

Soled D, Goel S, Barry D, Erfani P, Joseph N, Kochis M, Uppal N, Velasquez D, Vora K, Scott KW. 2020. Medical student mobilization during a crisis. Acad Med. [accessed 2020 June 25]. https://journals.lww.com/academicmedicine/Abstract/9000/Medical_Student_Mobilization_During_A_Crisis_.97220.aspx

Srinivasan DK. 2020. Medical students' perceptions and an anatomy teacher's personal experience using an e-Learning platform for tutorials during the Covid-19 crisis. Anat Sci Educ. 13(3):318–19. [accessed 2020 June 25]. https://anatomypubs.onlinelibrary.wiley.com/doi/abs/10.1002/ase.1970

Sterne JAC, Hernán MA, McAleenan A, Reeves BC, Higgins JPT. 2019. Chapter 25: Assessing risk of bias in a non-randomized study. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.0. John Wiley & Sons, Inc. [accessed 2020 June 25]. www.training.cochrane.org/handbook

Sterne JAC, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, Henry D, Altman DG, Ansari MT, Boutron I, et al. 2016. ROBINS-I: a tool for assessing risk of bias in non-randomized studies of interventions. BMJ. 355: i4919.

Sudhir M, Mascarenhas S, Isaac J, Alfroukh J, Abdul Rahuman S. 2020. Adapting to the need of the hour: communication skills simulation session using an online platform during COVID-19. MedEdPublish. 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/3048

Taylor D, Grant J, Hamdy H, Grant L, Marei H, Venkatramana M. 2020. Transformation to learning from a distance. MedEdPublish. 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/2999

Torres A, Domańska-Glonek E, Dzikowski W, Korulczyk J, Torres K. 2020. Transition to on-line is possible: solution for simulation-based teaching during pandemic. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/abs/10.1111/medu.14245

Ungtrakul T, Lamlertthon W, Boonchoo B, Auewarakul C. 2020. Virtual multiple mini-interview during a COVID-19 pandemic. Med Educ. [accessed 2020 June 25]. https://onlinelibrary.wiley.com/doi/abs/10.1111/medu.14207

Veasuvalingam B, Goodson ML (2020). Falling back on technology mindfully during COVID-19 pandemic: NUMed campus experience. MedEdPublish. 9(1). [accessed 2020 June 25]. https://www.mededpublish.org/manuscripts/2998

Table 1. Quality assessment / risk of bias of the interventions presented

Bias source	High quality	Unclear quality	Low Quality
Underpinning bias (U)	Clear and relevant description of theoretical models or conceptual frameworks that underpin the development	Some limited discussion of underpinning, with minimal interpretation in the context of the study	No mention of underpinning
Resource bias (R)	Clear description of the cost / time / resources needed for the development	Some limited description of resources	No mention of resources
Setting bias (S)	Clear details of the educational context and learner characteristics of the study	Some description, but not significant as to support dissemination	No details of learner characteristics or setting
Educational bias (E)	Clear description of relevant educational methods employed to support delivery	Some educational methods mentioned but limited detail as to how applied	No details of educational methods
Content bias (C)	Provision of detailed materials (or details of access)	Some elements of materials presented or summary information	No educational content presented

Figure 1: PRISMA flow diagram for included studies

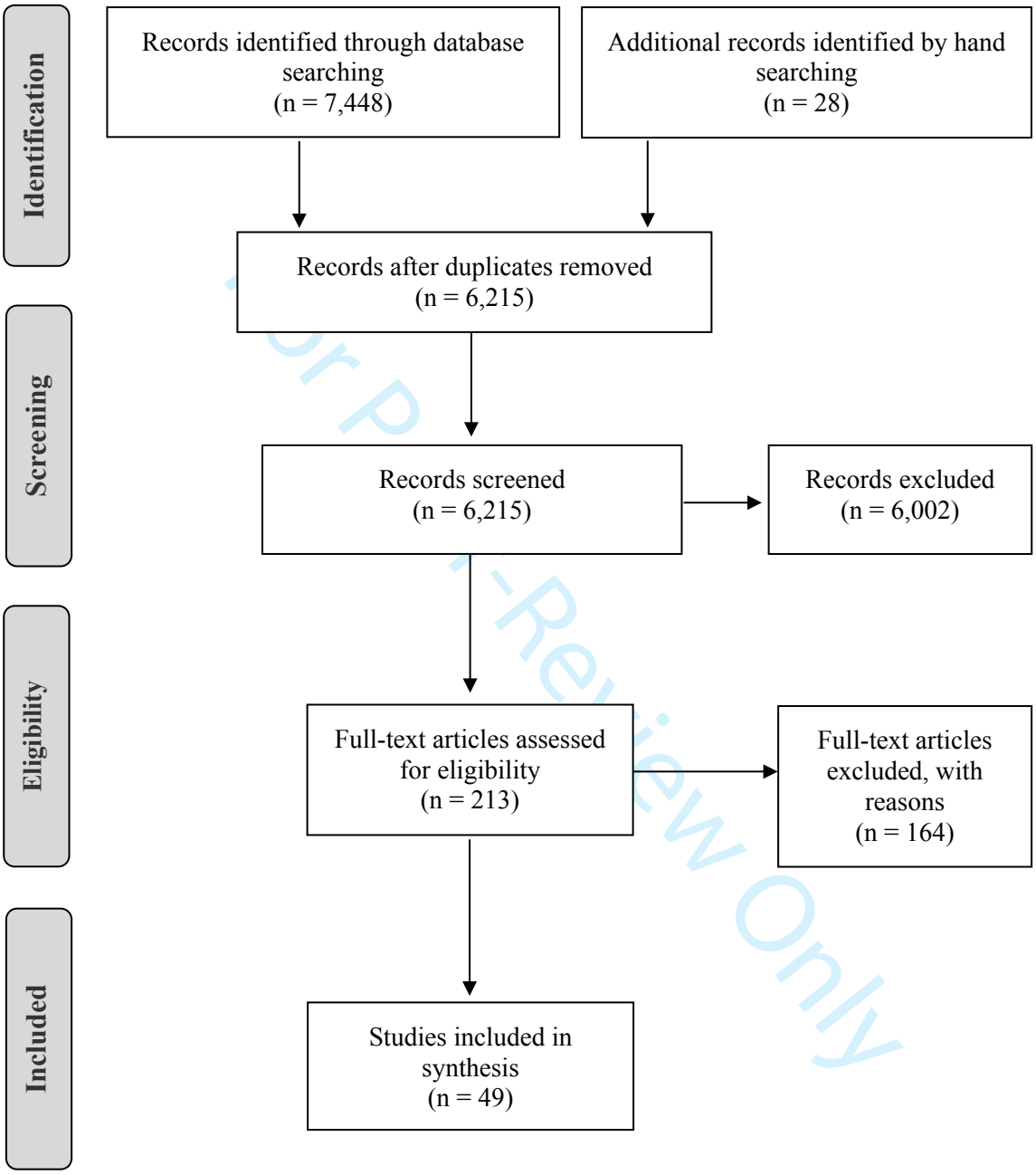

Table 2: Origin characteristics of included studies

Location	Number of Studies						
	Level of medical education*				Institutional Setting		
	U	P	M	ND	Hospital	University	Unspecified
United States	5	8	1		10	3	1
Canada	4	2	1	1	3	5	
Central America			1			1	
South America	1					1	
Europe	5	3	2		5	4	1
Africa	1	1				2	
Asia	8	4			3	9	
International			1				1
Totals: 49	**24 (49%)**	**18 (37%)**	**6 (12%)**	**1 (2%)**	**21 (43%)**	**25 (51%)**	**3 (6%)**

* U = undergraduate, P = postgraduate (GME/CME), M = mixed, ND = not described

Figure 2: Infographic summarizing key findings

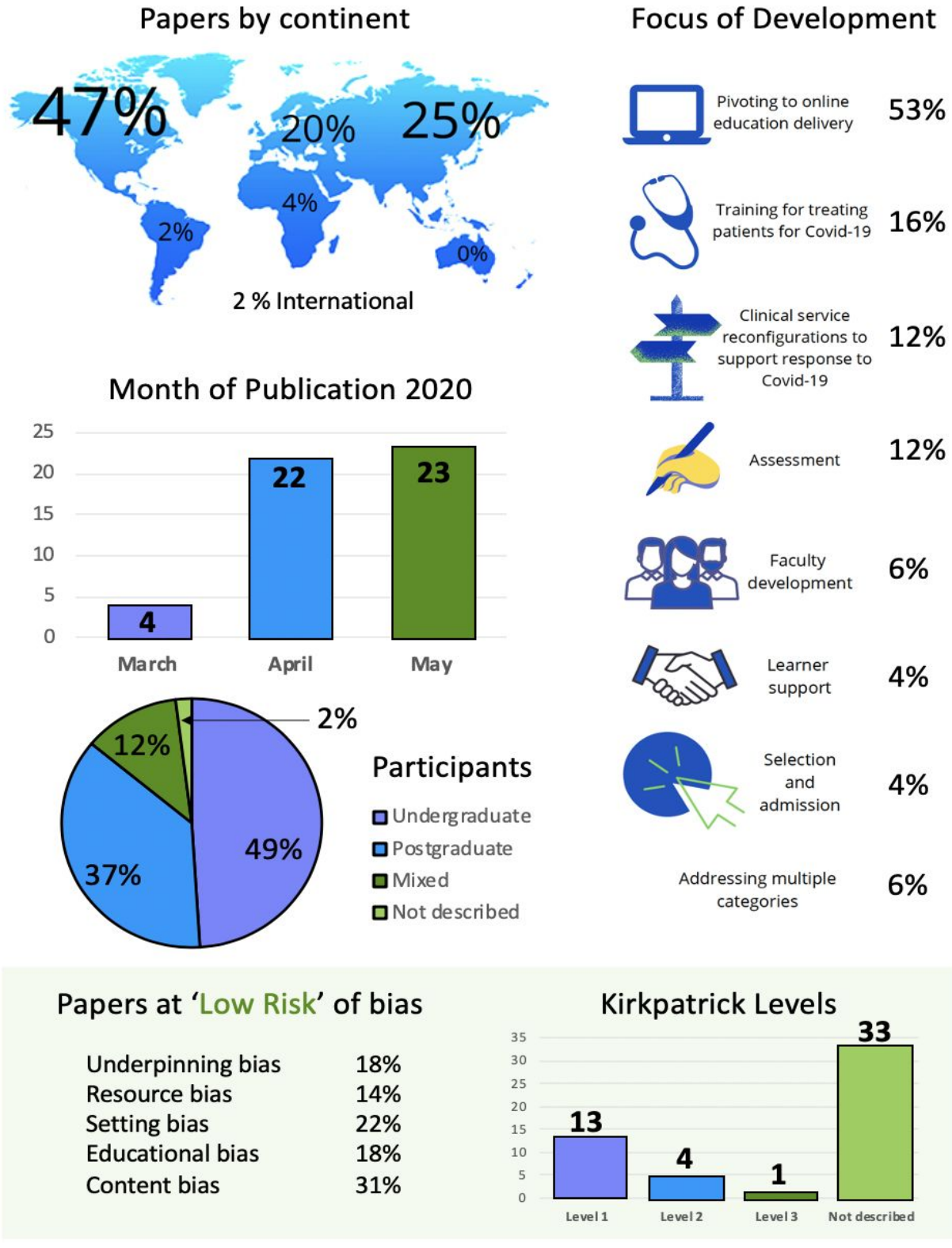

Table 3. Summary of characteristics of included studies

Author	Month pub-lished	Setting	Geographical location	Learners	Focus of development	Brief summary	Bias					Kirk-patrick	Main results	Summary of conclusion
							U	R	S	E	C			
Agarwal et al.	May	Post-graduate	New York USA	Neurology residents (n = ND)	Service delivery, teaching delivery (shift to online), learner support	Teaching delivered online. Skeleton staff for inpatient care. Virtual supervision of outpatient care. Twice weekly online support sessions.						ND	Residents have been resilient in response to changes.	Changes have enabled continuation of clinical care and education.
Ahmed et al.	April	Post-graduate	Bahrain	Medical educators (n = ND)	Faculty development	Assessment item writing workshop delivered online via Zoom. Youtube videos provided training on features of Zoom.						ND	Trainees demonstrated a high level of satisfaction.	Educators need to focus on learner engagement and have the technological tools to support education.
Almarzooq et al.	May	Post-graduate	Massachusetts USA	Cardiology fellows (n=20)	Teaching delivery (shift to online)	Regular half day teaching programme moved to online delivery using MS Teams.						ND	*Session was even more engaging than usual (face-to-face)*	Online teaching is more engaging than face-to-face.
Balanchivadze & Donthireddy	May	Post-graduate	Michigan USA	Haematology & Oncology fellows (n=14)	Service reconfiguration & teaching delivery (shift to online)	Fellows split into three teams rotating between specialist care, COVID-19 care, and working from home. Education delivery switched to online using Skype or Zoom.						ND	N/A	Changes have allowed fellowship programs to continue education, remotely, while supporting patient care.
Blake et al.	April	Mixed (frontline healthcare workers & students)	United Kingdom (globally available)	Healthcare workers, academics, students (n = 55) 17,633 users in 1st 7 days)	Mental health and wellbeing	Development of a digital package to support healthcare worker and student psychological well-being.						levels 1, 2, 3	Digital tool was rapidly created and deployed. Assessment of outcomes on all three levels was positive.	The digital package was useable, practical, meaningful, appropriate to meet providers well-being needs, and delivered at an acceptable cost.
Boodman et al.	May	Mixed Under-graduate & Post-graduate	Winnipeg Canada	Clinical medical students and graduate students on interpro-fessional teams (n = ND)	Delivery of a weekly evidence-based newsletter	Production of a weekly newsletter responding to covid-19 questions posed by doctors. *"Medical leaders at the local, provincial and national level cited the newsletter as their most reliable source of COVID-19 information."*						ND	N/A	*"This team-based model addressed discreet educational goals while contributing in a tangible way to an evolving pandemic and may have value outside of a pandemic."*

Boursicot et al.	March	Under-graduate	Singapore	4th year senior medical students (n = 56, divided into 4 cohorts)	Assessment	OSCE administration with enhanced safety measures.					ND	OSCE successfully implemented	*"Stay calm and carry on with important work, while taking appropriate precautions to ensure safety."*
Brown et al.	May	Post-graduate	York United Kingdom	Med Ed PhD students, including physicians (n = ND)	Learner support and pastoral care	Needs assessment. Established online Community of Practice using Barnett et al.'s 7-step framework.					Level 1	Established online community of practice	Improved learner support.
Buonsenso et al.	April	Post-graduate	Trento and Rome Italy	Obstetricians / gynaecologists already skilled in ultrasound & obstetricians (n = 11)	Faculty training & development - rapid re-skilling	Rapid online teaching program (https://covid19.disi.unitn.it/iclusdb/login) to provide new knowledge on lung ultrasound to diagnosis COVID to obstetric and gynaecology providers.					Level 2	Median correct answer pre (6) post (9)	*"Our course represents one possible model of implementing lung ultrasound education."*
Burns & Wenger	April	Under-graduate	Washington USA	Senior year medical students (n = 6)	Teaching delivery (shift to online) of a 2-week paediatric bootcamp using Zoom	Synchronous online learning using brief didactic present-ations, flipped classroom sessions, small-group discussions, and role-play with facilitated debriefing.					Level 1	Average rating of 4.5 or higher on a 5-point Likert scale	*"…was successfully adapted for remote, synchronous learning via the Zoom platform"* to meet physical distancing requirements.
Calhoun et al.	April	Under-graduate	Washington USA	Clinical medical students spread over 6 sites. (n = 280)	Curriculum redesign	Changes to year 3 & 4 surgery curricula and assessments including innovative virtual clerkships to augment shortened in-person learning time.					ND	No change to assessment plans with reduced placement duration.	Difficult decisions had to be made regarding curriculum design and assessments. Virtual learning opportunities can augment shortened clinical placements.
Chick et al.	April	Post-graduate	California USA	Surgical trainees (post-graduate years 1-5) (n = ND)	Teaching delivery (shift to online)	Flipped virtual classroom; Online practice questions; Academic teleconferences; Telehealth clinics with resident involvement; Facilitated use of surgical videos					ND	N/A	COVID-19 will change the way we educate our residents for at least the coming months if not significantly longer

Choi et al.	April	Post-graduate	Hong Kong	Clinical team with doctors (n = 11) and nurse/support staff (n = 33) (n = 44)	Faculty / staff training & development	High fidelity *in situ* simulations using infection isolation room with anteroom, donning / doffing PPE, SimMan 3G (COVID-19 patient). Intubation and placement of central IV catheter. Workflow observed.					ND	Learning from simulations led to changes in safety guidelines, modified environments, improved workflows & ability to follow infection control guidelines. A visual aid was also produced.	*"…in situ simulation provides a potentially useful tool to rehearse the safe care of patients in anticipation of treating an emerging infectious disease such as COVID-19."*
Christensen et al.	March	Mixed Under-graduate & Post-graduate	Copenhagen Denmark	Medical Students (years 4-6) and Junior Doctors (n = 21)	Teaching and learning approaches	This study compared live instructor-led training with video-based instruction in personal protective equipment (PPE) donning and doffing.					Level 2	PPE donning and doffing competencies of the control (instructor) and intervention (video) group at 1 month were similar. Data suggest video is time and resource effective when training participants.	Video maximises the number of participants to be trained; minimises time and PPE-use for training; and ensures physical distancing.
Cleland et al.	May	Mixed	International (broadcast to 5 continents)	Online attendees (n = 518)	AMEE webinar: *Adapting to the impact of COVID-19: Sharing Stories, Sharing Practice*	90-minute webinar with 4 themes: Campus-based teaching and assessment; Clinical teaching and learning; Selection and assessment; Educator Needs					ND	*"Need to recognise that health professions' educators across the globe are doing their best, often with limited resources and tight infection control restrictions."*	*"Many local responses and innovations could have the potential to change the shape of medical education and training in the future"*
Durrani	May	Post-graduate	New Jersey USA	ND	Lecture-based debate for delivery of teaching online	Creation and delivery of educational content utilizing a debate format with post-lecture debriefing, discussion, and spaced repetition.					Level 1	6-question questionnaire using a Likert scale revealed favourable reception in all areas	*"Lecture-based debate allowed for a high degree of resident engagement and entertainment while allowing for effective dissemination of evidence-based medicine and core concepts."*
Eltayar et al.	April	Post-graduate	Alexandria Egypt	ND	Changed existing 'How to create MCQs' workshop to online delivery	Zoom session to deliver MCQ writing session					Level 2	MCQs newly designed after the workshop were higher quality than those submitted pre-workshop.	Better participation amongst attendees by conducting workshops online.
Fernandez-Altuna et al.	May	Mixed Under-graduate & Post-graduate	Mexico	Students (n = 8,000) Residents (n = 18,000) Faculty (n = 5000)	1) Shift in institutional focus 2) Delivery of teaching online	Brought curriculum online, purpose-built website for staff, development of innovative tech solutions in response to COVID, community engagement and information dissemination.					ND	N/A	Med schools must adapt to providing services online. There are challenges to the transition.

Finn et al.	May	Post-graduate	Hull United Kingdom	Medical educators (n = 10-30 per discussion)	Built on use of social media to learn from wider community	Twitter was utilised as a platform for weekly conversations to engage educators #pandemicpedagogy. Short videos were made to showcase doctoral students work in lieu of conferences.					Level 1	*"Feedback was overwhelmingly positive."*	Twitter can be used in pandemic for showcasing, sharing and networking.
Gaber et al.	March	Under-graduate	Cairo Egypt	Medical students, 35 teams of 25 students (n = 875)	Delivery of teaching online	Zoom was utilized for TBL. Reading material was given to students who were then asked to solve 10-20 questions individually, then as a team.					Level 1	96.5% attendance rate, 50.7% questionnaire response, 85% satisfaction rate.	TBL can be successfully delivered via Zoom
Gardiner et al.	April	ND	Vancouver Canada	ND	Shifts in teaching methods / delivery	Described 2 ways to integrate UV fluorescent powder, as a visual virus surrogate, into simulation scenarios requiring tracheal intubation of manikin.					ND	2 Models demonstrate virus dispersal in tracheal intubation scenarios.	This approach offers a powerful visual tool to reinforce, guide and consolidate COVID-19 airway management
Haines et al.	May	Under-graduate	Vancouver Canada	3rd year medical students (n = 160)	Development of new educational experience.	Development of Medical Student Response Team (MSRT) to address the growing public health crisis.					ND	ND	MSRT can be used in a pandemic *"to coordinate safe opportunities to support physicians and public health agencies."*
Hanel et al.	April	Post-graduate	Ontario Canada	Multi-disciplinary team of emergency room staff (n = ND)	Video-based learning then in situ simulation of clinical skills	Video recording of COVID-19 respiratory failure in situ simulation event shared both virtually and in ED. Facilitator led discussions and debriefs, followed by run-throughs in the ED, handling medications and equipment and becoming comfortable with use of isolation rooms.					ND	*"Allowed the teams to identify and modify site-specific latent safety threats (LSTs), which are system-based."*	*"Used a video-recorded simulation with virtual distribution to aid in the development of a … protocol, incorporating staff input and education under the constraints and pressures of a global pandemic."*
Hannon et al.	May	Under-graduate	Utah USA	3rd year medical students (n = 49)	Virtual physical exam skills assessment	*"Implemented a narrative physical exam whereby students verbalized manoeuvres they would perform and standardize patients reported findings."*					Level 1	53% (25 students) thought remote OSCE was not as good as the in-person OSCE for assessing clinical skills.	Remote OSCE is feasible and has cost savings. However, due to low fidelity and technology glitches the OSCE will be changed from must-pass to must-complete.
Hofmann et al.	May	Under-graduate	USA	Clinical medical students (n = 14)	Virtual ward rounds with Covid-19 patients via videoconference	iPad fixed to computer on wheels running video conferencing app, so students could see / hear patient encounters and interact with physicians during ward rounds.					Level 1	All students strongly agreed they would recommend virtual COVID rounds.	Findings support conducting virtual COVID rounds

Johnston et al.	May	Under-graduate	Calgary Canada	Final (3rd) year medical students (n = 25)	New education method	Virtual Check In tool (Table 1 describes; focus of check in is different than a typical visit as it is not issue driven)					ND	Kern's framework as guide allowed rapid development and deployment of tool to participate in virtual check-ins. Evaluation has not yet occurred.	Virtual check-ins allow students to continue to develop clinical skills; tool is *"safe"*, *"beneficial for patients"*, and *"straightforward for preceptors to implement"*
Kang et al.	April	Post-graduate	Guangdong Province China	Practicing health professionals (n = 36)	Simulation	Training programme using in situ simulated patient scenario for emergency response teams conducting surgeries on COVID-19 patients.					ND	Anaesthesia Precaution Checklist for COVID-19 infected patients developed. Each item must be ascertained or implemented before entering the infectious surgical room.	Anaesthetic and surgical team should be trained in using PPE using simulations.
Kanneganti et al.	April	Post-graduate	Singapore	32 specialty programs detailed in Table 1 (n = ND)	Teaching delivery (shift to online) and in person, physically distanced small groups	Specialty training programmes switched to videoconferencing. Some programmes utilized in person small group teachings with precautions, as well as e-learning modules.					ND	Teaching practices with the innovative use of technology, can adapt specialty training programmes in pandemics.	Adapting to a 'new normal' can help keep trainees up to date with their core clinical competencies and equipped to deal with clinical pathology now and tomorrow.
Keegan et al.	May	Under-graduate	Calgary Canada (users in 74 countries)	Faculty (n = 2007 users at time of writing)	Faculty development	PIVOTMedEd (Partners in Virtual and On-line Teaching in Medical Education) at www.pivotmeded.com - curated resources on online curricula delivery (classroom and clinical); discipline-specific resources; general resources (including basic science, indigenous health, patient safety, and leadership)					ND	Successfully curated 84 resources to date which are open-access and support educators pivoting their curriculum online.	*"Beyond COVID-19, pivotmed.com will continue to curate open-access materials supporting online medical education."*.
Khan	April	Under-graduate	London United Kingdom	Medical students (n = ND)	Teaching delivery (shift to online)	Clinical and practical skills teaching using an adaptation of Peyton's 4-stage approach: 1) Demonstration of skill with video; 2) Discussion of skill with teacher, augmented by video clips; 3) Narration of skill by students, with help of peers; 4) Q&A and clinical contextualisation					ND	Response *"overwhelmingly positive"* per tutors and students	Peytons 4-stage approach is one possibility for remote clinical skills teaching delivery.

Lapolla & Mingoli	May	Under-graduate	Italy	Final year / graduating medical students (n = 9,640)	Early transition (graduation)	Permanent cancellation of licensing exam; Early graduation and transition to clinical care.					ND	10.3% potential augmentation of workforce; shortened licensing process by ~9 months	Fast-tracking to graduation can augment the healthcare workforce.
Lubarsky	May	Under-graduate	Quebec Canada	Second year medical students (n = ND)	Delivery of education	2-week course called Transition to Clinical Practice in Neurology- students were given an assignment to imagine they were movie critics tasks with reviewing films demonstrating neurology conditions					ND	Debriefing and small group discussion were important complements to viewing films. Allowed appreciation of biopsycho-social context and complex relationships between patients and providers.	Cinemeducation is useful and enjoyable for maintaining neurological education under extenuating circumstances
Merali et al.	May	Post-graduate	Canada	Internal medicine residents (n = ND)	Curriculum development	Medicine Basecamp, a 10-week online internal medicine curriculum, to address knowledge-gaps and provide structure to reduce anxieties of redeployed trainees.					Level 1	19,900 webpage views in 34 days of release. Trainees expressed positive feedback	The intervention provides a structured curriculum in internal medicine for redeployed trainees
Moszkowicz et al.	April	Under-graduate	France	Surgical medical students (n = ND; 10 per group)	Delivery of anatomy education	Students connect daily to live anatomy lesson in Google Hangouts.					ND	Videoconferencing teaching sessions with students at home are a viable strategy to address high absenteeism, the costs and ethical issues of human tissue donation.	Blended learning methods and modern educational tools should continue post COVID-19
Murdock et al.	May	Mixed Under-graduate & Post-graduate	USA	Medical students, residents and fellows (n = ~1500; 59-135 learners per session, 15 sessions)	Delivery of case-based teaching	"Virtual morning report" created on videoconferencing platform					ND	VMR is an adaptable, accessible platform that can be used simultaneously at multiple institutions. Careful attention must be given to creating a supportive learning environment, as virtual platforms are susceptible to hacking.	Study supports VMR as viable model for virtual case-base teaching conference
Oldenburg & Marsch	April	Post-graduate	USA	Dermatology residents (n = ND)	Delivery of education	Mulit-provider video appointments via Haiku: resident leads the encounter and briefly discusses assessment and plan with patient present; attending confirms / changes plan.					ND	Patients were accepting of this method of teaching.	*"Teledermatology is likely going to become a longstanding method of the future practice of dermatology…"*

Parisi	April	Under-graduate	Brazil	4th year medical students (n = ND)	Shift in teaching methods	Online standardized patient (SP) encounter focused on the technical and communication skills for managing a patient with diabetes. Simulation + educator led debrief with SP				ND	Authors developed an interactive online encounter to teach about diabetes.	Online SP encounter supports technical skill development, but may not support non-verbal communication skill development necessary to facilitate adherence.
Rasmussen et al.	April	Under-graduate	Denmark	4th year medical students and masters students (n=329 and 161, respectively)	Shift in teaching methods and clinical deployment	Fast track courses in ventilator therapy and nursing assistance to train students to deploy clinically as temporary residents, ventilator therapy assistants, or nursing Assistants; also implemented new portfolio system to support and track progression.				ND	Rapid deployment and re-training on digital platform of med students on placements focussed on staffing COVID-19 response needs	Effective approach to deployment in context
Rose et al.	April	Post-graduate	USA	Emergency medicine residents (n = 1080)	Livestreaming of presentation and discussions	2 hour livestream, 6 speakers, 20 minutes each with synchronous facilitated discussions on Slack: large group channels were dedicated for each speaker and small group channels were dedicated to specific residency programs.				Level 1	84% felt same of better quality than in-person conferences and 93% enjoyed the event overall	*"Present a model for massive, online, interactive conferencing that allows for social connection and academic engagement amongst residents."*
Roy & Cecchini	April	Post graduate	USA	Pathology resident (n = 1)	Shift in teaching methods, supplemental online case learning	Fellow provided cases (e.g., pathology slides) to learner each day to supplement the decreased surgical volume. Videoconferencing was used to discuss cases and provide feedback at end of day.				ND	N/A	*"The current state of events may act as a catalyst for new teaching approaches."*
Samarasekera et al.	May	Under graduate	Singapore	Medical students years 1-5 (n = ~1500)	Shift in teaching methods, assessment, admissions	Ensuring academic continuity required 1) A coordinated leadership and management process; 2) Prioritising safety for all stakeholders; 3)Dissemination of information; 4) Maintaining rigor and quality of training				ND	Learning transitioned online; admissions implemented an online focused skills assessment; OSCEs and exams were administered in different formats.	These systematic and holistic measures to ensure academic continuity may help other schools in preparing for pandemics.
Singh et al.	May	Under-graduate	Rajasthan, India	Medical students (n = 398)	Teaching delivery (shift to online)	Online instruction using Google Classroom: mix of lectures and practical demonstrations/ case discussions were employed with a break of 10-15 minutes between sessions.				Level 1	While appreciative of the platform, nearly 50 % of the students still believed that physical classroom was better than e-classroom.	Medical education by online education is feasible and can be implemented in a short period of time.

Soled et al.	March	Under-graduate	Massachusetts USA	Medical students (n = 500)	Development of a medical student response team (table 1).	Formation of 4 committees and identification of deliverables: 1) education for the medical community, 2) education for the broader community, 3) activism for clinical support, and community activism.					ND	*"Medical students were strongly and intrinsically motivated to help. Trainees, especially those in their post-clerkship period, were well-positioned to practically assist with the COVID-19 response…"*	Though not yet fully trained physicians, students can leverage their training to serve in a pandemic, supporting frontline healthcare workers and patients.
Srinivasan	April	Under-graduate	Singapore	1st year medical students (n = 18)	Teaching delivery (shift to online)	Conversion of anatomy teaching to e-learning: creation of e-tutorials utilising Zoom to enable discussion of anatomy of head and neck					Level 1	*"87.5% satisfied with the understanding and learning of anatomy using Zoom."*	Zoom can be used as an effective teaching tool for conducting e-tutorials in anatomy. Further computer-based learning methods are crucial for continuing medical education reforms.
Sudhir et al.	May	Under-graduate	Dubai United Arab Emirates	Medical students (n = ND)	Virtual simulation education	Communication skills training session for 2 groups of students involving facilitators and simulated patients were conducted simultaneously using 5 sub channels on Microsoft Teams.					Level 1	*"Majority of the participants [90%] believed that the online platform had a user-friendly interface and was easy for facilitators, SPs and students to become skilful with in a personalized and intuitive manner."*	Not all simulations sessions can be replaced virtually or online, but communication skills training can be facilitated. Pre-briefing and preparation is critical to success.
Taylor et al.	April	Under-graduate	United Arab Emirates	Medical students (n = ND)	Teaching delivery (shift to online)	Blended use of a variety of learning strategies described as 'open learning'. Same cognitive theories apply to learning, but additional techniques are required to support students navigating between synchronous and asynchronous modalities.					ND	Successfully transformed a traditional medical university into one where all delivery, resources and support was delivered remotely.	Distance learning - *"To make this happen, an institution needs to be agile, identify key champions for change, and invest in the technical resources and personnel to make it possible.".*
Torres et al.	May	Under-graduate	Poland	4th year medical students (n = ND)	Teaching delivery (shift to online)	Geriatrics course was converted to online environment consisting of 8 computer-based simulations supporting remote ordering and resulting of labs and images.					ND	*"… students' engagement, emotions, and topics discussed during debriefings (reflecting educational objectives) were similar to on-site simulations."*	*"The presented approach provided an acceptable alternative to on-site simulation-based training"*

Ungtrakul et al.	May	Under-graduate	Bangkok, Thailand	Medical school applicants (n = ND)	Change in recruitment practices (Admissions)	Virtual Multiple Mini Interview (MMIs) (minus teamwork scenarios)		ND	Virtual MMIs feasible, less costly; candidates comfortable with online tools; most features of MMIs can be maintained virtually with a few notable exceptions	MMI *"successfully implemented" for 2020 interview season"*
Veasuvalinga m & Goodson	May	Under-graduate	Malaysia	Medical students (n = ND)	Transformation of medical curriculum	Creation of student-centred/self-directed online learning environment with online lectures, e-tutorials, seminars with breakout rooms, discussion boards, and formative assessments (quizzes) with feedback		ND	Faculty time-intensive to restructure everything into online environment. Requires communication and teamwork and the "*collective support of all members of staff' is imperative."*	The shift online is transformational. *"Though not all will be different, this turning point has increased faith in technology sparking a change in behaviour away from traditional approaches."*

Abbreviations: ND = Not Described; N/A = Not Applicable; PPE = personal protective equipment; IV = intravenous; AMEE = Association of Medical Educators in Europe; MCQ = multiple choice question; TBL = team-based learning; OSCE = Objective Structured Clinical Exam

Risk of Bias: U = Underpinning theory described, R = Resources described, S = Settings described, E = Educational methods described, C = Content described