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ABSTRACT

Background The COVID-19 outbreak has dramatically impacted medical education, both bedside and academic teaching had to be adapted to comply with the reorganisation of care and social distancing measures.

Objectives To overview the impact of the pandemic on medical education, including the pedagogical responses adopted and their assessment by medical students and residents.

Material and methods This restricted systematic review was performed using Rayyan QCRI, to select observational or interventional articles and field experience reports assessing the impact of the COVID-19 pandemic on medical education for medical students and residents. Study design, study population, geographical origin, use of an educational tools (including softwares and social media), their type and assessment, were recorded. For studies evaluating a specific tool the Medical Education Research Study Quality Instrument (MERSQI) was used to assess study quality.

Results The literature search identified 1480 references and 60 articles were selected. Most articles focused on residents (41/60; 69%), and half (30/60; 50%) involved surgical specialties. Online courses were the most frequently used pedagogical tool (52/60; 88%). Simulation tools were used more frequently in articles involving surgical specialties (15/29; 52%) compared with medical specialties (2/14; 12%) (p=0.01). Only four studies reported the assessment of pedagogical tools by medical students, their MERSQI scores ranged from 5.5/18 to 9.0/18.

Conclusion Medical education was highly impacted by the COVID-19 pandemic particularly in surgical specialties. Online courses were the most frequently attempted solution to cope with social distancing constraints. Medical students' assessment of pedagogical tools was mostly positive, but the methodological quality of those studies was limited.

INTRODUCTION

Since March 2020, the world has been facing the COVID-19 pandemic and despite the development of several vaccines,[1] the situation remains critical and the pandemic uncontrolled. Not only have healthcare systems been dramatically impacted but most governments have also adopted nationwide emergency measures, including closure of universities and lockdowns to contain the spread of the virus. The COVID-19 pandemic has disrupted medical education revealing its strengths and weaknesses. As a consequence, on the one hand in most countries medical students were excluded from in-hospital daily activities, in-persons classes and clinical rotation[2]; on the other hand, medical residents were involved in the management of COVID-19 patients, and non-urgent staff, meetings, conferences, in-persons classes, elective surgical procedures and clinical rotations were cancelled.[3] Thus, all educative programmes and internships had to evolve from in-person to remote learning using various tools.[4] This unprecedented pandemic has provided an opportunity to take stock of the resources available, to highlight the shortcomings, to test numerous innovations in the field of digital learning and simulation, and perhaps to implement lasting changes in the teaching of medical students and residents, in the faculty as well as at the bedside.

The aim of this restricted systematic review was first, to report an overview of the impact of the COVID-19 pandemic on medical education; second, to report which pedagogical solutions were tried; and lastly to report medical students' and residents' feedback.

MATERIAL AND METHODS

This restricted systematic review has been performed according to the flexible framework for restricted systematic reviews published by the Centre for Evidence-Based Medicine, University of Oxford[5] and to the Synthesis without meta-analysis guideline.[6]

Literature search and information sources

We searched MEDLINE/PubMed (Education Resources Information Centre, a specialised search education database) and the Cochrane Database of Systematic Reviews until 1 June 2020 for original articles and reviews restricted to French and English Language. The search strategy combined free text search, exploded Medical Subject Headings (MeSH) terms. The grey literature was not explored.

The PubMed search equation was the following: ((medicine/education[Mesh] OR general surgery/education[Mesh] OR surgery/education[Mesh]) OR medical education[MeSH Terms]) OR (continuing medical education[MeSH Terms]) OR (medical students[MeSH Terms]) OR (academic training [MeSH Terms]) OR (medical education) OR (continuing medical education)

OR (medical students) OR (faculty practice) OR (academic training)) AND ((coronavirus OR "corona virus" OR coronaviridae OR coronaviridae OR betacoronavirus OR covid19 OR "covid19 19" OR nCoV OR "CoV 2" OR CoV2 OR sarscov2 OR 2019nCoV OR "novel CoV" OR "Coronavirus" [Mesh] OR "Coronavirus Infections" [Mesh] OR "covid19" [Supplementary Concept])).

Study selection and eligibility criteria

The restricted systematic review was performed using RayyanQatar Computing Research Institute QCRI (http://rayyan.qcri.org) to select the included articles.[7]

Observational or interventional articles and reviews were considered if (1) they assessed the impact of the COVID-19 pandemic on medical education, (2) the study population was medical students and residents. A single reviewer (FC) screened titles and abstracts after removing duplicates. After reading full text of preselected manuscripts, three types of articles were included by two investigators (MB and AL):

- Field experience reports describing pedagogical tools used or changes made during the COVID-19 pandemic in order to maintain medical education in a specific setting (a country, a teaching hospital, a medical or surgical specialty…).
- Observational and interventional articles reporting either the development of a new pedagogical tool during COVID-19 pandemic and its assessment by medical students or residents.
- Surveys measuring the impact of the COVID-19 pandemic on medical education.

Articles were excluded if:

- The period did not correspond to the COVID-19 pandemic.
- The involved students were not medical students or residents.
- They were editorials or letters with ineligible outcomes.
- They dealt with the impact of the COVID-19 on students' evaluation: exams/applications.
- The topic was the deployment of students to manage COVID-19 patients.
- The language was not English or French.

Data extraction and analysis

The recorded information for each selected study included the study design, study population (medical student vs resident), country of the study, involved specialty (medical vs surgical and type). The changes made as well as the list of educational tools used to preserve medical education during the COVID-19 pandemic were assessed. Educational tools were classified as follows:

- Online courses which were subdivided in 10 subgroups: lectures, tutorials, podcasts, webinars, journal club, virtual conferences, virtual cases reviews, web-based video, morbidity and mortality review and written material.
- e-learning programmes defined as structured educational programmes using electronic and/or interactive tools.
- Telemedicine defined as the use of telecommunications technology to maintain interaction between students and patients (virtual visits, teleconsultation…).
- Virtual educational tool/simulation: defined as the use of simulation or virtual augmented reality tools.
- Other tools.

Software and social media used were also recorded. Data were extracted independently by two investigators (FC and either MB or AL). Disagreements were discussed and resolved by consensus between the investigators. Because of the heterogeneity of medical education systems and included articles, we did not conduct a meta-analysis. Results are presented as narrative synthesis with summary tables and figures.

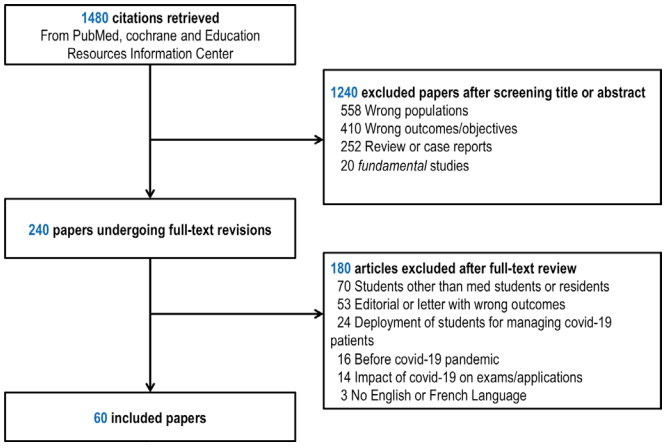

Figure 1 Flow chart of the restricted systematic review illustrating literature search and articles selection strategy and included articles.

Quality of included articles

For quantitative studies that evaluated a specific tool for medical education during the COVID-19 pandemic, we used the Medical Education Research Study Quality Instrument (MERSQI) to assess study quality on 10 criteria: study design; number of institutions; response rate; type of data; internal structure; content validity; criterion validity; appropriateness of data analyses; sophistication of data analyses and outcome level.[8] The possible total MERSQI score can range from 6 to 18. Evidence for the validity of the MERSQI has been shown to be associated with acceptance vs rejection of medical education manuscripts.[9]

Statistical analyses

Data are presented as median (range) or counts (percentage). We used the Fisher's exact test to compare qualitative variables. A two-tailed $p<0.05$ was considered statistically significant. Analyses were performed with JMP software (V.14 (SAS Institute)).

RESULTS

Literature search and characteristics of the included articles

Literature search identified 1480 citations of interest, of which 60 were included in this restricted systematic review[3 10–69] (figure 1). Among them, 48 (48/60; 80%) were field experience reports describing pedagogical tools used during the COVID-19 pandemic and 12 (12/60; 20%) were observational or interventional studies assessing a pedagogical tool or using a survey to characterise the impact of COVID-19 on medical education. In the 12 observational/interventional studies, the population ranged from 6 to 852 (not available, NA=1).

Most of articles originated from America: USA (38/60; 63%) and Canada (4/60; 7%). Seven articles originated from Asia (7/60; 12%) and eight from Europe (8/60; 13%) (table 1 and online supplemental table 1).

Most articles focused on residents (41/60; 69%), 11 articles (11/60; 18%) on both residents and medical students and 8 articles (8/60; 13%) on medical students only. Half of articles (30/60; 50%) involved surgical specialties, 16 articles involved medical specialties (16/60; 26%) and 7 (7/60; 12%) articles involved medico-technical specialties (NA 7/60; 12%). The list of specialties is reported in online supplemental table 2.

Table 1 Characteristics of included articles (n=60)

	N (%)
Manuscript type and study design	
Manuscript type	
Original article	14 (23)
Review	5 (8)
Letter	41 (69)
Type of study	
Observational/interventional	12 (20)
Field experience report	48 (80)
Geographical data	
Continent	
America	43 (72)
Asia	7 (12)
Europe	8 (13)
Oceania	2 (3)
Student category and specialty type	
Student category	
Medical students	8 (13)
Residents	41 (69)
Both	11 (18)
Specialty type	
Surgery	30 (50)
Medical	16 (26)
Technical	7 (12)
NA	7 (12)

NA, not available

Table 2 Comparisons of main pedagogical tools used between medical specialties (n=16 articles) and surgical specialties (n=29)

Type of tool	Medical n (%)	Surgical n (%)	P value
Online courses	13 (81)	27 (93)	0.33
e-learning programme	2 (12)	5 (17)	1
Telemedicine	2 (12)	4 (14)	1
Virtual educational tool/simulation	**2 (12)**	**14 (52)**	**0.01**
Other	2 (14)	4 (14)	1

Tools with p-values < 0.05 are highlighted in bold

Educational tools, software and social media used as solutions during the COVID-19 pandemic

The types of educational tools used to maintain medical education during the COVID-19 pandemic among 59 studies with available data are reported in figure 2A. Online courses were the most frequently reported pedagogical tool (52/60; 88%). Among online courses, lectures were found in 34 articles (34/60; 58%), virtual case review in 22 articles (22/60; 37%) and tutorials in 17 articles (17/60; 29%). Furthermore, virtual educational or simulation tools were mentioned in 18 articles (18/60; 30%), an exhaustive e-learning programme was reported in seven articles (7/60; 12%) and the use of telemedicine was reported in 10 articles (10/60; 17%).

The details of software and social media used were available for 33 articles. The use of Zoom (Zoom Video Communications) was reported in 20 articles (20/33; 60%), Google Meet (formerly known as Hangouts Meet) in 6 articles (6/33; 18%) and Cisco Webex Teams and Meeting in 5 articles (5/33; 15%) (figure 2B). Social media were used in 10 articles (YouTube, n=6 (18%) articles, Twitter n=2 (6%) and Facebook n=2 (6%)).

Comparison of pedagogical tools reported between surgical and medical specialties

The comparisons of pedagogical tools used between medical specialties and surgical specialties are reported in table 2. Virtual and simulation tools were used more frequently in articles involving surgical specialties (15/29; 52%) compared with medical specialties (2/16; 12%), (p=0.01). The use of online courses, e-learning programmes and telemedicine was similarly reported by medical and surgical specialties.

Consequences of the COVID-19 pandemic on medical education and assessment of new pedagogical tools by medical students or residents

Eight studies (8/60; 13%) reported the impact of the COVID-19 pandemic on the education of medical students or residents in various surgical specialties using a survey.[19 27 32 34 40 51 52 63 64] The main results of these studies are reported in table 3. The evaluated criteria varied across these studies. Most students reported a decrease in patient-contact time, elective surgery activity and indefinite postponement of clinical rotations,[19 27] with a negative impact on surgical training and surgical skills acquisition.[19 27 32 51 52]

As a consequence, most students expressed their concerns regarding career planning and board examinations scores,

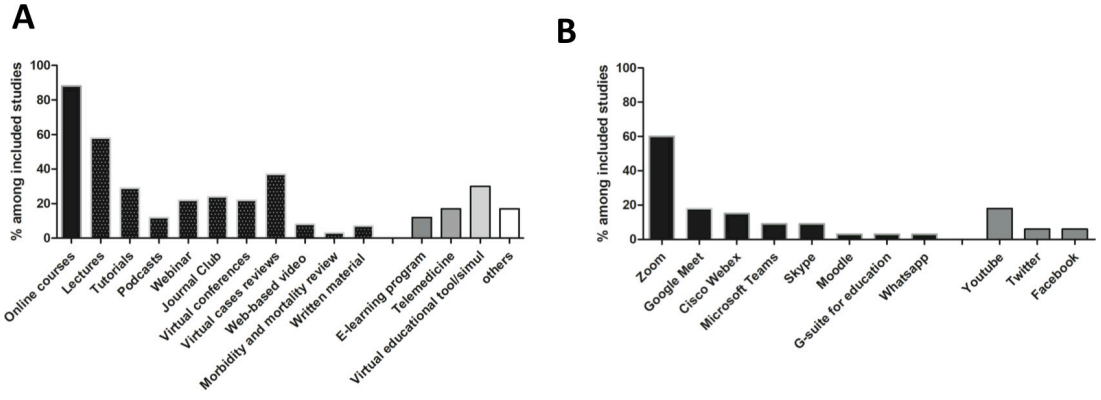

Figure 2 Educational tools, softwares and social media used during the COVID-19 pandemic. **(A)** Educational tools used as solutions to maintain medical education (n=59 articles). Others: including virtual flipped classroom n=2, movies n=2, gaming/quiz competitions n=1, better access to corpses for dissection n=1, individual mentorship n=1, Massive Open Online Course (MOOC) n=1, radiological collection n=1, collaboration tool to curate medical education resources n=1. (B) Softwares or social media used to maintain pedagogy (among 33/60 articles with available data).

Table 3 Results of survey reporting the impact of the COVID-19 pandemic on medical education and assessment of pedagogical tools

First author (Ref)	Specialty	Type of participants	Nb of participants/Nb invited (response rate)	Main results
Rosen[19]	Urology	Residency programmes directors	65/144 (45%)	► Patient contact time decreased from 4.7 to 2.1 days per week (p<0.001). ► Redeployment was reported in 26% of programmes. ► 60% of programmes had concern that residents will not meet case minimums due to COVID-19. ► 77% reported remote clinical work and 52% televisits. ► All programmes had begun to use videoconferencing and 60% planned to continue. ► In states with a higher incidence of COVID-19: – Resident redeployment and exposure to COVID-19 positive patients were more frequent (48% vs 11%, p=0.002) and (70% vs 40%, p=0.03), – Concerns regarding exposure (78% vs 97%, p=0.02) and personal protective equipment availability (62% vs 89%, p=0.02) were less frequent.
Garcia[27]	Neurosurgery	Medical students.	315/875 (36%)	► 2/3 reported indefinite postponement of clinical clerkship and most have suspended in-person didactics. ► Many reported using unstructured time to improve neurosurgical knowledge, with increasing frequency by increasing medical school years. ► More than half report that the pandemic has had a significant negative impact on academic productivity. ► 1/3 MS1 reported dissatisfaction with neurosurgical career planning. ► 1/5 MS1 are less likely to pursue a career in neurosurgery. ► The majority of MS2 and MS3 are delaying their US Medical Licensing Examination steps I and II. ► 3/4 MS3 reported indefinite postponement of subinternships, and most are unsatisfied with communication from external programmes as it relates to subinternships. ► 1/3 MS4 are graduating early to participate in COVID-19-related patient care. ► A vast majority are requesting logistical help to prepare for residency remotely: student-focused webinars, student-focused sessions at upcoming neurosurgical conferences, and finding ways to accommodate for expected changes in external subinternships are solutions frequently reported.
Guadix/[32]	Neurosurgery	Medical students	133/852 (16%, then six excluded responses)	► Most affected aspects of their neurosurgery residency application: conferences and networking opportunities (63%), clinical experience (59%), board examination scores (42%), subinternships (39%), clinical research experience (38%). ► 76% MS3 reported >1 cancelled or postponed neurosurgery rotation. ► Concerns regarding how COVID-19 would affect surgical skills acquisition increased significantly the higher the MS year. ► Students were more likely to take 1 year off from medical school after than before the start of the COVID-19 pandemic, measured from 0 to 100 (25.3 vs 39.5; p=0.004). ► Virtual mentorship pairing was the highest rated educational intervention suggested by MS1 and MS2. ► Virtual surgical skills workshops were the highest rated educational intervention for MS3 and MS4.
Alhaj[34]	Neurosurgery	Residents	52/53 (98%)	► 48% dealt directly with patients with COVID-19. ► 57.7% had a session about personal protective equipment. ► 98% perceived an impact on neurosurgery training at the hospital. ► 80% felt daily studying hours were affected. ► 90% believed that this pandemic had influenced their mental health.
Rose[40]	Emergency medicine	Residents	NA (targeted audience n=1080)	► Most residents were unfamiliar with Slack messaging platform and may have felt reserved about navigating the platform during discussion. ► 84% of residents felt that ALiEM Connect had the same or better quality than in-person conference experiences. ► 93% enjoyed the event overall.
Mishra[52]	Ophthalmology	Resident (95.6%) and Fellows (4.4%)	716/NA (716 valid responses)	► 24.6% had been deployed on COVID-19 duty. ► 80.7% felt that the COVID-19 lockdown had negatively impacted their surgical training (50% or more reduction in their surgical training). ► 47.2% noticed a negative impact on their theoretical/classroom learning. ► 54.8% perceived an increase in stress levels during the COVID-19 lockdown. ► 77.4% reported that their family members had expressed an increased concern for their safety and well-being since the lockdown began. ► 75.7% felt that online classes and webinars were useful during the lockdown period.
Zingaretti[51]	Aesthetic surgery	Resident	115/146 (72%)	► 60% reported 50%–75% elective surgery activity decrease, affecting a lot their training and professional growth for 68%. ► 66% reported an increase of learning activities compared with pre-COVID-19. ► <5% use virtual didactic courses during COVID-19 pandemic. ► 60% find that didactic tools during COVID-19 19 are useful but not sufficient.

Continued

Table 3 Continued

First author (Ref)	Specialty	Type of participants	Nb of participants/Nb invited (response rate)	Main results
Pertile[64]	Surgery (Polyspecialistic)	Residents	756/NA (756 included questionnaires)	► 61.3% experienced a reduction and 34.6% a complete interruption of surgical activities. ► 14.8% surgery residents were redeployed to COVID-19 non-surgical units ► General surgery residents were more frequently redeployed (p<0.01) than other surgical specialty residents. ► Northern Italian regions surgery residents were more commonly relocated to non-surgical wards than those belonging to central and southern Italian regions (p<0.01). ► General surgery residents did not change their professional ambitions in comparison to other specialties residents (10% vs 17.2%; p=0.02). ► Redeployed surgery residents reported that the pandemic had a positive impact on their clinical training in 49.1% and a negative impact on surgical training in 87.5%.

MS, medical student's year; NA, not available.

and thus postponed their examinations.[27 32] More than half of students perceived an increase in stress levels,[34] an impact on mental health.[34 52] Students were more likely to take 1 year off from medical school after than before the start of the COVID-19 pandemic.[32]

Between 14.8% and 70% of residents were deployed on COVID-19 duty depending the level of COVID-19 incidence in the country.[19 27 52] More than half of students had a session about personal protective equipment,[34] but between 62% and 97% of residents expressed concerns regarding exposure and personal protective equipment availability.

Most of these studies reported an increase in videoconferencing and remote clinical work.[19 27 32 51 52]

Only four studies[41 46 61] reported the assessment of specific pedagogical tools by medical students (4/60; 7%) during the COVID-19 pandemic using a questionnaire. The MERSQI scores ranged from 5.5/18 to 9/18 (online supplemental table 3). All studies were single group post-intervention descriptive studies only reporting the satisfaction of the students. The main results of these studies are reported in table 4. Three studies investigated remote lectures and virtual cases[41 61] and one study investigated remote standardised patient encounters.[46] The level of satisfaction was very high for all studies, with an improvement of the relationship with the teacher.[41 61]

The 48 field experience reports describing tools used or suggested during COVID-19 pandemic are summarised in online supplemental table 4.

DISCUSSION

This restricted systematic review synthesises the impact of the COVID-19 on medical education and portrays educational solutions attempted for maintaining medical education despite social distancing. About two-thirds of articles focused on residents and 50% referred to surgical specialties. Online courses were the most frequently reported pedagogical tool (52/60; 88%). Virtual reality and simulation tools were reported significantly more frequently in articles involving surgical specialties than in articles involving medical specialties which highlighted that the needs and/or pedagogical interests for medical education are different between medical and surgical specialties. Impact of the pandemic on medical education varies across specialties and depends on the incidence of COVID-19 in the location of the medical education programme.[19]

Predominance of surgical articles

Most of the articles related to the impact of the COVID-19 pandemic concerned surgical specialties (50%, compared with 27% for medical specialties and 12% for medico-technical specialties), suggesting a higher impact on surgical specialties than other specialties. Indeed, cancellation of all elective surgical procedures has led to a drastic decrease of surgical training and to surgical skill decay. Interestingly, virtual simulation was more frequently reported in surgical specialties than others. This result is consistent with the concerns of residency programmes regarding continuation of surgical skills training. The disruption of surgical training has also led to a mental health impact of surgical trainees leading to questioning the pursuit of a surgical career.[27] Conversely, most medical specialty residents have been charged with treating COVID-19 patients.[19] This clinical activity was an occasion to train clinical skills such as interviewing, clinical reasoning, supporting patient emotion, counselling or explaining diagnostic test results. However, specialties directly impacted by the management of COVID-19 patients, such as pneumology and intensive care medicine, were underrepresented in the literature. Still, most of these specialties maintained medical education thanks to the continuation of medical activities.

Predominance of articles concerning residents

Overall, a majority of the articles reported the impact of the pandemic on residents. This result may reflect the substantial proportion of clinical skills training in residency programmes compared with academic teaching, particularly in technical specialties such as surgery, interventional cardiology or endoscopy. Conversely, thanks to the predominance of theoretical teaching in medical students' education, continuation of programmes using e-learning, videoconferences, and virtual classes was feasible and efficient.[41 46 61] In addition, standardised patients interviews using telehealth format also permitted improvement and assessment of clinical skills among medical students and residents.[31 36 46 54 55 57]

Predominance of articles concerning academic teaching

This review shows that 88% of the articles reported the use of online courses, suggesting a translation from in-person to virtual classes. Pre-existing courses and educational material probably facilitated the fast implementation of online courses to cope with cancellation of in-person classes due to social distancing. Similarly, free social media and meeting platform software allowed the development of online courses without delay. Conversely, few studies reported the development of new educational tools, such as virtual flipped class room, movies, gaming/quiz competitions….[20 33 42 57] Although the pandemic necessitated to find quick and feasible solution for medical education within medical

Table 4 Assessment of pedagogical tools by medical students

First author (ref)	Type of participants	Nb of Participants/Nb invited (response rate)	Type of educational tool Pedagogical tool	Main results
Singh[61]	Medical students Undergraduates from second to eighth semester	208/398 (52%)	Lectures and virtual case reviews Online classes with G Suite for Education using Google Classroom coupled with Google Meet for Video conferencing	► 75% had not attended any online classes previously. ► 92.3% stated that they were given the opportunity to ask questions. ► Interaction with the teacher was better than (27.9%) or as good as (27.9%) that during physical classroom. ► But 51% found physical classroom better than e-classroom.
Geha[41]	Medical students Internal medicine students	6/6 (100%)	Lectures, podcasts and virtual case reviews VCC for 14 days: ► Interactive sessions with students and teachers ((n=25 videoconferences) ► Resident-level case conferences (n=27 sessions) ► Daily podcasts to learn about a topic (n=11 podcasts) ► Students analysed 11 cases (from podcasts or worksheets) and submitted diagnostic schemas and assessments. They also submitted verbal presentations.	Students completed a survey with 5-point Likert responses: Drafting schemas (5.0), writing diagnostic assessments (4.83), oral presentations (4.83), podcasts (5.0) and case conferences (4.0). ► Students cited 'major improvements' in their diagnostic assessments and schema construction and 'moderate improvement' in oral presentations. ► 5/6 reported receiving more feedback on their diagnostic arguments during the VCC than in internal clerkship. ► 4/6 reported better classmate colearning and collaboration during the VCC.
Mooney[46]	Medical students Undergraduate MS2	105/NA	Virtual case reviews Three standardised patient encounters, mapped to expected clinical competencies, were developed and administered through a telehealth format in Zoom (Zoom Video Communications, San Jose, California, USA). Interview and patient communication were assessed by standardised patients and faculty member observer feedback. Clinical reasoning and oral presentation were assessed by faculty member observers. Students self-assessed their written presentations using exemplar notes. Reflection on feedback was further fostered through daily self-reflection assignments and faculty member-facilitated Zoom groups (three students each). Professionalism competencies were assessed through structured peer feedback.	► Measurement of nearly all clinical competencies was possible ► Few physical examination competencies were assessed. ► Expedited training and inventory of technology access were necessary to swiftly build technological capacity and ensure effective use across participants. ► Removing physical infrastructure barriers (suitable rooms) expanded capacity for simultaneous assessment of learners by 50%. ► Increased standardised patients diversity and lower programmatic costs. ► Faculty member, student and standardised patient satisfaction with the fidelity of cases and overall assessment quality were high.
Kivlehan[63]	Paediatric rehabilitation medicine residents and fellows	30/53 (57%)	E-learning programme including 13 lectures, 3 journal clubs and one virtual arts initiative.	► Most respondents reported that the virtual lectures series (79.3%), journal club (78.9%) and virtual arts initiatives (75%) were valuable to their education. ► Common benefits: access to subject experts, networking, lecture recording, and location flexibility. ► Common concerns: lack of protected time, virtual platform fatigue, and decreased engagement. ► Relative to before the pandemic, 70% felt less satisfaction with clinical education and 60% felt greater satisfaction with non-clinical education. ► 83.3% of graduating trainees felt confident to graduate.

NA, not available; VCC, virtual clerkship curriculum.

schools and health sciences programmes, this need was mitigated by competing priorities of healthcare delivery as many medical educators are also clinicians. The development of online courses may have been the first step toward a digital learning translation. Time for innovations will come later. Consequently, a systematic review on new educational tools may be performed at the end of the pandemic.

Over-representation of the USA

Among articles included, 61% investigated medical education in the USA. This result is consistent with the overall proportion of medical education articles that originates from North America.[70] In addition, medical education departments emerged in the early 60s in the USA, and most medical schools in the USA have a medical education office.[71] Conversely, medical education departments first appeared in European medical universities in the early 2000s[72] and are not yet widespread in all European universities.

Assessment of the quality of medical education tools during the COVID-19 pandemic

Most included articles were field experience reports. Only 12/60 reviewed articles were observational/interventional studies, the MERSQI could be evaluated in only 4 of them, ranging from 5.5 to 9/18. Furthermore, among these four methodologically

acceptable articles three are letters with few details about the evaluation of the educational tool. Moreover, the study population was very small in the survey by Geha *et al*[41] and no detail concerning the evaluation of the educational tool by medical students was given in the survey by Mooney *et al*.[46]

This highlights the low level of currently available evidence on the impact of the COVID-19 pandemic on medical education.

Comparison with a systematic review of the COVID-19 medical literature

Liu *et al* performed a systematic review of all medical literature on COVID-19 published between 1 January and 24 March 2020.[73] Some similarities between this review and ours can be found. First the authors highlighted a great number of editorials, commentaries, and opinions in the medical literature, reaching 58% of the articles corresponding to the topic. We found 81% of expert opinions or feedback articles in our review. Second, the lack of methodologically robust studies was also mentioned and was explained by the insufficient time to design such studies. Third, the paucity of technology related articles in the COVID-19 medical literature was emphasised and the same weakness was noticed in our review, with no truly innovative educational tool evaluated in the literature at the time of our review.

Limitations

This review has several limitations. First, it was carried out too early to include robust study design evaluations of new educational tools. Moreover, specialists highly involved in the clinical care of COVID-19 patients had less time to perform medical education studies or write medical education opinion papers. On the opposite, specialists whose clinical activity was delayed due to the pandemic, such as surgeons, had more time to do so. Second, the new online educational tools include a wide variety of terms that are not necessarily referenced in MeSH and our search may have missed relevant articles. This could also have induced a misclassification of some learning tools. For instance, one article uses 'forum' in the title and 'e-learning programmes' in the introduction, which correspond to websites with cases, lectures, written material and interactive master classes.[21]

Perspectives

Our review shows that the disruption of medical education highly impacts the well-being and training of medical students and residents. Implementation of online courses using meeting platforms is a quick and efficient solution to maintain a link between the university and its students. Furthermore, some studies suggested that thanks to anonymous course format, a subgroup of students were more likely to ask questions during remote conference.[60] In addition, online courses are suitable for innovative pedagogical solutions such as serious games or reverse pedagogy classes.[20 33 42 57] Surgery residents should be particularly supported using simulation to maintain technical training.

Lastly, the COVID-19 pandemic gives the opportunity to all pedagogical chairs to test innovative solutions using all available media. In order to recommend good practices with remote medical education, a rigorous methodological evaluation based on MERSQI criteria is of utmost importance. Future studies should pay attention to strong experimental designs (such as randomisation, control group…) to assess relevant outcomes (with objective measurements, response rate reporting, results beyond descriptive analysis and results on patient/healthcare outcome).[8]

CONCLUSION

To conclude, this systematic review has demonstrated that resident's medical education was highly impacted by the COVID-19 pandemic particularly in surgical specialties. Online courses were the most frequently attempted solution to cope with social distancing constraints although they are not very efficient for the improvement of clinical skills. Medical students' opinion on pedagogical tools was mostly positive.

Main messages

- In this restricted review including 53 studies, online courses were the most frequently used pedagogical tool.
- Virtual reality and simulation tools were used significantly more frequently in surgical specialties compared with medical specialties.
- Only three studies reported the assessment of the quality of the pedagogical tools by medical students, using Medical Education Research Study Quality Instrument score and suggested low-quality studies.

Current research questions

- The long-term impact on students' final choice of specialty and career needs to be evaluated.
- The delay in skill acquisition will have to be quantified and should be compared between specialties to assess the variability of the impact of the pandemic on medical education.
- The limited number of evaluated studies and the low quality of these studies indicate that this restricted review needs to be repeated to include a larger number of more robust studies.

What is already known on the subject?

The COVID-19 outbreak has dramatically impacted medical education, both bedside and academic teaching.

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REFERENCES

1 Kim JH, Marks F, Clemens JD. Looking beyond COVID-19 vaccine phase 3 trials. *Nat Med* 2021;27:205–11.
2 Whelan A, Prescott J, Young G. *Guidance on Medical Students' Participation in Direct Patient Contact Activities*. Washington, DC: Association of American Medical

Colleges, 2020: 1–6. https://www.aamc.org/syste m/files /2020-04/meded -April -14-Guidance-on-Medical-Students-Participation-in-Direct-Patient-Contact-Activities.pdf
3 Moszkowicz D, Duboc H, Dubertret C, *et al*. Daily medical education for confined students during coronavirus disease 2019 pandemic: a simple videoconference solution. *Clin Anat* 2020;33:927–8.
4 Rose S. Medical student education in the time of COVID-19. *JAMA* 2020;323:2131–2.
5 Plüddemann A, Aronson JK, Onakpoya I, *et al*. Redefining rapid reviews: a flexible framework for restricted systematic reviews. *BMJ Evid Based Med* 2018;23:201–3.
6 Campbell M, McKenzie JE, Sowden A, *et al*. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. *BMJ* 2020;368:l6890.
7 Ouzzani M, Hammady H, Fedorowicz Z, *et al*. Rayyan-a web and mobile app for systematic reviews. *Syst Rev* 2016;5:210.
8 Reed DA, Cook DA, Beckman TJ, *et al*. Association between funding and quality of published medical education research. *JAMA* 2007;298:1002–9.
9 Reed DA, Beckman TJ, Wright SM, *et al*. Predictive validity evidence for medical education research study quality instrument scores: quality of submissions to JGIM's medical education special issue. *J Gen Intern Med* 2008;23:903–7.
10 Hare SS, Rodrigues JCL, Jacob J, *et al*. A UK-wide British Society of thoracic imaging COVID-19 imaging Repository and database: design, rationale and implications for education and research. *Clin Radiol* 2020;75:326–8.
11 Nahai F, Kenkel JM. Accelerating education during COVID-19 through virtual learning. *Aesthet Surg J* 2020;40:1040–1.
12 Newman NA, Lattouf OM. Coalition for medical education-A call to action: a proposition to adapt clinical medical education to meet the needs of students and other healthcare learners during COVID-19. *J Card Surg* 2020;35:1174–5.
13 Kanneganti A, Sia C-H, Ashokka B, *et al*. Continuing medical education during a pandemic: an academic institution's experience. *Postgrad Med J* 2020;96:384–6.
14 Slanetz PJ, Parikh U, Chapman T, *et al*. Coronavirus disease 2019 (COVID-19) and radiology Education-Strategies for survival. *J Am Coll Radiol* 2020;17:743–5.
15 Durrani M. Debate style lecturing to engage and enrich resident education virtually. *Med Educ* 2020;54:955–6.
16 García-Lozano JA, Cuellar-Barboza A, Garza-Rodríguez V, *et al*. Dermatologic surgery training during the COVID-19 era. *J Eur Acad Dermatol Venereol* 2020;34:e370–2.
17 Schneider SL, Council ML. Distance learning in the era of COVID-19. *Arch Dermatol Res* 2020. doi:10.1007/s00403-020-02088-9. [Epub ahead of print: 08 May 2020].
18 Tomlinson SB, Hendricks BK, Cohen-Gadol AA. Editorial. innovations in neurosurgical education during the COVID-19 pandemic: is it time to reexamine our neurosurgical training models? *J Neurosurg* 2020:14–15.
19 Rosen GH, Murray KS, Greene KL, *et al*. Effect of COVID-19 on urology residency training: a nationwide survey of program directors by the Society of academic Urologists. *J Urol* 2020;204:1039–45.
20 Morawo A, Sun C, Lowden M. Enhancing engagement during live virtual learning using interactive quizzes. *Med Educ* 2020;54:1188.
21 Tretter JT, Windram J, Faulkner T, *et al*. Heart university: a new online educational forum in paediatric and adult congenital cardiac care. The future of virtual learning in a post-pandemic world? *Cardiol Young* 2020;30:560–7.
22 Keegan DA, Chan M-K, Chan TM. Helping medical educators worldwide to pivot curricula online: pivotmeded.com. *Med Educ* 2020;54:766–7.
23 Hoopes S, Pham T, Lindo FM, *et al*. Home surgical skill training resources for obstetrics and gynecology trainees during a pandemic. *Obstet Gynecol* 2020;136:56–64.
24 Roy SF, Cecchini MJ. Implementing a structured digital-based online pathology curriculum for trainees at the time of COVID-19. *J Clin Pathol* 2020;73:444.
25 Zuo L, Dillman D, Miller Juvé A. Learning at home during COVID-19: a multi-institutional virtual learning collaboration. *Med Educ* 2020;54:664–5.
26 Bray DP, Stricsek GP, Malcolm J, *et al*. Letter: maintaining neurosurgical resident education and safety during the COVID-19 pandemic. *Neurosurgery* 2020;87:E189–91.
27 Garcia RM, Reynolds RA, Weiss HK, *et al*. Letter: preliminary national survey results evaluating the impact of COVID-19 pandemic on medical students pursuing careers in neurosurgery. *Neurosurgery* 2020;87:E258–9.
28 Mukhopadhyay S, Booth AL, Calkins SM, *et al*. Leveraging technology for remote learning in the era of COVID-19 and social distancing. *Arch Pathol Lab Med* 2020;144:1027–36.
29 Sahi PK, Mishra D, Singh T. Medical education amid the COVID-19 pandemic. *Indian Pediatr* 2020;57:652–7.
30 Reinholz M, French LE. Medical education and care in dermatology during the SARS-CoV2 pandemia: challenges and chances. *J Eur Acad Dermatol Venereol* 2020;34:e214–6.
31 Regier DS, Smith WE, Byers HM. Medical genetics education in the midst of the COVID-19 pandemic: shared resources. *Am J Med Genet A* 2020;182:1302–8.
32 Guadix SW, Winston GM, Chae JK, *et al*. Medical student concerns relating to neurosurgery education during COVID-19. *World Neurosurg* 2020;139:e836–47.
33 Lubarsky S. Movie night! an entertaining online educational method for introducing students to common presentations in neurology. *Med Educ* 2020;54:856–7.
34 Alhaj AK, Al-Saadi T, Mohammad F, *et al*. Neurosurgery residents' perspective on COVID-19: knowledge, readiness, and impact of this pandemic. *World Neurosurg* 2020;139:e848–58.
35 Shih KC, Chan JC-H, Chen JY, *et al*. Ophthalmic clinical skills teaching in the time of COVID-19: a crisis and opportunity. *Med Educ* 2020;54:663–4.
36 Oldenburg R, Marsch A. Optimizing teledermatology visits for dermatology resident education during the COVID-19 pandemic. *J Am Acad Dermatol* 2020;82:e229.
37 Kogan M, Klein SE, Hannon CP, *et al*. Orthopaedic education during the COVID-19 pandemic. *J Am Acad Orthop Surg* 2020;28:e456–64.
38 Comer BT, Gupta N, Mowry SE, *et al*. Otolaryngology education in the setting of COVID-19: current and future implications. *Otolaryngol Head Neck Surg* 2020;163:70–4.
39 Kanneganti A, Lim KMX, Chan GMF, *et al*. Pedagogy in a pandemic - COVID-19 and virtual continuing medical education (vCME) in obstetrics and gynecology. *Acta Obstet Gynecol Scand* 2020;99:692–5.
40 Rose C, Mott S, Alvarez Al'ai, *et al*. Physically distant, educationally connected: interactive conferencing in the era of COVID-19. *Med Educ* 2020;54:758–9.
41 Geha R, Dhaliwal G. Pilot virtual clerkship curriculum during the COVID-19 pandemic: podcasts, peers and problem-solving. *Med Educ* 2020;54:855–6.
42 Seymour-Walsh AE, Weber A, Bell A. Practical approaches to pedagogically rich online tutorials in health professions education. *Rural Remote Health* 2020;20:6045.
43 Fong ZV, Qadan M, McKinney R, *et al*. Practical implications of novel coronavirus COVID-19 on hospital operations, board certification, and medical education in surgery in the USA. *J Gastrointest Surg* 2020;24:1232–6.
44 Gawad N, Towaij C, Stuleanu T, *et al*. Prioritizing resident and patient safety while maintaining educational value: emergency restructuring of a Canadian surgical residency program during COVID-19. *Can J Surg* 2020;63:E302–5.
45 Roskvist R, Eggleton K, Goodyear-Smith F. Provision of e-learning programmes to replace undergraduate medical students' clinical general practice attachments during COVID-19 stand-down. *Educ Prim Care* 2020;31:247–54.
46 Mooney CJ, Peyre SE, Clark NS, *et al*. Rapid transition to online assessment: practical steps and unanticipated advantages. *Med Educ* 2020;54:857–8.
47 Kaup S, Jain R, Shivalli S, *et al*. Sustaining academics during COVID-19 pandemic: the role of online teaching-learning. *Indian J Ophthalmol* 2020;68:1220–1.
48 Nadgir R. Teaching remotely: educating radiology trainees at the workstation in the COVID-19 era. *Acad Radiol* 2020;27:1291–3.
49 Plancher KD, Shanmugam JP, Petterson SC. The changing face of orthopaedic education: searching for the new reality after COVID-19. *Arthrosc Sports Med Rehabil* 2020;2:e295–8.
50 Calhoun KE, Yale LA, Whipple ME, *et al*. 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* 2020;220:44–7.
51 Zingaretti N, Contessi Negrini F, Tel A, *et al*. The impact of COVID-19 on plastic surgery residency training. *Aesthetic Plast Surg* 2020;44:1381–5.
52 Mishra D, Nair AG, Gandhi RA, *et al*. The impact of COVID-19 related lockdown on ophthalmology training programs in India - Outcomes of a survey. *Indian J Ophthalmol* 2020;68:999–1004.
53 Stambough JB, Curtin BM, Gililland JM, *et al*. The past, present, and future of orthopedic education: lessons learned from the COVID-19 pandemic. *J Arthroplasty* 2020;35:S60–4.
54 Hall AK, Nousiainen MT, Campisi P, *et al*. Training disrupted: practical tips for supporting competency-based medical education during the COVID-19 pandemic. *Med Teach* 2020;42:756–61.
55 Agarwal S, Sabadia S, Abou-Fayssal N, *et al*. Training in neurology: flexibility and adaptability of a neurology training program at the epicenter of COVID-19. *Neurology* 2020;94:e2608–14.
56 Torres A, Domańska-Glonek E, Dzikowski W, *et al*. Transition to online is possible: solution for simulation-based teaching during the COVID-19 pandemic. *Med Educ* 2020;54:858–9.
57 Chick RC, Clifton GT, Peace KM, *et al*. Using technology to maintain the education of residents during the COVID-19 pandemic. *J Surg Educ* 2020;77:729–32.
58 Murdock HM, Penner JC, Le S, *et al*. Virtual morning report during COVID-19: a novel model for case-based teaching conferences. *Med Educ* 2020;54:851–2.
59 Ali SR, Dobbs TD, Whitaker IS. Webinars in plastic and reconstructive surgery training - a review of the current landscape during the COVID-19 pandemic. *J Plast Reconstr Aesthet Surg* 2020;73:1357–404.
60 Crosby DL, Sharma A. Insights on otolaryngology residency training during the COVID-19 pandemic. *Otolaryngol Head Neck Surg* 2020;163:38–41.
61 Singh K, Srivastav S, Bhardwaj A, *et al*. Medical education during the COVID-19 pandemic: a single institution experience. *Indian Pediatr* 2020;57:678–9.
62 AlGaeed M, Grewal M, Richardson PK, *et al*. COVID-19: neurology residents' perspective. *J Clin Neurosci* 2020;78:452–3.
63 Kivlehan E, Chaviano K, Fetsko L, *et al*. COVID-19 pandemic: early effects on pediatric rehabilitation medicine training. *J Pediatr Rehabil Med* 2020;13:289–99.
64 Pertile D, Gallo G, Barra F, *et al*. The impact of COVID-19 pandemic on surgical residency programmes in Italy: a nationwide analysis on behalf of the Italian Polyspecialistic young surgeons Society (SPIGC). *Updates Surg* 2020;72:269–80.
65 Lewis CT, Zeineddine HA, Esquenazi Y. Challenges of neurosurgery education during the coronavirus disease 2019 (COVID-19) pandemic: a U.S. perspective. *World Neurosurg* 2020;138:545–7.

66 Li CH, Rajamohan AG, Acharya PT, *et al*. Virtual read-out: radiology education for the 21st century during the COVID-19 pandemic. *Acad Radiol* 2020;27:872–81.
67 Torlinski T, Kaur Mullhi R, Parekh D, *et al*. Postgraduate education and specialty training in anaesthesia and intensive care medicine during the COVID-19 pandemic: experience from a large teaching hospital in the United Kingdom. *Anaesthesiol Intensive Ther* 2020;52:434–7.
68 Vargo E, Ali M, Henry F, *et al*. Cleveland clinic Akron General urology residency program's COVID-19 experience. *Urology* 2020;140:1–3.
69 Warhadpande S, Khaja MS, Sabri SS. The impact of COVID-19 on interventional radiology training programs: what you need to know. *Acad Radiol* 2020;27:868–71.
70 Tutarel O. Geographical distribution of publications in the field of medical education. *BMC Med Educ* 2002;2:3.
71 Al Shawwa LA. The establishment and roles of the medical education department in the faculty of medicine, King Abdul Aziz University, Jeddah Saudi Arabia. *Oman Med J* 2012;27:4–9.
72 University of Maastricht. Department of Educational Development & Research, 2003. Available: http://www.educ.unimaas.nl
73 Liu N, Chee ML, Niu C, *et al*. Coronavirus disease 2019 (COVID-19): an evidence map of medical literature. *BMC Med Res Methodol* 2020;20:177.