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Authors

Kaul, Viren
Gallo de Moraes, Alice
Khateeb, Dina
[et al.](#)

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Medical Education During the COVID-19 Pandemic



Viren Kaul, MD; Alice Gallo de Moraes, MD; Dina Khateeb, DO; Yonatan Greenstein, MD; Gretchen Winter, MD; JuneMee Chae, MD; Nancy H. Stewart, DO, MS; Nida Qadir, MD; and Neha S. Dangayach, MD



All aspects of medical education were affected by the COVID-19 pandemic. Several challenges were experienced by trainees and programs alike, including economic repercussions of the pandemic; social distancing affecting the delivery of medical education, testing, and interviewing; the surge of patients affecting redeployment of personnel and potential compromises in core training; and the overall impact on the wellness and mental health of trainees and educators. The ability of medical teams and researchers to peer review, conduct clinical research, and keep up with literature was similarly challenged by the rapid growth in peer-reviewed and preprint literature. This article reviews these challenges and shares strategies that institutions, educators, and learners adopted, adapted, and developed to provide quality education during these unprecedented times.

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More than 58 million cases of COVID-19 have been confirmed worldwide. Medical education has been dramatically affected by this pandemic. Transmission of COVID-19 was decreased by social distancing but resulted in a significant need to adapt the delivery of education. Trainees and educators faced significant challenges due to economic repercussions, in preserving wellness and upholding equity, diversity, and inclusion (EDI), particularly with a fully virtual interview season for medical school, residency, and fellowship applications. Surges in the number of patients with COVID-19 led to redeployment of trainees and staff from noncritical care specialties to serve

on dedicated COVID-19 floors and ICUs. An unprecedented increase was noted in peer-reviewed literature and nonpeer-reviewed preprints.^{1,2} Clinicians struggled to differentiate facts from misinformation and remain up to date.^{3,4} The substitution of traditional lectures with digital learning platforms to meet the unique needs of learners due to these challenges was accelerated by COVID-19.

The goal of the current review was to highlight the impact of COVID-19 on trainees, educators, and adaptations to the delivery of medical education in the midst of an ongoing pandemic.

ABBREVIATIONS: AAMC = Association of American Medical Colleges; EDI = equity, diversity, and inclusion; IMG = international medical graduate; PCCM = pulmonary and critical care medicine; PPE = personal protective equipment

AFFILIATIONS: From the Crouse Health/Upstate Medical University (V. Kaul); Mayo Clinic (A. Gallo de Moraes); Berks Schuylkill Respiratory Specialists (D. Khateeb); Rutgers New Jersey Medical School (Y. Greenstein); University of Alabama at Birmingham (G. Winter); Mayo Clinic Health System-Franciscan Healthcare at La Crosse (J. M. Chae);

University of Kansas Medical Center (N. H. Stewart); David Geffen School of Medicine at UCLA (N. Qadir); and the Mount Sinai School of Medicine (N. S. Dangayach).

CORRESPONDENCE TO: Viren Kaul, MD; e-mail: virenkaul@crousemed.com

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Materials and Methods

A team of educators from the American College of Chest Physicians met digitally in June 2020 to address the topical issue of the impact of COVID-19 on various aspects of medical education. Following the first round of discussions by the lead authors (V. K., A. G., and N. S. D.), a list of topics to be addressed was created based on a literature search and personal experience. The common themes identified included challenges to didactics in the traditional format, rapid adaptation to virtual platforms, the economic and mental health challenges related to

the pandemic, and how different types of learners, medical students, residents, and fellows have been affected by the pandemic with alteration to their training. These themes were divided into discrete topics and shared with the writing group for input. For the intended scope of the review with rapid availability of new information, and with a goal to be thorough yet concise, topics were condensed or combined and reorganized based on the input from the contributing group of educators. The key challenges placed on medical education by the COVID-19 pandemic with potential mitigation strategies are summarized in [Table 1](#).

The Economic Repercussions

Significant loss of income was experienced by hospitals and physician practices due to the widespread economic impact of COVID-19. Health-care spending was reduced by 18% in the first financial quarter of 2020.⁵ Salaries had to be reduced by institutions despite increased working hours. Although hazard pay was provided by some centers, others had to cancel bonuses to meet financial shortfalls. The sharpest decline was experienced by surgical and pediatric practices, with many offices cutting pay, furloughing, and even laying off staff due to cancellations of elective procedures. Similarly, graduate medical education-related funding for continuous medical education was limited by institutions, and this could likely affect educators disproportionately. Trainees participating in the Public Service Loan Forgiveness Program were granted relief when Congress signed into law the Coronavirus Aid, Relief, and Economic Security Act on March 27, 2020, suspending payments and interest accrual on all government-held federal student loans from March 13, 2020, through September 30, 2020.⁶ Challenges posed by financial uncertainty made it imperative for institutions to reach out to trainees and educators facing financial hardship and provide resources for obtaining financial advice or assistance to alleviate some of the stress. Studies describing the economic impact of the COVID-19 pandemic on students and educators will be needed to help plan better for the future and to guide institutions in making appropriate budget allocations toward technological adaptations needed for the delivery of medical education and for providing feedback, testing, and interviewing.

Impact on EDI

Non-White populations have been disproportionately affected by COVID-19, and the long-standing disparities in health care^{7,8} have been magnified. Implicit biases of health-care professionals and the

lack of EDI education in academic medicine has, at least in part, contributed to these disparities. Cognitive stressors linked to implicit bias⁹ have been amplified by the uncertainties of this pandemic. Therefore, now more formal curricula on social determinants of health and implicit bias training need to be prioritized by medical educators. To support this effort, resources provided by institutional EDI offices or published frameworks can be used.¹⁰ Open-access resources on EDI have also been provided by the American Medical Association Education Hub.¹¹ Even prior to the pandemic over the past two decades, as medical school enrollments doubled, the percentage of underrepresented students fell by 16%.¹² Trainees who depend on campus-based resources may be disproportionately affected by COVID-19-related restrictions. The impact of these changes on trainees of all backgrounds must be considered by the educators and programs and take measures to improve remote access for these trainees. Female trainees, who constitute nearly one-half of our trainees, may be more affected by disruptions in the availability of child care or elder care due to COVID-19, which may then significantly affect work-life integration and academic productivity especially.¹³⁻¹⁵ Students from disadvantaged backgrounds may be more affected by the lack of away rotations and the lack of direct interactions with faculty on clinical rotations (which may affect faculty writing strong letters of recommendation).¹⁶ Similarly, students from minority communities maybe more affected by the current national conversations and unrest surrounding racism and social injustice, making it even more challenging than before for them to navigate the application process and coursework alike.

In light of the pandemic and these growing challenges to EDI, special attention to sources of implicit bias will need to be paid by admissions committees for medical school, residencies, and fellowships. Strategies for

TABLE 1] Key Challenges Faced in Medical Education During COVID-19 and Relevant Mitigation Strategies

Aspect of Medical Education	Key Challenges	Strategies to Mitigate Impact
The economic repercussions	<ol style="list-style-type: none"> 1. Loss of income for institutions and training programs 2. Decreased funding for GME and CME activities 	<ol style="list-style-type: none"> 1. CARES Act provided relief to trainees participating in the Public Service Loan Forgiveness Program 2. Offer financial guidance to trainees and educators 3. Budget allowances for technological adaptation of education
Impact on equity, diversity, and inclusion	<ol style="list-style-type: none"> 1. Amplification of cognitive stressors linked to implicit bias 2. Women trainees more likely to be affected 3. Students from disadvantaged background may be more affected by lack of away opportunities and direct faculty interactions 	<ol style="list-style-type: none"> 1. Use institutional resources or other open-access resources such as by the AMA to become more aware about implicit bias 2. Provide resources to address potential stressors (eg, child care or elder care facilities) 3. Implement strategies for factoring in impact of disruptions from unduly affecting application or interview process
Impact on mental health and wellness	<ol style="list-style-type: none"> 1. Increased vulnerability to emotional suppression 2. Exposure to stigma and resultant loneliness 3. Development of mood and sleep disorders 	<ol style="list-style-type: none"> 1. Establish and promote a culture of safety, well-being, and empathy 2. Rotate trainees off high-intensity rotations regularly 3. Provide accessible mental health resources 4. Provide resources to stay in touch with family and friends digitally 5. Institute surveillance and address programs for burnout
Education delivery	<ol style="list-style-type: none"> 1. Cancellation of in-person classes and training 	<ol style="list-style-type: none"> 1. Digitalize and encourage innovation in education delivery in the digital format
Medical students on the frontline	<ol style="list-style-type: none"> 1. Prevent coercion into service 2. Development of feelings of guilt, shame, or moral injury by students not involved in direct patient care 	<ol style="list-style-type: none"> 1. Institute strict guardrails to ensure that student participation in direct patient contact activities is voluntary 2. Encourage involvement in nondirect care and nonclinical activities, including research and community service
Alteration of training for residents and fellows	<ol style="list-style-type: none"> 1. Deployment of noncritical care specialty trainees to critical care areas 2. Development of deficiencies in native specialty training 	<ol style="list-style-type: none"> 1. Provide adequate clinical and on-ground guidance to redeployed trainees 2. Monitor progress and assess competence of trainees individually
Hidden curriculum	<ol style="list-style-type: none"> 1. Redeployed trainees pressured to practice outside comfort zone 2. Fear about speaking up about redeployment 	<ol style="list-style-type: none"> 1. Ensure adequate supervision and support for trainees, especially those redeployed from noncritically trained specialties 2. Create opportunity to discuss redeployment with program and institutional leadership
Challenges with interviewing	<ol style="list-style-type: none"> 1. Exacerbation of existing biases, especially against underrepresented minorities 	<ol style="list-style-type: none"> 1. Creation of structured interview process to avoid biases during interviews
Challenges with testing	<ol style="list-style-type: none"> 1. Uncertainty about testing dates, testing sites, and deferral of testing 	<ol style="list-style-type: none"> 1. Ensure flexibility and open lines of communication regarding frequent changes in testing schedules 2. Acknowledge the uncertainty and provide plans in case testing needs to be deferred or cancelled
Impact on international medical graduates	<ol style="list-style-type: none"> 1. Significant delays in visa processing and start times 2. Difficulty in finding waiver jobs 3. Inability to deploy to hotspot hospitals due to immigration limitations 	<ol style="list-style-type: none"> 1. Plan for late start and allow adaptation time and resources 2. Assist graduating trainees in job placements according to their immigration needs 3. Deploy international graduates within native systems where immigration rules would not be challenged

(Continued)

TABLE 1] (Continued)

Aspect of Medical Education	Key Challenges	Strategies to Mitigate Impact
Impact on medical literature and dissemination of information	<ol style="list-style-type: none"> 1. Need for rapid dissemination of information to be balanced with accuracy of peer review 2. Rapid spread of misinformation 	<ol style="list-style-type: none"> 1. Maintain integrity of peer review process despite the pressure to publish the deluge of data 2. Create well-appraised literature banks that can be reliably used by clinicians and educators
Social media	<ol style="list-style-type: none"> 1. Compromise of patient privacy 2. Creation and dissemination of insensitive content 	<ol style="list-style-type: none"> 1. Review the purview of the HIPAA regulations and ensure patient privacy even when sharing anecdotes 2. Careful creation of content keeping societal, social, professional, and personal responsibilities in mind

AMA = American Medical Association; CARES = Coronavirus Aid, Relief, and Economic Security; CME = Continuing Medical Education; COVID-19 = coronavirus disease 2019; GME = Graduate Medical Education; HIPAA = Health Insurance Portability and Accountability Act of 1996.

preventing such bias from affecting the admissions process will need to be reinforced. A clear commitment to upholding EDI has been made by some schools; for instance, the Dean of the University of Washington published a letter that clearly states how the University will conduct interviews this year.¹⁷ Special guidance on avoiding implicit bias has been provided by the guide from the Association of American Medical Colleges (AAMC) on virtual interviews.¹⁸

Impact on Mental Health and Wellness

The mental health burden from this pandemic can be attributed to anticipatory anxiety,¹⁹ dealing with a high degree of sickness and death, increased work commitments with significant reduction in recovery time, impact of the illness on colleagues and families, economic stressors, social isolation, and societal pressures, among other reasons. Health-care professionals, including trainees, have been cognitively and emotionally challenged by the significant morbidity and mortality occurring over a sudden and short span of time. Traditionally, emotional expression in medicine has been considered unprofessional.²⁰ Trainees observe the reactions of their role models and are vulnerable to emotional suppression and patient dehumanization. A culture of empathy and emotional well-being for all trainees should be emphasized by sponsoring institutions, programs, and faculty. This culture may be achieved by offering staffing schedules that rotate trainees from high-intensity to low-intensity responsibilities, providing appropriate and accessible mental health resources, fostering an environment that encourages expression of emotion, and offering psychosocial support in the form of regular check-ins with trainees.²¹

Mental health problems such as stress disorders, insomnia, and mood disorders, even in those with no preexisting conditions, can be worsened by social isolation. Health-care workers and trainees struggle with isolation just like the general public due to decreased social engagement, less sensory stimulation, and diminished engagement with meaningful activities.²²⁻²⁴ In addition to isolation from quarantines and stay-at-home orders, avoidance from others due to stigma maybe experienced by health-care workers, which can further exacerbate loneliness.²⁵ It was noted by the World Health Organization that health-care workers are at an increased risk for mental health problems not only due to emotional distress from social isolation but also due to exposure to death and disease, personnel and personal protective equipment (PPE) shortages, and moral distress in the care of patients.^{22,26} Another related issue is professional uncertainty for trainees applying for their first jobs. Hiring has been frozen by a number of institutions due to pandemic-related budget cuts. The full burden of the mental health toll on health-care workers and trainees is not yet known, but it will likely be significant.

People have been encouraged by experts to stay virtually connected through telephone calls, text messages, and video chats. Leaders have been encouraged to reach out to employees to provide support and share information to minimize the effects of social isolation. Program leadership and faculty have been requested to update their trainees regularly and encourage virtual engagement.²⁷ Avoidance could be a symptom of suffering mental trauma. Programs should reach out to trainees and faculty who miss virtual classes and meetings, as they may be struggling psychologically. Prior to this pandemic, academic medical departments

across the country had wellness initiatives to prevent burnout. Such initiatives included meditation, yoga, peer-to-peer counseling programs, and faculty training in mind-body medicine among others. The effectiveness of the various programs is an ongoing area of research. Several of these were successfully transitioned to digital platforms.²⁸ Meditation apps such as Headspace provided special discounts for health-care workers.²⁹ With temporary closure of gyms, virtual yoga classes were started by physician leaders such as Arghavan Salles, and innovative solutions such as “recharge rooms” were built at some hospitals to provide frontline health-care workers a space to de-stress.^{30,31}

Education Delivery and On-demand Learning

To facilitate asynchronous learning while social distancing, educators relied on online learning and Web conferencing platforms such as Zoom, Google Hangouts, and GoToMeeting.^{32,33} In-person attendance at preclinical lectures was declining even prior to the pandemic, and students were increasingly viewing lectures online.³⁴ Broadly, all in-person training, including clerkships, medical school rotations, small group sessions, and traditional didactic forums, were suspended in the early part of the pandemic.^{35,36}

Clinically oriented activities such as medical school rotations and clerkships were reinstated by some institutions following careful consideration of local factors. The future of these educational avenues remains uncertain. Didactic sessions, including national conferences, were predominantly held virtually.³⁷ Residency and fellowship programs were transitioned to digital platforms for conducting key didactic sessions, including grand rounds and journal clubs. Teamwork management programs (eg, Slack and Asana), game-based learning platforms (eg, Kahoot!), and social media networks (eg, Twitter) were being used to reinforce concepts based on the principles of spaced repetition.³⁸

A notable consequence of the pandemic was the cancellation of many medical student clinical rotations, thereby limiting opportunities for hands-on learning. Virtual reality-enhanced classrooms and application of game theory via online escape rooms were being explored as exercises for critical thinking and communication skills in simulated clinical experiences.³⁹

Although the full impact and perception of virtual education will only become evident over time, early evidence supports that trainees found virtual education engaging in settings such as virtual rotations.⁴⁰ Innovative amalgamation of virtual platforms and

technologies with educational principles is expected to lead to educational offerings such as virtual and virtual reality-based clinical rotations, educational digital escape rooms (such as the one offered at the American College of Chest Physicians Annual Meeting 2020), and conference or meeting delivery that allows real-time interaction (such as offered by Gatherly).⁴¹

Medical Students on the Frontline

Facing an unprecedented shortage of qualified health-care workers, several safe alternatives for expanding the workforce, including deploying qualified and willing medical students, were considered by institutions.⁴² Countries such as Italy, Ireland, and the United Kingdom engaged their students early as health-care workers while students in Canada were pulled from clinical duties.⁴³⁻⁴⁵ A number of American medical schools graduated some students early. Guidelines were developed by the AAMC to ensure that students’ participation in direct patient care was voluntary, with guarantees of sufficient PPE, adequate testing, and health-care coverage. Importantly, efforts were made by institutions to prevent students from feeling coerced into service.⁴⁶ Guilt, shame, or moral injury may be experienced by medical students not involved with delivering clinical care or unable to do so. However, maintaining their focus on completing their education should be the main objective, even in the face of this pandemic, and such feelings should be addressed by mentors in a supportive manner, including providing guidance on alternative avenues to help during these unprecedented times.⁴⁷

Student participation in direct patient care was restricted by another important factor. Some institutions had to limit the number of team members entering patient rooms and performing the physical examination each day to reduce the possibility of transmission to health-care workers as well as to conserve PPE. Usually more senior members of the team performed these physical examinations and procedures, excluding other junior members such as medical students.

Students with underlying health conditions have been permitted to assist in patient care via telehealth or other noncontact duties such as research.⁴⁸ Clinical and educational resources to navigate these opportunities should be readily available to students engaging in direct patient care.^{49,50} A potential strategy for safely integrating students into patient care could be providing clinical care within their medical schools’ affiliated

health systems or the institution where they anticipate starting residency.⁴⁹ Frequent check-ins by supervising faculty can help continually assess the needs of students.⁵¹ Institutions should provide flexible examination timelines and graduating schedules as well as ensure adequate transition time to future programs.

Students have also served meaningfully in nonclinical roles. COVID-19 call centers to provide guidance on symptoms and seeking medical care were organized by the University of Colorado medical students.⁵² The COVID-19 Medical Student Response Team, created by Harvard Medical School students and recruiting > 500 volunteers, developed educational materials, engaged in advocacy efforts, offered community services in the form of child care or grocery delivery, and provided clinical care. Groups such as the COVID-19 Healthcare Workers Childcare Co-op and CovidSitters assisted health-care workers with child care, pet sitting, and running errands.^{53,54} PPE was collected and redistributed by medical students across the United States.⁵⁵ In Chicago, students created the group #GetMePPE that crowdfunded donations of PPE to distribute to hospitals and community organizations.⁵⁶

Alteration of Training for Residents and Fellows

Trainees were redeployed from noncritical care specialties to the frontlines of EDs, wards, and ICUs. The Accreditation Council for Graduate Medical Education developed a staging process to increase resident and fellow availability for COVID-19 efforts while prioritizing trainee and patient safety.⁵⁷ In a survey of residency program directors from New York City, 75% reported redeploying residents.⁵⁸ Several large academic institutions in New York City staffed COVID-19 procedural and ICU teams using supervised physician pyramid models that included diverse groups of specialist and subspecialist trainees.⁵⁹ Acknowledging that some redeployed physicians would have expected gaps in skills, COVID-19-specific educational curricula were developed by programs and medical societies alike.^{60,61}

On March 16, 2020, hospitals were asked to consider halting elective procedures and surgeries by the Surgeon General. Cancellation, postponement, and reduction of nonurgent procedures, ED visits, and hospital admissions had a tremendous impact on medical training in noninterventional as well as interventional specialty programs. Residents and fellows found

themselves at risk of deficient specialty-specific case requirements, with trainees closest to graduation most at risk.⁶² Fellows in medical subspecialty programs also encountered a decrease in consultations and nonurgent outpatient care experiences salient to developing competence in their respective fields.⁶³ In response to this gap in learning and skill acquisition, the Accreditation Council for Graduate Medical Education recommended that program directors along with Clinical Competence Committees assess the competence of individual trainees for unsupervised clinical practice.⁶⁴ To sustain a beneficial educational experience, some programs established new academic committees to facilitate important didactic sessions and set scholarly goals for time not spent in direct patient care and promote the completion of research projects. This crisis presented a unique opportunity for trainees to acquire experience in emergency management, including resource allocation, triage, and disaster response. These skills, while not in the armamentarium of most trainees, have led to creation of a generation of clinicians with the experience to respond to similar events at the local, regional, or national level.

Pulmonary and critical care medicine (PCCM) programs faced unique challenges as their trainees found themselves leading the charge against COVID-19. Training programs included fellows in pandemic preparedness heading up critical care teams during surge periods. Although redeployment caused trainees in other specialties to lose out of education in their native specialties, PCCM fellows likely gained more experience in their field of training. PCCM training programs worked to provide a framework that would allow fellows to maintain board eligibility, have their clinical and procedural competencies assessed with the increased clinical exposure, make up for lost experience in noncritical care training areas, maintain well-being, and ensure safety by evaluating fellow involvement in high-risk situations such as aerosol-generating procedures (eg, bronchoscopy, intubations). Restructuring didactics and clinical service to allow continued education in the face of significantly increased workload was one of the key challenges identified by Pulmonary and Critical Care fellowship leadership early in the pandemic.⁶⁵

Hidden Curriculum

The hidden curriculum embodies social and cultural messages of medicine learned by trainees that influence professional identities, behaviors, perspectives, attitudes, and biases of learners.⁶⁶ Some core themes include

hierarchy, patient dehumanization, emotional suppression, the limits of medicine, balance, and sacrifice.⁶⁷ Within the hierarchical structure of medicine, there has been a history of bullying, mistreatment, and abuse rooted in the teacher-learner power differential.⁶⁸ During the COVID-19 pandemic, many redeployed trainees were more vulnerable than usual as they were asked to practice medicine outside of their comfort zones. At some institutions, trainees were fearful of retaliation for speaking up against redeployment.^{69,70} The responsibility to ensure that trainees do not suffer mistreatment falls upon the leadership of institutions and program faculty members. Recognizing the opportunity to stress the importance of practicing humanism, compassion, bearing witness to suffering, building resilience, and sitting with grief as a health-care professional, the Gold Foundation recently released a series of webinars addressing these important topics that are a part of the hidden curriculum.⁷¹

Challenges With Interviewing

The AAMC recommended all training programs move to an online or virtual format for the 2020 to 2021 interview season.^{18,72} Several resources have been developed to assist programs and trainees navigating this new format of interviewing. To provide interviewees with a fulfilling interview experience, programs should update their websites to provide insightful details, ensure that faculty have quiet spaces and appropriate equipment, provide practice sessions for the faculty, and have backup strategies in place, including alternate interview dates should technology fail on the day of the interview.^{73,74}

Challenges With Testing

On May 26, 2020, the United States Medical Licensing Examination announced the discontinuation of the Step 2 Clinical Skills examination.⁷⁵ Similarly, uncertainty exists surrounding the timing of various national subspecialty certification and oral certifying examinations.⁷⁶ The American Board of Internal Medicine announced on June 5, 2020, that they would waive late fees for scheduling of written certifying and recertifying examinations to allow for flexibility.⁷⁷ Employers and institutions need to be aware of these uncertainties and work toward mitigating stress. Clear, consistent communication from testing bodies and professional organizations along with alternative dates, fee waivers, and changes in format to online testing could help alleviate some of the anxiety. Ensuring safety during tests has been an area of concern, with medical

schools evaluating and implementing the use of virtually proctored shelf examinations.⁷⁸ At the time of writing this review, there were no plans for delivering video-proctored examinations from the American Board of Internal Medicine; however, precautions are in place to mitigate transmission per the Centers for Disease Control and Prevention and World Health Organization guidelines, including use of masks during the administered board examinations.⁷⁹ The American Board of Internal Medicine has also provided alternative testing dates for various examinations and an option to defer the examination to the following year.⁷⁷

Impact on International Medical Graduates

International Medical Graduates (IMG) have always faced unique challenges.⁸⁰ During the COVID-19 pandemic, IMGs have faced additional difficulties due to immigration and travel-related changes. About 4,600 incoming trainees who require visas were at risk of losing their training positions if their applications were not approved by respective consulates or embassies on time.⁸¹ Trainees applying for J1 waiver jobs are experiencing significant delays. It is noteworthy that the physicians who sign up for J1 waiver positions provide services in underserved areas where the lack of health-care workers could have an even graver impact.

IMG physicians are facing the possibility of having to return to their home countries without definite plans, adding to financial and emotional turmoil. These challenges caused uncertainty for training programs as well. Inability to start training on time placed strain on the residency and fellowship programs that had to choose between allowing a delayed start without a clear time frame as opposed to securing a new candidate to fill the position. Finally, currently employed IMGs who are undergoing the waiver process and are interested in providing clinical support at a hotspot hospital that is not their home institution are unable to do so due to the strict limitations placed by visa stipulations regarding their work institutions. This adds to challenges of redistributing the workforce effectively. As of 2015, IMGs constitute 29.2% of the 5,482 pulmonary medicine physicians and 41% of the 10,158 critical care medicine physicians in the United States.⁸²

Impact on Medical Literature and Dissemination of Information

In a curated online resource available via PubMed (ie, LitCovid), there were > 32,917 peer-reviewed articles on new clinical features, management strategies, and novel

treatments for COVID-19 between January and July 2020.¹ Countless non-peer-reviewed and preprint publications were released. The limits of the traditional peer review process were tested during this time. Many journals accelerated their peer review processes for COVID-19-specific literature. Unfortunately, several articles, even those published in high-impact journals, were found to have significant flaws in data and conclusions. A study published in March 2020 was widely reported to have established that anticoagulation led to decreased mortality in critically ill patients. However, this observational study compared prophylactic anticoagulation vs no prophylaxis and did not explore therapeutic anticoagulation.^{83,84} A large observational cohort study concluded that 88.1% of patients requiring mechanical ventilation died.⁸⁵ This study was widely cited by the media as well. Many readers noted an error in these data, and the article was subsequently corrected to indicate that mortality was 24.5%, with 72.2% of patients who were mechanically ventilated still requiring hospitalization at the time of publication. Concerns were raised regarding multiple aspects of one of the first trials of hydroxychloroquine and azithromycin for COVID-19, including the veracity of the data and the publication process.^{86,87} These data played a role in former President Donald J. Trump's enthusiasm for hydroxychloroquine and for the expedited approval for use by the US Food and Drug Administration.

During the pandemic, preprint publication archives gained popularity because data could be shared rapidly. As of the writing of this paper, medRxiv, a preprint archive that was founded in 2019 by Cold Spring Harbor Laboratory, the *British Medical Journal*, and Yale University, has more than 3,200 papers published on COVID-19. In the years leading up to the pandemic, academics argued that the current peer review model is necessary to ensure rigorous reporting of data while others argued that the current practice of peer review was slow and subjective, stifled innovation, and reduced the speed of progress.⁸⁸ A study published in a preprint archive reported that peer-reviewed articles had higher quality reporting compared with the preprint publications, although the difference was deemed small by the authors.⁸⁹ In May 2020, a high-impact publication on the use of hydroxychloroquine and macrolide antibiotics was published, followed by a study in June 2020 on cardiovascular disease and drug therapy in COVID-19. Both studies gained significant traction in medical circles as well as media but were eventually

retracted when it was discovered that they had used data from a fabricated registry.⁹⁰⁻⁹² The need to balance rapidity of information release and dissemination needs to be balanced with the responsibility that this information is accurate. A rushed peer review process can potentially allow flawed studies to be published, leading to confusion in the medical community and questions on the scientific integrity of the field of medicine.

The rapid flow of information mandated the need for better understanding of the science prior to clinical application or education, more than ever before. Educational efforts in the form of journal clubs focusing on evaluation rather than a simple summarization of newly available literature are needed to help health-care professionals appropriately interpret the results of new studies and understand their limitations. The pandemic reinforced that principles of medicine need not be abandoned in favor of sensational new data without appropriate appraisal.⁹³ The Fast Literature Assessment and Review team (FLARE) initiative, which aims to quickly compile and critically appraise new literature on COVID-19,⁹⁴ is an example of innovative and well-appraised curation of data that may help educators stay on top of the firehose of information during a pandemic.

Social Media

Between January and March 2020, conversations about COVID-19 on social media grew rapidly, with > 2.8 million tweets and 18.1 million retweets.² Both accurate and inaccurate information has been spread via social media.⁹⁵ Prior to the COVID-19 pandemic, a study evaluating medical tweets from professional accounts on Twitter found that approximately one-half were false based on expert review.⁹⁶ However, professional societies play an important role in directing clinicians to reputable sources and open-access educational material. Resources for COVID-19 education such as journal clubs, podcasts, webinars, and article repositories were developed by critical care organizations across the world, including the American College of Chest Physicians, the American Thoracic Society, the Society of Critical Care Medicine, and the European Society of Intensive Care Medicine.⁹⁷⁻⁹⁹ Dedicated resources for non-critical care-trained clinicians such as the American Thoracic Society's Critical Care Training Forum were rapidly envisioned and delivered by these organizations as well.^{100,101} Twitter chats moderated by professional societies provide access to communities of experts, which may help combat questionable and non-evidence-

based information.¹⁰² When users encounter misinformation, they should be proactive in challenging and correcting it with references to high-quality, evidence-based and expert-driven, peer-reviewed literature.^{103,104}

Institutions and training programs have had existing policies to encourage the responsible use of social media even prior to the pandemic. Periodic training for trainees and faculty can help them reflect on the challenges presented by emerging platforms and public health situations while maintaining a professional social media presence.¹⁰⁵ Sharing cases online with details of presentation, disease course, laboratory values or imaging, and outcomes may lead to unintentional violations of the Health Insurance Portability and Accountability Act of 1996 regulations.¹⁰⁶ Educators and learners must remember that they share the digital space with patients as well as caregivers. The use of TikTok, a platform that has gained prominence among young adults, by health-care professionals to share videos has faced criticism.¹⁰⁷ The most polarizing videos have included health-care workers discussing patient care matters in an insensitive or hurtful manner as they shame patients for seeking care.¹⁰⁸ Other videos with health-care workers dancing while wearing PPE have garnered criticism for giving the appearance that they were wasting PPE, leading to public mistrust.

Conclusions

Experiences of the areas that were hardest hit during the pandemic led to important and thoughtful changes to guide safe redeployment of trainees to areas of need. The adoption of digital platforms for both asynchronous and synchronous group learning was accelerated by social distancing during the COVID-19 pandemic. Several challenges were created by the rapid increase in peer-reviewed and non-peer-reviewed literature in staying up to date and ensuring accurate translation of data. The limits of traditional peer review were tested by the pandemic. Social media helped rapidly disseminate information, but the challenges of maintaining privacy, professionalism, and preventing the spread of misinformation were magnified. There were several opportunities for innovation in medical education during this pandemic, and a number of innovations were implemented successfully. The long-lasting effects on medical education by the pandemic need to be studied systematically.

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