



Graduate medical education in anaesthesiology and COVID-19: lessons learned from a global pandemic

Larry F. Chu^a and Viji Kurup^b

Purpose of review

The recent global pandemic has dramatically altered the anaesthesiology educational landscape in unexpected ways. It is important that we pause to learn from this crisis.

Recent findings

Most resident trainees actively caring for COVID-19 patients present with probable or subclinical finding of post-traumatic stress disorder. Anaesthesia resident training programmes evolved to continue the mission of anaesthesia education in the face of institutional restrictions and evolving clinical crises.

Summary

The recent global COVID-19 pandemic has illustrated how external stressors can cause significant disruption to traditional medical education pathways. Resilience to external disruptive forces in anaesthesia education include a willingness of leadership to understand the problem, flexibility in adapting to the needs of learners and instructors in the face of key challenges, deployment of technology and innovation-minded solution-finding where appropriate, and attention to Maslow's hierarchy of needs.

Video abstract

<http://links.lww.com/COAN/A77>

Keywords

COVID-19, graduate medical education, pandemic preparedness, resilience

INTRODUCTION

The recent global COVID-19 outbreak has dramatically altered many aspects of anaesthesiology education and training [1]. Due to the evolving nature of the pandemic and eventual determination of aerosol vector of transmission, social distancing measures prevented many face-to-face educational interactions [2]. Aerosol-generating procedures such as intubation that are common in anaesthesiology were deemed too risky for trainees. Most elective surgical procedures were halted as a source control measure [3,4]. The dramatic reduction in elective procedures reduced the surgical case mix and volume for trainees. At the same time, a global supply chain shortage of personal protective equipment (PPE) including N95 respirators that protect against SARS-CoV-2 [5–8], the virus that causes COVID-19, led many institutions to limit anaesthesia trainees from clinical care. Altogether, this series of events dramatically altered the landscape of anaesthesiology education and training. The purpose of this review is to reflect on the impact of these events, how institutions adapted to them and document the lessons learned and key takeaways to secure future pandemic preparedness.

TEXT OF REVIEW

A fragile learning environment

Contemporary anaesthesiology resident trainees live, work and learn in a fragile educational work environment [9]. Repeated cross-sectional studies of US anaesthesia trainees from 2013 to 2016 have documented that a majority of residents suffer from burn-out, one-third suffer from distress and 12% suffer from depression. A report by the Royal College of Anesthetists in 2017 found that 61% of anaesthesia trainees reported their jobs negatively affected their mental health, while 85% were at an increased risk of

^aDepartment of Anesthesiology, Stanford Anesthesia Informatics and Media (AIM) Lab, Stanford University School of Medicine, Palo Alto California and ^bDepartment of Anesthesiology, Yale University School of Medicine, New Haven, Connecticut, USA

Correspondence to Larry F. Chu, Professor of Anesthesiology, Director, Stanford Anesthesia Informatics and Media (AIM) Lab, Stanford University School of Medicine, 2370 Watson Court, Suite 235, Palo Alto, CA 94303, USA. Tel: +1 650 464 3450; e-mail: lchu@stanford.edu

Curr Opin Anesthesiol 2021, 34:726–734

DOI:10.1097/ACO.0000000000001065

KEY POINTS

- Point 1: Our trainees live, work and learn in a fragile environment that is susceptible to external stressors, which makes it important to have the voices of trainees when developing new models of instruction during a crisis.
- Point 2: Institutions and departments across the globe innovated and evolved during the pandemic to continue to deliver quality instruction while keeping in mind the social distancing guidelines and supporting the mental health of trainees.
- Point 3: As we emerge from the pandemic, the lessons learned should guide us in building new and more inclusive methods of instruction.

workplace burnout [10]. Learners cite long work hours, inadequate support for nonclinical work-related duties, fear of harming the patient, inadequate time for sleep and even societal views towards physicians as contributing to the negative aspects of the anaesthesia training environment [11]. The consequences of these stress factors on anaesthesia resident trainees and anaesthesiologists include self-harm such as substance use disorder [12] and recent data which suggest that male anaesthesiologists experience the highest rates of suicide among physicians who work in the medical profession [13].

External stressors impair a fragile resident trainee learning environment

The global COVID-19 pandemic caused additional external stress on the already-fragile learning and work environment of resident anaesthesiologists. The SARS-CoV-2 outbreak caused intense anxiety and psychological pressure on some resident trainees, increased physical workload, excessive work-related anxiety due to patient mortality and potential personal health risks due to aerosol transmission and potential exposure to the virus. Exposure to these types of traumatic events, especially under acute stress settings, may decompensate and lead to posttraumatic stress disorder (PTSD). There is some recent evidence that indicates the prevalence of PTSD is higher among emergency care trainees than emergency care expert providers due to both their inexperience and the pressure of evaluation in an academic setting [14]. A study of over 500 resident physicians working in a COVID-19 ICU found that 34.3% had probably PTSD and 21.5% had sub-clinical PTSD [1].

During pandemics, academic medical centres need to balance their responsibility to ensure the

safety of patients, students, faculty and staff with minimizing the disruptions to the educational programme. Recognizing how this stress affected individuals and the larger collective learning community is important in developing solutions to address learning.

Maslow's hierarchy of needs: a framework to approach pandemic response

The response of the education team to a crisis needs to be intentional, as the number of resources and/or time available to make a positive impact for learners may be limited in such situations. One useful framework for understanding how to direct allocation of resources is Maslow's hierarchy of needs.

Abraham Maslow, an American psychologist, published an article in a 1943 paper entitled 'A Theory of Human Motivation'. In it, he proposed that human motivation is dependent on a hierarchy of psychological needs [15]. In that paper and a subsequent 1954 book entitled *Motivation and Personality* [16], Maslow proposed that five core needs form the basis for human behavioural motivation. Although it was initially proposed to understand human motivation, it has been applied in education, too.

Maslow identified the first four levels as 'depriving', 'deficiency' or d-needs. These lower levels of his hierarchy (physiologic, safety, love/belonging, esteem) must be fulfilled first as needs become more and more complex as we travel up the pyramid (Fig. 1). The goal of attaining higher-level needs comes from the desire to grow as a person and focus less on the needs of basic survival (e.g. physiologic and safety needs). Self-actualization requires meeting, at least to some extent, all other basic needs sequentially starting from the very bottom of the pyramid.

Building a firm foundation for learning during a pandemic

Educators in many institutions recognized that at the beginning of the pandemic, according to Maslow's hierarchy of needs, trainees were in the bottom of the pyramid (Fig. 1). A global supply chain shortage of N95 respirators created uncertainty about the availability of PPE and the trainee's personal safety. The asymptomatic transmission period of COVID-19 also created concern for the health and safety of their families, to whom they might unknowingly transmit the virus from the hospital (Fig. 1, right). The 'd-needs' of anaesthesia residents during the early COVID-19 pandemic period were not adequately met; therefore, many of them were

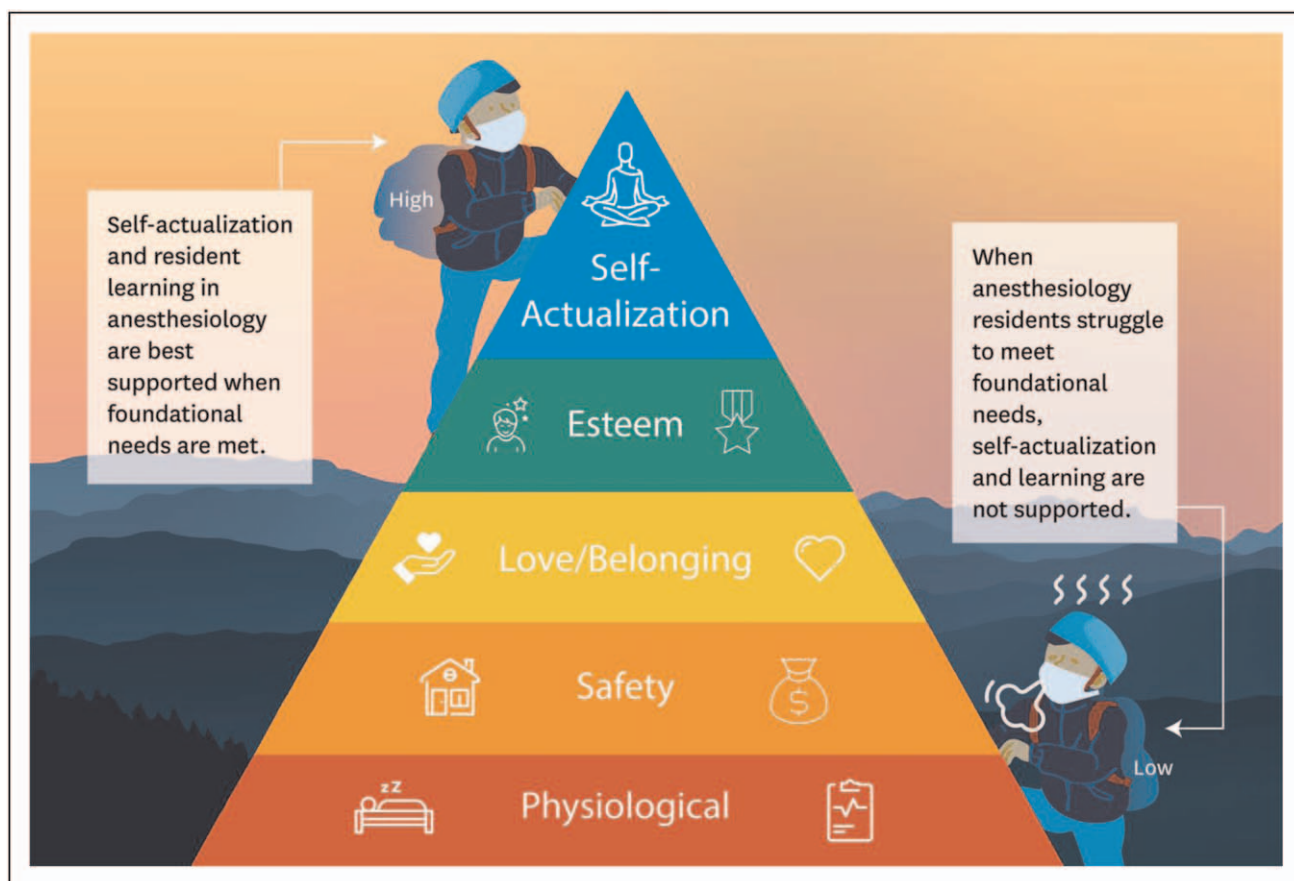


FIGURE 1. Maslow's Hierarchy of Needs as they relate to self-actualization and resident learning. (right) The anaesthesia trainee is challenged to meet basic needs on Maslow's hierarchy, including adequate sleep and safety. (left) The anaesthesia trainee has adequate support of physiological, safety, love/belonging, esteem and self-actualization needs. Learning is well supported in this scenario.

not intellectually and emotionally available to learn. We have referenced how some programmes have recognized challenges presented by the COVID-19 pandemic on graduate medical education (Table 1) and how they could possibly be mitigated through programmatic responses addressing various Maslow hierarchies (Table 2).

Physiological needs

Departments must ensure that trainees have access to food and supplies during the pandemic as widespread closure of retail stores affects their ability to purchase necessities. Reduced hours of operation were not compatible with resident working schedules. Changes to the physical environment can also cause changes in physiological needs that impact learning. The mandatory use of N95 respirators during the pandemic can cause psychomotor and cognitive function decline and increase anxiety of the wearer [17–20]. In response, at one of the author's programmes (VK), all didactics were immediately suspended to give trainees time to make sure

they felt safe. At the same time, the programme planned changes in rotation assignments and quarantine policies for those who were sick or had travelled recently. It took a few weeks for students to feel safe and reach the point where they were available to learn. Student representatives can help keep tabs on the trainees to find the point at which the majority of the trainees will feel safe enough to engage in the educational process again.

Need for safety

Trainees, as well as instructors, had good reason to fear for the health and safety of their spouses, significant others, children and parents. In that initial phase, educators need to focus on guiding trainees to resources available for self-care and wellness. This ensured that everyone felt safe and could prioritize their health safety.

We made sure there was enough PPE along with a policy for emergency intubations. New guidelines were developed with input from experts. When there was a shortage of PPE, the team at Yale

Table 1. Challenges presented by COVID-19 pandemic

Maslow's hierarchy (the 'd-needs')	Didactic programme	Clinical responsibilities	Nonclinical work responsibilities	Assessment
Esteem	<ul style="list-style-type: none"> Social isolation can make recognition and fulfilment challenging 	<ul style="list-style-type: none"> High mortality in COVID-19 ICU can lead to PTSD and low self-esteem 	<ul style="list-style-type: none"> Self-quarantine and social isolation has been shown to lead to mental distress [30]. 	<ul style="list-style-type: none"> Cancellation of assessment examinations can challenge traditional modes of recognizing academic accomplishment.
Love/Belonging	<ul style="list-style-type: none"> Team training and group learning reduced due to social distancing. 	<ul style="list-style-type: none"> Long work-hours and fear of transmitting virus caused social isolation from support groups and loved ones 	<ul style="list-style-type: none"> Separation from children and elderly parents needing care caused anxiety in trainees. 	<ul style="list-style-type: none"> Anxiety and depression can affect performance on tests
Safety	<ul style="list-style-type: none"> Personal safety of residents endangered during certain clinical learning settings. 	<ul style="list-style-type: none"> Shortage of PPE threatened personal safety Aerosol generating procedures threatened personal safety 	<ul style="list-style-type: none"> Increased social unrest and violence targeting minorities and communities of colour 	<ul style="list-style-type: none"> In-person convening for assessment examinations risks transmission of SARS-CoV-2.
Physiological	<ul style="list-style-type: none"> Basic 'd-needs' unmet leading to sub-optimal support for learning environment. 	<ul style="list-style-type: none"> Contracting COVID-19 during clinical duties endangers health. Fear of transmitting disease to loved ones necessitating isolation from loved ones at home 	<ul style="list-style-type: none"> Restaurant and grocery stores closure, limited hour openings of store not friendly to medical trainee work hours. Shortage of essential items such as hand sanitizer. 	<ul style="list-style-type: none"> All trainees may not have access to devices and network capabilities for online assessments. Basic 'd-needs' unmet leading to sub-optimal support for assessment of learning.

Table 2. Mitigation and resolving solutions implemented

Maslow's hierarchy (the 'd-needs')	Didactic programme	Clinical responsibilities	Nonclinical work responsibilities	Assessment
Esteem	<ul style="list-style-type: none"> Creating appreciation board in department to celebrate work of trainees during the pandemic. 	<ul style="list-style-type: none"> Provide screening and PTSD counselling tools for residents in COVID-19 ICU. 	<ul style="list-style-type: none"> Delivering notes of appreciation from patients and staff Creating public service health messages on social media with trainee involvement 	<ul style="list-style-type: none"> Provide self-assessment tools and knowledge retrieval practice to allow residents to build portfolio of accomplishment.
Love/Belonging	<ul style="list-style-type: none"> Building wellness sessions within didactics Creating meal trains for trainees who contracted the illness 	<ul style="list-style-type: none"> Making sure all trainees were using PPE appropriately Creating groups within each setting 	<ul style="list-style-type: none"> Periodic check-ins for trainees Schwartz rounds (Schwartz Rounds The Schwartz Center) 	<ul style="list-style-type: none"> Mentoring and peer support via online and distance mechanism can improve group cohesion and help navigate anxiety and depression.
Safety	<ul style="list-style-type: none"> Educational sessions moved to online format Involving trainees in decision making for resuming didactics 	<ul style="list-style-type: none"> Case mix was changed to eliminate elective procedures. Trainees limited from caring for COVID-19 patients in some settings. 	<ul style="list-style-type: none"> Demonstrate support for communities of colour and identify programs for security and safety at hospital and community. 	<ul style="list-style-type: none"> Using simulation for assessment during rotations when traditional schedules are disrupted.
Physiological	<ul style="list-style-type: none"> Suspending regular didactic programs until trainees feel ready to learn Holding regular townhalls to address trainee needs Emergency contact numbers available to all 	<ul style="list-style-type: none"> Distributing appropriate PPE to trainees Reassigning trainees to clinical sites that were appropriate for level of training 	<ul style="list-style-type: none"> Working with grocery stores near hospitals to arrange for early and late hours for trainee use and online delivery of food and groceries 	<ul style="list-style-type: none"> Suspending traditional assessments until trainees are in appropriate frame of mind

designed and assembled 3D printed face shields and used them, while the supply could be increased. Faculty and residents learned how to use the CAPR systems for COVID intubations. At another author's programme (L.C.), trainees were restricted from caring for COVID-19 or PUI patients, and clinical duties were assigned to reduce risk of aerosol exposure.

During this time, faculty also modelled self-directed learning, one of the most under-appreciated lessons of this pandemic. When faced with ambiguity, every member of the department read material, accessed critical care and reviewed medical society guidelines. All members attended talks given by experts across different departments and accessed guidelines from national organizations. Everyone was accountable in learning how to best care for patients.

Clinicians took it upon themselves to investigate methods of decreasing aerosol spread while intubating patients and splitting ventilators for critically ill patients. This was a period of intense personal growth, and we witnessed the organic rise in leadership of many residents and faculty. As the pandemic spread across the globe, institutions prepared using multiple modalities including simulation [21]. In-situ simulation can uncover hidden threats and plan for extra time and personnel that may be needed in emergencies. Kuhn *et al.* [22^{**}] highlight the importance of well designed cognitive aids to help healthcare workers remain safe during a pandemic.

Need for love and belonging

Social isolation led to increased reporting of anxiety and depression among healthcare workers. Faculty and trainees experienced self-imposed separation from their young children and elderly parents. Departments paid attention to taking care of sick residents and faculty through meal trains, periodic check-ins and video visits.

Need for higher self-esteem

The staff felt a sense of frustration and inadequacy when treating patients. There was a sense of loss of control as we were dealing with the new disease, rapidly changing situations and temporary guidelines. The cancellation of assessments can interrupt the traditional modes of recognizing academic accomplishment. High mortality observed in ICU can lead to PTSD, generate low morale and hamper one's self-esteem.

Need for self-actualization

It is only when the d-needs have been addressed that trainees and faculty can re-focus on teaching and learning.

Assessing and responding to environmental impact

Learner concerns

Service and safety concerns have had a marked effect on trainees education. Trainees and trainers across six continents reported that reduced caseload, subspecialty experience and supervised procedures impaired their learning [3]. Most procedures that carry high risk were being performed by the most experienced member of the team, which was frequently the faculty. Many basic skills such as bag-mask ventilation, laryngeal airway use and direct laryngoscopy were abandoned in favour of video laryngoscopy to minimize health concerns. This deprived junior students from learning basic airway skills at the beginning of their training. Worldwide, the case mix changed as elective surgeries were cancelled and only emergent cases were performed. For senior residents, this period interrupted the time when they were supposed to be learning advanced techniques and working in teams [3]. The lack of exposure of students to faculty made it difficult for many students to get reference letters that they could have solicited if they had the traditional personal interaction during their rotations.

Educational concerns

A large international study showed that frontline healthcare workers expressed anxiety about the pandemic irrespective of its severity in their regions and reported higher levels of stress when they felt unsupported [23]. It is important to acknowledge this perception even if the learners are not directly affected yet. In the UK for example, medical students were called upon to volunteer during the pandemic, and many took on clinical roles in hospitals and communities with less than adequate training, leading to greater levels of anxiety among these students. Students from marginalized communities were also more likely to report inadequate information and training [24^{*}]. An important issue that programs had to quickly address was protecting patient information when most of the traditional learning activities moved online. Discussions could not freely involve sensitive patient information. It needed all participants to identify themselves by name when logged into a teaching session. Most departments used Zoom or Microsoft Teams accounts.

Changes in the learning environment

Physical changes

The physical environment underwent significant changes over the course of the pandemic. New security

measures were instituted in many hospitals and medical centres. This required checkpoints for entry to facilities, implementation of check questionnaires and frequent COVID-19 testing. PPE itself causes changes to the wearer's physical environment. Psychomotor abilities decreased. Steadiness decreased by 31% when participants wore the full-FFR, and movement time increased by an average of 3–12% [17].

The task of riding a bicycle increased oxygen consumption by 10% when individuals wore half and full-face respirator [17]. Heart rate was significantly higher during respirator wear, and balance was disturbed [25]. Significant cognitive decline was found in the error rate of a serial sevens test when participants performed the cognitive test wearing the full-face, negative-pressure respirator [18]. Several studies have shown that respirators can induce or worsen anxiety [19,20]. Anxious individuals experience more discomfort, perform for shorter times and accomplish less total work than their less anxious counterparts, even when the rate of work can be adjusted. Respirator design can influence anxiety [19]. PAPR hoods result in hearing impairment comparable to moderate to severe hearing loss [26].

Social distancing

The need for social distancing of 6 feet between learners has created unique challenges in the physical learning environment in some institutions. Many classrooms that can normally accommodate in-person teaching for a typical graduate medical education cohort are now no longer practical with social distancing. High-fidelity simulation and other in-person activities may require restructuring in facilities without classrooms designed appropriately for social distancing.

Smaller sessions

Most institutions settled for consistent small group sessions to prevent cross-cluster student mixing. This facilitated case-tracking and contact tracing.

No food/socialization

Aerosol spread of COVID-19 while eating [27] has caused concern about providing group meals as part of graduate medical education activities. Many activities that have occurred around meals now no longer include catering. This has impacted learning by shortening learning sessions to account for separated meal times. Opportunities for mealtime learning such as noontime lectures and evening lecture series have been eliminated in some programmes.

Modal changes

Modes of graduate medical education have shifted from primarily in-person bedside/procedural

teaching to distance and online learning. Teleconferencing for lectures now predominates didactics, and the rising surge of the new Delta variant of COVID-19 has caused many teaching programs to resume online-only lectures.

Advocacy

Pandemics can also uncover systemic inequities within communities. The COVID-19 pandemic did so with higher rates of infection and mortality in marginalized communities. This prompted many training programmes to integrate advocacy-based initiatives into their trainee education. Many educators have recognized the need for social justice in the curriculum of institutions of higher education [28].

COVID-19 and education in regional anaesthesia

The concern for general anaesthesia producing increased aerosols led to many practitioners increasingly using regional anaesthesia. Recommendations on how to perform regional anaesthesia procedures include performing the procedure in the operating theatre, limiting the number of personnel present and allowing only the most experienced person to execute the procedure [29]. The concern is that as we aim for the procedure to be performed by the most experienced clinicians in order to decrease the risk of failure and the possibility of complications such as pneumo-thorax and conversion to general anaesthesia, we are also reducing the options of trainees to learn how to perform them. Simulations might play an important role in making sure that trainees gain these basic skills before performing them on patients.

Emerging from the pandemic

A number of changes that were instituted in education during the pandemic are here to stay. Trainees and faculty in many studies have welcomed the hybrid format and would like to see it continued even after the pandemic. This allows individuals who cannot physically be present attend and participate in educational sessions.

Hybridizing models

The incorporation of online teaching and learning methods have been used by institutions and teachers for a very long time. They have taken many forms. The advantages of online learning are that it is scalable and can be done asynchronously (just-in-time). We now have the ability to incorporate new and diverse voices into the programme without geographical constraints. As making digital resources is time and labour intensive, having faculty and trainees who cannot deliver clinical care

work on digital learning materials is incredibly useful.

When using these technologies, it is also important to confirm that learners have access to digital devices that the content can work on multiple platforms. The online content should have a mechanism for in-person interaction, especially to reinforce concepts and promote understanding. Rather than trying to replicate in-person environments, the online platform should be used creatively to promote engagement and interaction. It is important that such a process be firmly grounded in educational theory and assessed for effectiveness when implemented [30]. Some groups have reported successful use of this method during the pandemic [31¹¹].

Self-directed learning

The pandemic highlighted the importance of self-directed learning for both trainees and faculty when faced with a new disease and evolving guidelines. We must ensure that trainees have access to high-quality anaesthesiology resources such as Learnly, Open Anesthesia and Anesthesia Toolbox to help provide pathways for self-directed learning when traditional, in-person learning is not an option.

Case studies and examples

The SAVEd (Self-Isolating Virtual Education) project in UK

Trainees in the UK who were self-isolating either due to being part of 'high-risk' population or those who had tested positive for SARS-CoV-2 were motivated to actively contribute during the pandemic. They designed and hosted a combination of prerecorded and live, online tutorials [32]. This is a good example of giving medical professionals who are not able to participate in clinical work the opportunity to contribute by designing digital resources, which is usually time consuming.

Learnly and COVID-19 evidence service

Communities of Practice can be critical to rapidly organizing and disseminating practical knowledge during a global pandemic. Early in the COVID-19 crisis, one of the co-authors (L.C.) organized a COVID-19 evidence service that took questions from anaesthesiologists who were members of a national anaesthesia consortium of academic programmes called Learnly. Answering questions and sharing information among this group of institutions led to the first widely disseminated information about heat-treatment for reuse of N95

respirator. This later led to scientific studies and WHO-guidance based on data shared through the consortium effort [7,8]. Utilizing existing consortiums to share and disseminate expertise can accelerate discoveries and solution-finding during a crisis.

Flipped classroom (Yale)

Flipped classroom use in GME education was already on the rise [33]. This format that involves the use of preclass asynchronous content delivery, combined with in-class interactive work, lent itself to easy conversion to complete virtual sessions during the pandemic. The biggest challenge in moving all teaching to the online format was to find ways to promote engagement. Although the format has a good combination of synchronous and asynchronous learning, educators still had to design ways to promote learners' participation in discussions.

Likewise, many of the OSCE skills, such as communication, professionalism, interpretation of monitors and interpretation of echocardiograms, can likely be conducted over videoconference. Attendee interaction was encouraged using features embedded in the video conference platform such as the Poll feature of Zoom or a standalone app like PollEverywhere. Faculty also made the teaching sessions engaging by integrating online gaming software into lessons such as Jeopardy and Weakest Link.

Virtual engagement of large groups (Stanford anaesthesia summer institutes)

Large-scale engagement of learners during the pandemic continued for some programmes. One of the co-authors (L.C.) successfully ran a 2-week virtual programme that taught clinical skills, patient interviewing, empathy and pathways to compassionate careers in medicine for two consecutive years during COVID-19. Using virtual reality, Zoom conferencing, group project-based learning and virtual mentoring of clinical skills such as suturing, students in groups as large as 120 were successfully mentored, demonstrating increased empathy and interest in both anaesthesiology and compassionate careers in medicine [34].

Residency recruitment with virtual engagement

Programme directors and resident applicants had to readjust the interview schedules to accommodate for travel restrictions and physical distancing. It meant that applicants would have to choose their residency institutions without a tour, and programme directors had to choose their residents

without having physically met them. Although this would have been unheard of before the pandemic, it became acceptable to both very soon. There are also calls to continue these virtual interviews even after the pandemic [35].

Stanford anaesthesiology residency recruitment

The Stanford Anaesthesia programme asked one of the co-authors (L.C.) to create an online resource to guide applicants through the residency recruitment process emphasizing inclusivity and diversity. Principles of design-thinking were used to interview prior applicants to the programme about unique aspects of the experience they both valued and thought could be improved. The applicant journey was mapped using design-thinking, and a website was developed in advance of the virtual interview day that provided information tailored to the needs of applicants. Equity and inclusivity of applicants was considered in the design of the website and resources through interview process review with members of the department's diversity committee and a continual feedback instrument on the website. A virtual reality tour of the department's physical resources (operating room, PACU facilities) was constructed to help orient applicants to the new hospital environment so potential residents would have an opportunity to evaluate the learning environment as part of the virtual touring experience [36].

CONCLUSION

The COVID-19 global pandemic revealed fragility in the modern healthcare industry through PPE supply chain shortages and exposed limitations in how our current graduate medical education system supports the basic needs of its learners during unprecedented conditions. It is important to understand the needs of learners through Maslow's hierarchy and how to prioritize the support of these needs. Most importantly, we can structure our graduate medical education programs going forward to not only learn from COVID-19, but to help our graduates flourish in their careers by promoting skills that support lifelong resilience and self-actualization.

Acknowledgements

We wish to acknowledge the support of the Stanford University Anesthesia Informatics and Media (AIM) Lab for their assistance in providing video for this review.

Financial support and sponsorship

None.

Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

1. Pasin L, Sella N, Correale C, *et al.* Pandemic COVID-19: the residents' resilience. *Acta Biomed* 2020; 91:e2020120.
 2. Howard J, Huang A, Li Z, *et al.* An evidence review of face masks against COVID-19. *Proc Natl Acad Sci U S A* 2021; 118:e2014564118.
 3. Sneyd JR, Mathoulin SE, O'Sullivan EP, *et al.* Impact of the COVID-19 pandemic on anaesthesia trainees and their training. *Br J Anaesth* 2020; 125:450–455.
 4. Martinelli SM, Chen F, Isaak RS, *et al.* Educating anesthesiologists during the Coronavirus disease 2019 pandemic and beyond. *Anesth Analg* 2021; 132:585–593.
 5. Lendvay TS, Chen J, Harcourt BH, *et al.* Addressing personal protective equipment (PPE) decontamination: methylene blue and light inactivates severe acute respiratory coronavirus virus 2 (SARS-CoV-2) on N95 respirators and medical masks with maintenance of integrity and fit. *Infect Control Hosp Epidemiol* 2021; 1–10.
 6. Zhao M, Liao L, Xiao W, *et al.* Household materials selection for homemade cloth face coverings and their filtration efficiency enhancement with triboelectric charging. *Nano Lett* 2020; 20:5544–5552.
 7. Liao L, Xiao W, Zhao M, *et al.* Can N95 respirators be reused after disinfection? And for how many times? *ACS Nano* 2020; 14(5):6348–6356. <https://doi.org/10.1021/acsnano.0c03597>.
 8. Price A, Cui Y, Liao L, *et al.* Is the fit of N95 facial masks effected by disinfection? A study of heat and UV disinfection methods using the OSHA protocol fit test. *medRxiv* 2020. doi: <https://doi.org/10.1101/2020.04.14.20062810>.
 9. Sun H, Warner DO, Macario A, *et al.* Repeated cross-sectional surveys of burnout, distress, and depression among anesthesiology residents and first-year graduates. *Anesthesiology* 2019; 131:668–677.
 10. Royal College of Anaesthetists RC of A. A report on the welfare, morale and experiences of anaesthetist in training: the need to listen. ISBN: 978-1-900936-14-9. Accessed at <https://www.rcoa.ac.uk/sites/default/files/documents/2020-09/Welfare-Morale2017.pdf>
 11. Wainwright E, Looseley A, Mouton R, *et al.* Stress, burnout, depression and work satisfaction among UK anaesthetic trainees: a qualitative analysis of in-depth participant interviews in the Satisfaction and Wellbeing in Anaesthetic Training study. *Anaesthesia* 2019; 74:1240–1251.
 12. Warner DO, Berge K, Sun H, *et al.* Substance use disorder among anesthesiology residents. *JAMA* 2013; 310:2289–2296.
 13. Wible P. What I've learned from my tally of 757 doctor suicides. *Washington Post*; 2018.
 14. Lowery K, Stokes MA. Role of peer support and emotional expression on posttraumatic stress disorder in student paramedics. *J Trauma Stress* 2005; 18:171–179.
 15. Maslow AH. A theory of human motivation. *Psychol Rev* 1943; 50:370–396.
 16. Maslow AH. *Motivation and personality*. Oxford, UK: Harpers; 1954.
 17. Zimmerman NJ, Eberts C, Salvendy G, *et al.* Effects of respirators on performance of physical, psychomotor and cognitive tasks. *Ergonomics* 1991; 34:321–334.
 18. AlGhamri AA. The effects of personal protective respirators on human motor, visual, and cognitive skills. 2012. Accessed at: https://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=3297&context=doctoral_dissertations.
 19. Wu S, Harber P, Yun D, *et al.* Anxiety during respirator use: comparison of two respirator types. *J Occup Environ Hyg* 2011; 8:123–128.
 20. Johnson AT, Dooly CR, Blanchard CA, *et al.* Influence of anxiety level on work performance with and without a respirator mask. *Am Ind Hyg Assoc J* 1995; 56:858–865.
 21. Andrae MH, Dudak A, Cherian V, *et al.* Healthcare simulation to prepare for the COVID-19 pandemic. *J Clin Anesth* 2020; 66:109928.
 22. Kuhn L, Lim ZJ, Flynn D, *et al.* Safety briefing and visual design key to protecting healthcare personnel during the COVID-19 pandemic. *Am J Infect Control* 2020; 48:1122–1124.
- The authors present a model for education of healthcare workers in a pandemic. It includes clear and consistent messaging, and reinforces the need to consider all potential dangers to create a culture of safety and confidence. It also reinforces focus on healthcare worker wellness and teamwork.
23. Cag Y, Erdem H, Gormez A, *et al.* Anxiety among front-line health-care workers supporting patients with COVID-19: a global survey. *Gen Hosp Psychiatry* 2021; 68:90–96.

24. Norton EJ, Georgiou I, Fung A, *et al.* Personal protective equipment and infection prevention and control: a national survey of UK medical students and interim foundation doctors during the COVID-19 pandemic. *J Public Health Oxf Engl* 2021; 43:67–75.
- The study found that students identifying as black, Asian, Minority Ethnic were less likely to report sufficient PPE availability and training and had higher anxiety regarding the pandemic. This study highlights the need for mental health and wellness resources for this group of healthcare workers.
25. Seliga R, Bhattacharya A, Succop P, *et al.* Effect of work load and respirator wear on postural stability, heart rate, and perceived exertion. *Am Ind Hyg Assoc J* 1991; 52:417–422.
26. Kempfle JS, Panda A, Hottin M, *et al.* Effect of powered air-purifying respirators on speech recognition among healthcare workers. *Otolaryngol Head Neck Surg* 2021; 164:87–90.
27. Lu J, Gu J, Li K, *et al.* COVID-19 outbreak associated with air conditioning in restaurant, Guangzhou, China. *Emerg Infect Dis* 2020; 26:1628–1631.
28. Chawla KS, Jayaram A, McClain CD. The missing chapter: the education of surgery and anesthesiology trainees as civic advocates. *Ann Surg* 2021; 273:e125–e126.
29. Ashokka B, Ong SY, Tay KH, *et al.* Coordinated responses of academic medical centres to pandemics: sustaining medical education during COVID-19. *Med Teach* 2020; 42:762–771.
30. Sharif S, Sherbino J, Centofanti J, *et al.* Pandemics and innovation: how medical education programs can adapt extraclinical teaching to maintain social distancing. *ATS Sch* 2020; 1:344–347.
31. Cooke PC, Hajamohideen N, Gooneratne H. Developing a blended learning postgraduate teaching programme in anaesthesia: pandemic and beyond. *Postgrad Med J* 2021. doi: 10.1136/postgradmedj-2021-140155.
- The authors designed a combination of remote online face-to-face teaching sessions combined with asynchronous online components that encourage learner involvement and engagement.
32. Eusuf DV, England EL, Charlesworth M, *et al.* Maintaining education and professional development for anaesthesia trainees during the COVID-19 pandemic: the Self-isolating Virtual Education (SAVEd) project. *Br J Anaesth* 2020; 125:e432–e434.
33. Kurup V, Sendlewski G. The feasibility of incorporating a flipped classroom model in an anesthesia residency curriculum-pilot study. *Yale J Biol Med* 2020; 93:411–417.
34. Chu LF. Stanford Anesthesia Summer Institutes, Science, Technology and Medicine Summer Internship. <http://sasi.stanford.edu> [Accessed 16 August 2021].
35. Budhu J, Velazquez AI, Said RR, *et al.* Opinion & special articles: maximizing inclusiveness and diversity through virtual residency applications and interviews. *Neurology* 2021. DOI: 10.1212/WNL.0000000000012487.
36. Chu LF. Stanford Anesthesia Residency Interview Website. <http://interview.stanford.edu> [16 August 2021].