


Medical education challenges and innovations during COVID-19 pandemic

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ABSTRACT

COVID-19 pandemic has undoubtedly disrupted the well-established, traditional structure of medical education. The new limitations of physical presence have accelerated the development of an online learning environment, comprising both of asynchronous and synchronous distance education, and the introduction of novel ways of student assessment. At the same time, this prolonged crisis had serious implications on the lives of medical students including their psychological well-being and the impact on their academic trajectories. The new reality has, on many occasions, triggered the 'acting up' of medical students as frontline healthcare staff, which has been perceived by many of them as a positive learning and contributing experience, and has led to a variety of responses from the educational institutions. All things considered, the urgency for rapid and novel adaptations to the new circumstances has functioned as a springboard for remarkable innovations in medical education, including the promotion of a more "evidence-based" approach.

INTRODUCTION

As of the beginning of 2021, the COVID-19 pandemic continues to unfold. Several countries have responded to the autumnal/winter second wave of the pandemic by imposing curfews or complete lockdown measures in an effort to limit the viral transmission. However, and despite the spark of hope that the newly introduced vaccines have brought, there have been vast repercussions on the economy and education; one of the fields that the pandemic has substantially affected is the education of future medical professionals.

At the onset of the pandemic, the Association of American Medical Colleges proceeded to the unprecedented decision to suspend clinical rotations, and issued guidance for medical students to avoid activities involving direct patient contact, with many countries adopting similar strategies.¹ From that point on, the dynamic everyday changes brought on by the COVID-19 pandemic and the subsequent social distancing measures have resulted in continuous disruption of the routines of medical students, schools and institutions that have been copiously testing the medical educational systems' adaptability worldwide.

In this review, we explore the impact of the COVID-19 pandemic on the education and

assessment of undergraduate medical students, the repercussions on their mental health and future career plans, while exploring their experience as 'frontline workers', along with the institutional responses to these challenges. We also focus on how this unique period could act as a catalyst for substantial changes and further implementation of the 'evidence-based' approach in medical education.

ONLINE VERSUS FACE-TO-FACE EDUCATION

COVID-19 has already triggered the introduction of new methods of learning in medical education. In an effort not to distract the educational process, the academic institutions worldwide have accelerated the development of online learning environment.² Online distance education (ODE) can be generally delivered to medical students in two main formats: asynchronous distance education, such as recorded videos and podcasts, and synchronous (live) distance education (SDE), such as video conferences and virtual classrooms.³ One of the new models is the 'flipped classroom', which is a blended type of learning mode with an asynchronous component that could allow medical students for more schedule flexibility, and a synchronous component that offers interaction between medical students and faculty members.²

In recent years, SDE has been widely used for educational purposes in health science students. A recent meta-analysis of randomised clinical trials demonstrated a higher overall satisfaction (standardised mean difference 0.60, 95%CI 0.38 to 0.83; $p < 0.001$) for SDE compared with traditional education, showing that SDE was quite acceptable by medical students.³ The adoption of online learning in medical education can have several benefits: one of the most positive aspects of ODE is the flexibility of time and location and the subsequent increased convenience,^{4,5} which means medical students are able to adapt their schedule in an easier way. Besides schedule flexibility, ODE can also be much more cost-effective than classroom-based learning, as it does not require educators to move, while more individuals across different institutions (or even countries) can participate in virtual courses.⁶ In addition, e-learning assists medical students to better adapt to a web-based medical world that increasingly uses digital health services.

On the other hand, ODE can potentially hinder interpersonal contact and interaction between medical students and the faculty members, while



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at the same time it limits the students' opportunities to practise interviewing⁷ and thus cultivate the necessary communication and empathy skills for interacting with patients and their colleagues. Indeed, restricted access to clinical environment is a main obstacle to students' preparation for clinical practice, thus lowering their self-confidence.⁸ Although the lack of hands-on training in the preclinical years may have serious implications on the training of students, which might result in difficulties in the following clinical years, preclinical medical students may experience a lower impact on their education compared with those in the clinical years because preclinical activities are mainly lecture based.^{9–10} During the last year, there have been also serious implications in anatomy education including cadaveric education; medical students are given limited chances to handle basic surgical instruments and thus develop manual dexterity, while having less opportunities to deal with the three-dimensional relationship of anatomical structures.¹¹ Online attempts to substitute hands-on education as much as possible have been made, including demonstrations of practical procedures, remote patient consultation programmes and simulated cases. More such solutions are described in online supplemental table 1.^{12–36}

Furthermore, it is important to consider the technical challenges that online teaching and learning in medical students can pose, which include problems with audio and video, downloading or streaming errors, login problems, poor internet quality, security issues, as well as limited technical skills in both students and instructors.^{37–38} These difficulties can be more evident in developing countries which encounter many more technological challenges compared with technologically advanced countries that can implement ODE much easier.^{13–15}

In summary, the outbreak of COVID-19 has brought on new and unforeseen challenges in the field of medical education, related to the development of online learning. As the shift to online education poses important challenges, medical schools should be prepared to ensure a successful educational environment for medical students through emphasising the tech-based pedagogy, advising, motivating, inviting medical students' feedback, as well as through supporting medical educators to adapt to the new reality.^{39–40} The adoption of online learning is a key strategy for ensuring continuity in medical education during COVID-19 pandemic.

EXAMINATIONS

Another aspect of medical education that has been disrupted by the outbreak of the SARS-CoV-2 is the examinations of medical students.⁴¹ In many countries, clinical and written examinations have been postponed, cancelled or delayed or have been replaced by online examinations or new methods of assessment.⁴² For example, for objective structured clinical examinations (OSCEs), approximately one-third of medical schools in the UK had these clinical examinations cancelled. Four medical schools in the UK adjusted by using actors rather than real patients.⁴³ According to a structured qualitative survey including medical students from 32 UK medical schools, the effect of examination disruptions for both OSCEs and written examinations indicated a significant negative impact on preparedness ($p=0.0005$). On the contrary, the examination disturbances were not significant regarding confidence (written examinations $p=0.369$, OSCEs $p=0.738$).⁴³ With universities and educators having to adapt to the new reality of this pandemic, a debate between open book examinations (OBEs) and closed book examinations (CBEs) has arisen.⁴⁴ Due to the incapacity for organising examinations in person, OBE has been suggested as an alternative tool

of rigorous assessments in medical schools.⁴⁵ For example, at Imperial College London, the online assessment consists of an OBE of 150 questions. Randomising the order of questions for each student was necessary in order to prevent cheating. Medical students were presented with simulated patients and had to answer the requested questions through provided history and findings from clinical examination.⁴⁶ On the one hand, OBE has several advantages, especially in the time of the pandemic. First of all, the use of OBEs discourages medical students to solely memorise information and enhances their critical thinking, their analytical skills, as well as their conceptual understanding of medicine.⁴⁷ OBEs as an assessment for deep learning are more authentic to clinical practice and real-life expectations, reinforcing at the same time evidence-based medicine.⁴⁴ Integration of knowledge from multiple sources and the use of internet, as an invaluable learning tool for medical students, could help medical students to be more self-directed learners, while OBEs may foster deeper processing more effectively and strengthen their long-term memory. This type of assessment also reduces the anxiety surrounding the examination in medical students, who feel less pressured when sitting on a familiar and comfortable location, such as their room in their own home.⁴⁴ On the other hand, traditional CBEs are more familiar to both medical students and professors, and the adaptation to the new reality of OBEs during pandemic could be significantly stressful for them. According to Eurboonyanun *et al*, medical students prefer a traditional CBE over an online OBE.⁴⁸

Grading is also an important factor for medical students during their studies. Comparing fourth-year medical students' scores in the online surgery clerkship assessments with the traditional written examinations shows that mean scores are significantly different which has important implications regarding grading among medical students. Medical students who participated in the online OBE had a significantly higher mean score in both multiple choice questions ($p<0.001$) and essay examinations ($p<0.001$), but a significantly lower mean score in short answer examination ($p<0.001$) compared with the traditional written examinations. On the contrary, the online OBE group had a significantly lower correlation between the essay score ($p=0.005$) and their grade point average (GPA) ($p=0.029$) than the traditional groups.⁴⁸ Such data are essential in order to provide information about the comparison between the two methods of examinations with a view towards the reliable and fair medical students' assessment in the incoming online era.

In summary, OBEs and CBEs can both contribute to a blended assessment programme due to their complementary advantages. Changes enforced by this pandemic offer a vital opportunity to evaluate alternative modes of medical education and assessment.

MENTAL HEALTH

The challenge of going through medical school and medical education in general may contribute to the development of psychological distress such as anxiety, depression and stress among medical students; medical students are recognised as an at-risk group for developing anxiety disorders, with significantly larger rates than the general population, even under normal circumstance.⁴⁹ Medical students typically encounter stressful situations including high workload, many evaluations and assessments, the pressure of clinical environment, numerous responsibilities, anxiety regarding their grades, long hours of studying as well as concerns about their future career.^{50–51} A large systematic review and meta-analysis of 129 123 medical students in 47 countries estimated that the prevalence of depression or

depressive symptoms was 27.2% (95% CI 24.7% to 29.9%, $I^2=98.9\%$) and the overall pooled crude prevalence of suicidal ideation was 11.1% (95% CI 9.0% to 13.7%, $I^2=95.8\%$).⁵² COVID-19 pandemic has been associated with high levels of anxiety and panic, both in the general population and particularly in those working in healthcare settings.⁵³⁻⁵⁵ Imposition of unfamiliar public health measures including social distancing and lockdown, social fear related to COVID-19, closures of universities, fear of being infected by the SARS-CoV-2, anxiety for their removal from clinical practice, worry about older relatives and the abrupt swift to a new reality have negative impact on the psychological well-being of medical students.⁵⁶ While individual studies from Turkey, India and Iran and European countries like Malta⁵⁷⁻⁶¹ showed that the prevalence of depression and anxiety in medical students was significantly high, a recent systematic review and meta-analysis indicated that the prevalence of anxiety in medical students is similar to that prior to the pandemic.⁴⁹ Interestingly, a cross-sectional study showed that medical students' burnout syndrome, depression, anxiety and somatic symptoms rates decreased during online learning.⁶²

On the contrary, sleep quality of medical students appears to have deteriorated during the pandemic, with insomnia, difficulties falling asleep and frequent awakening during the night being commonly reported. Decreased appetite was also reported.^{60 61} Female gender was frequently associated with higher levels of anxiety and depression,^{57 61 63} while other predisposing factors leading to higher levels of psychological distress comprise of low monthly income of the family, lower GPA and experience of COVID-19 symptoms.^{60 61}

Students' mental well-being is of critical importance. Even though data on medical students' mental health during COVID-19 have been somewhat conflicting, early detection and intervention strategies should be implemented in order to help future physicians go through this challenging period and be better prepared for next large-scale crises.

RESIDENCY SELECTION

COVID-19 has an indirect impact on the selection of residency for many medical students at a global level. Due to the necessity for the containment of the contagious nature of this disease, medical students were temporarily removed from clinical settings. The inability to explore the specialties of interest, the loss of electives and core rotations may put more pressure and uncertainty on medical students about their career choice.⁶⁴ Medical students also encounter reduced clinical exposure to the field and limited access to the real-life residency. Research shows that exposure to the specialty of interest is critical for the professional development and strengthens medical students' confidence concerning their possible career choice.⁶⁵⁻⁶⁷ Furthermore, during this new challenging COVID-19 landscape, the input of mentors is probably needed more than ever.⁶⁸ Clinical exposure to positive role models may help some students to pursue a specialty that they had not previously considered. Due to their absence from clinical settings, medical students have limited personal exposure to positive role models and members of faculty and this may negatively influence career decisions and professional identity formation.⁶⁷

Another major concern about residency selection involves disruption of away rotations. Away rotations are elective activities that take place away from the student's academic environment, where students have the opportunity to gain experience with a different hospital, medical record system, faculty and patient population. Elective cancellations due to COVID-19

may induce difficulties not only in regards to away rotations, but also in obtaining meaningful letters of recommendation, as well as obstacles to improving one's curriculum vitae.^{65-67 69} The lack of letters of recommendation, specific grades and geographical preferences raises concerns about application process.⁷⁰ Medical students possibly feel less competitive, as a result of fewer opportunities and this may have a negative impact on their future. Other changes such as implementation of pass/fail grading system, devaluation of US Medical Licensing Examination (USMLE) Step 1 scores, limited access to USMLE 2 will affect students' application for residency selection.^{71 72} The disruptions caused by the pandemic will probably increase the number of applications and discomfort of medical students, while programme directors may rely on less reliable characteristics such as school reputation.

MEDICAL STUDENTS AS 'FRONTLINE WORKERS'

Conflicting views have been expressed on the role of medical students in the frontline of this pandemic.^{42 73-78} Should they have an active role by assisting the management of infected patients, thus gaining valuable clinical experience in times of health crisis, yet with the increased risk of exposure? Should they be assigned responsibilities for patients other than the ones infected, in order to somewhat alleviate their senior colleagues' burden by simultaneously continuing their bedside education, though still not minimising their chances of infection? Should they be entirely kept far from hospitals due to potential inadequacy of personal protective equipment (PPE), training, experience or emotional resilience and focus instead on reinforcing, for instance, their institutions or local communities? It seems that there is no universal commonly accepted view, especially given the variety of student characteristics (eg, pre-clerkship or clerkship, with or without health morbidities) and institutional settings. However, and despite the lack of consensus, the primary aim remains the establishment of a mutually beneficial situation for both students' and health systems' needs, local and governmental policies.

In addition, before medical students undertake roles as 'frontline workers', it is essential to first examine their willingness, motives or competence for undertaking such a role. In the Netherlands, students were eager to priorly arrange all necessary insurance issues and receive basic training in acute care principles, in order to assist their university or even regional health institutions.⁷⁹ In the UK, more than 5500 final-year students have been brought into the workforce, considering this kind of 'volunteerism' as a brand-new opportunity for self-directed clinical and research learning.^{61 80 81} A structured qualitative survey including students from a single institution in the UK found that their basic motivations to voluntarily support the National Health System were to 'contribute', 'learn', 'benefit from remuneration' and 'do something active during national lockdown'.⁸² According to a similar single-institution cross-sectional study conducted in Denmark, 80% of 486 student-participants had decided to join the pandemic workforce, with 'care', 'learning' and 'pride' constituting their top motivations.⁸³ Students also highlighted institutional support, especially in terms of provision of PPE and clarification of study plans, as a matter of top priority.⁸³ In King Saud University of Saudi Arabia, 34.3% and 23.1% of final-year students stated that they were 'willing' or 'somewhat willing', respectively, to contribute to the pandemic workforce.⁸⁴ The same study also demonstrated a positive correlation between willingness and self-perceived student competence in essential clinical skills. Similarly, students of Duke-NUS Medical School

in Singapore who were more willing to return to a clinical environment during the pandemic, exhibited greater internal motivation and sense of professional responsibility, and lower self-perception of harbouring risk to the patients.⁸⁵ Interestingly, one-third of participants in this survey were not in favour of recommencement of clinical rotations.⁸⁵

With regard to students' competence, surveys from Turkey and Iran displayed moderate to high levels of student knowledge on pandemic-related subjects, with the two studies using different testing strategies, yet the same quantitative cut-offs when defining these levels.^{86,87} A recent systematic review also revealed that the implementation of 'pandemic and disaster-themed training programmes' can be an effective intervention in boosting students' knowledge, attitude and skills and enhancing their pandemic preparedness.⁸⁸ Although this would be an ideal scenario, the aforementioned Iranian study interestingly displayed a significant difference in perception of COVID-19-related risks between students being trained in emergency and those trained in non-emergency wards, as well as a significant negative association of risk perception with preventive behaviour.⁸⁷ Haque *et al* further showed that adherence to preventive measures increased with age and educational attainment.⁸⁹ The latter indicate that in spite of knowledge and skills remaining a prerequisite, readiness to respond to pandemic-related duties varies between students and depends on their age, stimuli and experience.

In summary, although the usefulness of medical students acting as frontline workers during COVID-19 has not been universally agreed on, the emerging literature shows that a significant number of students have seen this as an opportunity to learn, volunteer and contribute. Online supplemental table 2 presents several illustrative actions and initiatives of students acting as 'frontliners'^{25 73 79 80 90–95} during the pandemic, which were organised either at a student, institutional or nationwide level.^{25 73 79 80 90–95}

INSTITUTIONAL ADAPTATIONS AND INNOVATIONS

The need for substitution of the daily live and hands-on education during this pandemic has cultivated the incorporation of a variety of innovational ideas into medical education across the world, that have involved the introduction of new technological concepts, and also novel ways for medical educators to interact with their students. All these innovative methods should be carefully examined, as they could constitute a source of future inspiration for medical educators. These encompass social media initiatives, virtual core clerkships and digital clinical placements, new teaching models, sessions of remote patient consultation, even the use of patient simulators.^{12–36} Online supplemental table 1 describes in detail such adaptive ideas, designed and executed by different institutions, groups or organisations during the COVID-19 pandemic.^{12–36}

A 'CRASH TEST' FOR EDUCATION IN THE FUTURE?

It appears that the urgency of the current predicament has forced a rapid transition from the conventional more 'analogue' approach to a more 'digital' model, even in settings in which the utilisation of digital tools was far less extensive.⁹⁶ There are two ways of examining future implications of this unparalleled period, at least as far as medical education is concerned. First and foremost, this pandemic has forced us to realise that medical education can become an extremely vulnerable asset in times of health crises and should not always be taken for granted in its traditional form, especially in the context of future COVID-19 waves and future pandemics.⁹⁷ In Singapore, medical educators

were driven by the past H1N1 pandemic to prepare a contingency plan for similar future crises.³⁴ Creating a hybrid environment of fundamental traditional methods with novel technological tools could solidify the provision of medical education even in times in which its integrity is threatened. As illustrated by the responsiveness of medical educators across the world, used technical means may range from feasible, everyday and easy-to-acquire applications to more complex systems of patient simulators or virtual-reality technologies and holographic representation of three-dimensional objects (online supplemental table 1).^{12–36} Such advanced technologies, however, may not be promptly and broadly incorporated into medical education, especially when considering the negative financial impact of the pandemic on institutions and states.⁹⁸ As Keegan and Bannister highlight, the

Main messages

- ▶ The rapid spread of COVID-19 has the potential to affect medical students physically, academically, financially and psychologically.
- ▶ Medical students have reacted in a variety of ways as frontline workers, according to their personal, institutional and even national needs.
- ▶ Several medical educators during the pandemic have used a 'develop, test and apply' model for educational innovations, reinforcing the concept of 'evidence-based medical education'.

Research questions

- ▶ What was the impact of COVID-19 pandemic on medical education, assessment, career plans, as well as, mental health of medical students?
- ▶ How did medical students react to the COVID-19 pandemic as frontline workers and how did medical educators adapt to these unforeseen circumstances?
- ▶ How can medical education benefit from this predicament in the future?

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Self assessment questions

1. Medical students during the COVID-19 pandemic:
 - a. Have been assigned the same responsibilities across different countries.
 - b. Have totally avoided frontline roles.
 - c. Have reacted in a variety of ways, depending on their personal, institutional and even national needs.
 - d. Have only undertaken roles inside their institutional environment.
2. During the COVID-19 pandemic:
 - a. Student–faculty partnership has been severely and universally undermined.
 - b. Student-centred social media initiatives have been organised.
 - c. Several medical educators have implemented a develop, test and apply model to promote innovative educational programmes.
 - d. An opportunity to reinforce the concept of evidence-based medical education has emerged.
3. The adoption of online learning in medical education can have several benefits:
 - a. One benefit is the flexibility of time and location.
 - b. Online learning can also be much more cost-effective than classroom-based learning.
 - c. Online learning can potentially enhance interpersonal contact and interaction between medical students and the faculty members.
 - d. Restricted access to clinical environment is a main benefit of online learning.
4. During COVID-19 pandemic:
 - a. The disruption of clinical exposure had an indirect negative impact on the selection of residency for many medical students.
 - b. Clinical exposure to positive role models may not help some students to pursue a specialty that they had not previously considered.
 - c. A major concern about residency selection involves disruption of away rotations.
 - d. Implementation of pass/fail grading system, devaluation of US Medical Licensing Examination (USMLE) Step 1 scores and limited access to USMLE 2 will affect students' application for residency selection.
5. During COVID-19 pandemic:
 - a. In many medical schools, clinical and written examinations have been postponed, cancelled or delayed.
 - b. Sleep quality of medical students appears not to have deteriorated.
 - c. Open book examination has been suggested as an alternative tool of rigorous assessments in medical schools.
 - d. E-learning assists medical students to better adapt to a web-based medical world that increasingly uses digital health services.

majority of institutions should first explore low fidelity solutions, such as feasible smartphone applications and the social media, focusing more on policy or mentality modifications and later seek more technologically advanced means.⁹⁸

From another point of view, the educational expeditious amendments that this pandemic has brought might soil the ground for further implementation of 'evidence-based education' in medicine. Many authors have used a 'develop, test and apply' model during

the pandemic, meaning that they developed their own innovational method of teaching or interacting with students, subsequently tested the method by acquiring the students' feedback or by comparing it with a more traditional approach, and then applied it with the ultimate purpose of continuous educational evolution.^{12–30 32–36 99 100} This model can be further implemented in the future. Data on application of a new method, along with its perceived strengths and limitations and results from the students' feedback, may then be published in order to inform or aspire educators from other settings across the world. These methods can prove to be even more efficient from both the educator's and the student's perspective, in case special teams composed for this purpose and consisting of both faculty members and student representatives participate in their development. The 'student–educator interaction' is essential, so that both the concepts of 'evidence-based teaching' and 'evidence-based learning' are combined harmoniously. Mehta *et al* have underlined this partnership as a determining facilitator of smooth curricular adaptation to the status quo of the pandemic.²⁷

CONCLUSIONS

In conclusion, the outbreak of COVID-19 pandemic has forced a rapid transition to online teaching of medicine and introduction of alternative student assessment methods, while it has created challenges in residency selection and future career plans of students, as well as having a significant psychological impact on them. Medical students have undertaken a variety of 'frontline' roles, with their actions being adapted to institutional and national healthcare needs, as well as their own knowledge, experiences and preparedness, which has been viewed by many students as an important learning experience. The urgency of the pandemic has rapidly brought on the development of many innovative educational strategies across the world, the majority of which encompass the use of a variety of digital tools. Such initiatives must act as a stepping stone for evidence-based medical education to thrive even more in the future. More large-scale studies from all over the globe are required to accurately depict how this unparalleled period has affected all aspects of medical education. Along with all the difficulties it brought, this pandemic reminded us that human collaboration through science is one of the greatest tools of humanity to deal with threats. Applying the same collaborative science in education, and specifically in medical education, could raise our optimism for the future of medicine. Education is our future, or in the words of Christine Gregoire: 'Education is the foundation upon which we build our future'.

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Answers

1. (a) false; (b) false; (c) true; (d) false
2. (a) false; (b) true; (c) true; (d) true
3. (a) true; (b) true; (c) false; (d) false
4. (a) true; (b) false; (c) true; (d) true
5. (a) true; (b) false; (c) true; (d) true