Teaching in Times of Crisis – What Have We Learned (So Far)?

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Abstract
Coronavirus disease has made an enormous impact on many fields of functioning, including the educational system. This impact was pronounced in higher educational system and accelerated the transition toward remote learning strategies in medical education, leading from traditional to online education during crisis. The aim of this article is to review the body of literature on medical education in the COVID-19 pandemic, as well as creating guidelines that can help improve and prepare the educational system for possible future crisis situations. A systematic review on the MEDLINE/PubMed database was performed on April 10th, 2022. We paired the terms "COVID-19", "coronavirus", "education", "training", "students" and "university" and the search initially yielded 214 articles. After examining effective literature, these studies showed that COVID-19 crisis has required to adapt student learning methods in order to improve and enable uninterrupted learning processes during the ongoing pandemic, mostly by implementing telemedicine-based training and virtual learning platform through webinars, virtual classroom, video and teleconferences, as well as online/mobile learning resources and simulation-based learning. Medical education in future will be complemented by multimedia elements and new strategies for using technologies for education. The advantages to innovation practices mainly included improved accessibility and implementation of new assessment techniques. Ensuring conditions for acquiring knowledge in a profession that cares of the well-being of others is always a priority and, although covid measures are becoming milder and do not have an enormous impact on education currently, some innovations that arose during the pandemic may be worth keeping.

Keywords: Educational System, COVID-19, Crisis, Medical Students, Systematic Review

Introduction

Coronavirus disease has made an enormous impact on many fields of functioning, such as social relations and the economy. It raised concerns and fear of being infected or transmitting the coronavirus infection to others in many people throughout the globe. Furthermore, it affected whole world's health systems (Singh & Singh, 2020), as well as educational ones. This impact was especially pronounced in higher education system. Closure of schools and universities affected more than 1.5 billion students and youth across the globe (Tarkar, 2020), with much of the teaching transferring from offline to online mode.

Medical students belonged to a highly vulnerable group of students during the pandemic and consequent changes in the educational system and modes of teaching and learning. Students' daily commute to teaching hospitals was a method of the virus spreading, so the cancellation of instructional programs and the use of virtual teaching methods have been put on the agenda during the past period (Ahmed, Allaf & Elghazaly, 2020). Furthermore, redistribution of medical staff to COVID wards, postponement of elective procedures, turning of wards into COVID wards and many other changes in medical system made in order to reduce exposure to the virus led to difficulties in performing student medical practice through lack of practical skills training, limited feedback and supervision, but also through motivational and mental health factors, which were additional aggravating factors in an already difficult situation (Hau, Weitz & Bork, 2020). Since an important part of medical education includes hospital-based education, rotations between departments and hospitals and having clinical mentors, the difficulties in performing the practical part of medical education imposed by coronavirus pandemic could certainly leave a significant impact on future doctors (Ahmed, Allaf & Elghazaly, 2020). Further, COVID-19-related challenges to clinical teaching have adversely impacted mental well-being of medical students globally (Sharma & Bhaskar, 2020), which is not surprising considering all the aforementioned difficulties in medical education they were faced with, alongside the additional concern of being a possible risk to patients, in addition to caring for their own and the health of their closed ones.

COVID-19 pandemic significantly left its mark on certain medical fields and students involved in them, such as clinical training which includes working with aerosol-generating equipment (Hassan & Amer, 2021). Anatomy education, as one of the basic parts of medical education, was not only hindered by the need for social distancing, but also because the use of cadaver specimens has the potential risk of virus transmission, leading to restrictions in educational process (Singal, Bansal & Chaudhary, 2020). The psychomotor and affective components of medical learning are being affected the most; virtual exposure is not sufficient enough to teach understanding and managing of patients, a humane approach which is highly important in medicine, as well as skills important in surgical practices (Kumar et al., 2021), which were hindered by on-line learning methods and other constraints in medical teaching imposed by the pandemic.

With all of the problems and changes in medical education system that came with the pandemic, importance of preparing the educational system for such crisis situations became a topic of immense importance. Quality coping with such situations is important for the entire education system and for students and experts in various fields, especially for future medical staff. In this systematic review paper, we focused on analyzing methods used in the state of crisis such as the COVID-19 pandemic, with the aim of learning from this experience and creating guidelines that can help improve and prepare the educational system for possible future crisis situations. Ensuring conditions for acquiring knowledge in a profession that

cares about the health and well-being of others is always a priority and, although covid measures are becoming milder and do not have an enormous impact on education currently as in the last few years, being prepared for similar future situations is of high importance.

A systematic review on the MEDLINE/pubmed database was performed on April 10th, 2022 and updated on July 1st 2022. We paired the terms "COVID-19", "coronavirus", „education" „training" „students" and „university" and the search yielded 214 articles. Based on relevance of content 161 records were excluded. Further, we excluded all systematic or narrative reviews and focused solely on original research articles/clinical studies. The final sample of studies included in the qualitative analysis consisted of 15 original studies, 14 of which contained some kind of evaluation of implemented practices, i.e. efficacy or learners' experience. The studies focused on educational practices implemented in the COVID-19 pandemic in the area of medical education, mostly medical students (N=7) and nursing students (N=4), but also other students (microbiology, paramedic; N=2), residents (N=1), faculty and doctors (N=2).

The main findings

Studies included in qualitative synthesis are briefly presented in Table 1, where aims, methods, evaluation criteria and effectiveness or acceptability of implemented practices are displayed. By analyzing innovative educational practices that were used and evaluated in these studies, we can conclude that the transition to an online form of teaching required finding creative solutions in adjustment to constraints in teaching methods imposed by the pandemic. Baloyi, Jarvis et Mtshali (2022) stressed that the transition to online teaching and learning due to COVID-19 lockdown restrictions demanded fast adjustment in order to save the 2020 academic year, which was an ambitious goal, but using Donabedian's tripartite model (Donabedian, 2005) focused on the availability of legislation, policies or policy guidelines and resources available to support the changes in response to the interruptions caused by the pandemic, they presented their way of dealing with the limitations and necessary changes in educational system, as well as the positive effects they achieved. Regarding the use of innovative approaches in learning process, Rüllmann et al. (2022), analyzed efficacy of peer-to-peer virtual case-based auscultation course via video conference in comparison to literature self-study, an important research area due to contact restrictions and limited interaction with patients in pandemic time. They showed that participation in the virtual auscultation course led to a significantly improved aspects of cardiac auscultation skills, as well as higher satisfaction rates and a higher increase in self-assessed competence compared to participants who engaged in literature self-study. Authors concluded that such course may facilitate the further acquisition of an essential clinical skill such as cardiac auscultation, even when contact restrictions will be lifted. Onwards, adapting and implementing new technologies such as 3D holograms with mixed reality proved to be helpful to medical students and medical professionals in better identification of pulmonary lesions (Liu et al., 2021). Liu et al. (2021) found in their study that 3D holograms with mixed reality had many benefits, such as lower frustration, lower mental and temporal demand. Therefore, such technology can be used in medical education to increase interest, improve understanding of body structures, improve spatial awareness, lower the learning curve. Adaptation that also proved beneficial for teaching was microlecture teaching. Kong et al. (2021) showed that microlecture teaching is superior to traditional teaching in a way that it improves theoretical and clinical operation skills of students as well as teaching satisfaction and has great potential in improving remote learning.

And while medical education can be easily delivered online, surgical skills training can be challenging to demonstrate online (Co & Chu, 2020). Research by Co et al. (2021) showed that there is no difference in performance between face-to-face teaching and web-based surgical skill learning session with live camera captured demonstrations. Therefore, this study demonstrates that even precise demanding skills can be taught successfully online. Nevertheless, lack of teaching personnel or restrictive measures can be problematic when medical skills need to be taught and demonstrated to students. Christiansen et al. (2020) compared live face-to-face demonstration with a video-based demonstration in personal protective equipment donning and doffing. Their findings suggest that there is no difference in performance between face-to-face and video-based demonstration. In addition, video-based demonstration proved to be resource-efficient as it took only one-third of the time compared to face-to-face demonstration, as well as could be watched many times and at any time.

Gamified learning is another technic that can be used to increase performance of virtual learning. Suppan et al. (2020) evaluated impact of gamified e-learning, but benefits were very limited. Therefore, more research and development are needed to further utilize gamified learning. On the other hand, Chang et al. (2022) examined nursing students' skill training in distance education via online game-based learning with the watch-summarize-question approach in comparison to solely using a video-based learning in control group; experimental group achieved statistically significant higher learning achievement, self-efficacy, learning engagement, and learning satisfaction than the control group. In accordance with some of the previously stated conclusions of mentioned research, integration of new computer technologies and teaching strategies should be considered as a standard for acquiring knowledge and skills, even in non-pandemic times, but thorough evaluation of effectiveness of each individual program should be made prior to implementing any new practices. Similar to gamified learning, simulation-based learning has a goal to increase performance of training. A human patient simulator is used to repeatedly experience the process of solving nursing problems through interactions in an environment similar to clinical setting (Son, 2020). Son (2020) found that simulator-based learning has a positive effect on learning attitude and critical thinking as well as learning transfer. It is also useful during pandemic because it doesn't put patient at risk. In a study which compared the impact of a commercially available virtual microbiology simulation (VUMIE™) with a traditional wet laboratory (wetlab) on pharmacy students' knowledge, skills and confidence (Baumann-Birkbeck et al., 2021), authors expressed positive views on using technology-based innovative practices. Since virtual simulation provided similar effects on students' knowledge, skills, and confidence as a traditional laboratory, and taking into account that simulation's implementation was not cost-prohibitive and provided students with a safe learning environment supporting deliberate practice, such practice could be implemented as a regular or additional educational method.

In examining nursing students' attitude on the practice of e-learning, Thapaet al. (2021) showed that minority of students evaluated e-learning as effective as traditional, although majority still had a favorable attitude regarding e-learning. As the main advantage of e-learning reduced costs and the ability to stay at home were stated, while internet problems and technical issues were major recognized disadvantages. In a study by Mortagy et al. (2022), most medical students claimed that online teaching is not as effective as face-to-face teaching, with many students evaluating teachers as not well prepared for the online sessions. Of course, on-line teaching methods differ significantly from each other, so it is quite important to investigate the efficiency and appropriateness of each individual method for

obtaining different types of knowledge and skills. In another research, while analyzing the impact of face-to-face teaching in addition to electronic learning, Currat et al. (2022) showed that live teaching improved skill acquisition and enhanced skill retention. Contrary to the stated finding, another study (Heitmann et al., 2022) examined the lecturer ratings of student's theoretical knowledge and practical skills in two clinical teaching formats, with and without patient contact, where the group without patient contact was rated significantly better by the lecturers. On the other hand, students expressed negative views on teaching format without patient contact and commented that lack of contact with patient during the course hampers their ability to apply the practical skills acquired in a clinical context. Since working with patients will be an integral part of clinical practice in student's future work, student's perceptions and needs are certainly important and should be considered atop of lecturer ratings of students' skills. Ahmad et al. (2020) analyzed upsides and downsides of both face-to-face and distance learning and concluded that both have strengths and weaknesses and shift in the future needs to be done with caution. That is in line with the idea of adjusting medical, as well as other university programs, to new technologies and virtual practices which are nowadays used in majority of areas, but also with an important notion that efficiency and appropriateness of each individual new method should be thoroughly scientifically explored before put to use as a teaching practice.

Conclusions

Analyses showed that various effective online solutions were employed, some of which could become a standard in future educational practice. Nevertheless, some studies mentioned shortcomings of certain forms of analyzed methods. Considering the variety of techniques used and the results obtained, it is of extreme importance to continue investigating the usefulness and applicability of new teaching methods and to use those that prove to be of high quality. This is important both for uncertain periods such as adaptation to the pandemic, which we recently encountered, but also when forming new guidelines for educational system, which is increasingly shifting towards new technologies. According to previously mentioned studies, innovative practices may include: technology-enhanced learning in form of webinars, virtual whiteboards, blogs, google classrooms, videoconferences, videocasts, websites, online conferences, simulation-based learning, virtual reality mobile learning, as well as technology-enhanced learning combined with traditional learning strategies. Furthermore, different technology-enhanced educational practices emphasize investment in virtual reality and the use of portable equipment (mannequins), newly created teaching practices and the use of information and communication technology platforms and online education methods (lectures and notes sent in the virtual learning environment, receiving notes via email and content production on the website, Instagram and YouTube) (Hao et al., 2022). In creating the online content for a specific area, type of knowledge or skill that should be learnt, it is necessary to consider student's perception and suggestions as to improve student satisfaction, which is necessary for their motivation for learning and career preparedness (Farrokhi, Mohebbi, Farrokhi & Khami, 2021). Advantages of technology-enhanced educational practices include greater flexibility, time saved on traveling to university and less costs incurred compared to physically attending university (Dost, Hossain, Shehab et al., 2020). However, in order to achieve optimal medical education, comprehension and consideration of limitations in e-learning, such as social isolation, lack of student-teacher interaction or technical and connectivity problems, is highly important in creating educational programs (Abbasi, Ayoob, Malik, Memon, 2020).

Innovative educational practices implemented in COVID-19 pandemic have undoubtedly ensured the continuity of education, bypassed many of the barriers to quality medical education created or compounded by the pandemic and broadened the possibilities of learning about specific areas of knowledge and skills that are less accessible to students during their training. Further, this pandemic provided unique opportunities for teaching about medical care in crisis, through the mentored and supervised involvement of students in patient care, in line with their competence/educational level.

Key points of the current review can be summarized through several areas which have been stressed through research on educational practices during the pandemic and these points should be considered in making new policies in educational systems, as well as in preparing the educational system for possible future crisis situations. These important topics include addressing the availability of technical prerequisites, which is absolutely indispensable, as well as financial cost of innovative educational solutions, which limit the availability of e-learning practices in developing areas. Further, considering the diversity of new practices, evaluation of their effectiveness, relying on relevant criteria, is highly important since effectiveness of practices may vary for different areas of medical teaching. Also, in accordance with the aforementioned, faculty/educators need to be trained for effective use of innovative educational practices. Important notice is that innovative practices can be built upon existing ones, as a logical extension and a useful upgrade that can be of use in achievement of learning objectives. Since hands-on experience needed for developing specific skills can be limited in crisis situations, a need to balance these difficulties in mastering skills through other, possibly new and technology-based teaching methods or educational activities is important. Due to contact restrictions and limited interaction in situations such as COVID-19 pandemic, limited possibilities of interacting with educators and other students was noticed; therefore, enabling systematic and elaborated online communication and mentoring in such conditions is extremely important. Onwards, since passive practices tend to be less engaging and stimulating for students, possibly affecting their learning process, it is important to ensure an active role for students, even when it comes to virtual learning methods and techniques.

Crisis situations such as this one need to be used as a learning experience for future crises. Teaching and learning processes and new techniques and practices should be further studied to gain a deeper understanding of the educational process in order to introduce necessary and useful changes and adjustments in educational system.

Author Year	Aim / Methods	Evaluation Criteria	Effectiveness /Acceptability
Rüllmann et al. (2022)	Learning cardiac auscultation skills via: A)Virtual case-based auscultation course held via video chat vs. B) Literature self-study	Performance using a high-fidelity auscultation simulator (SAM II); Satisfaction rating and a self-assessment of competence	Virtual auscultation course - improved description of heart murmurs; no difference between the groups in diagnostic accuracy and identification of the point of maximal intensity Virtual cours - higher satisfaction rates and a higher increase in self-assessed competence
Baloyi et al. (2022)	Nursing education faculty adopting Donabedian's tripartite (2005) model as the framework for the report on the transitioning to online teaching, learning and assessment	No	
Mortagy et al. (2022)	The medical students experiences with online education, anxiety, perceived academic performance and obstacles related to online education	Perception and the impact of online education on medical students' anxiety and perceived level of performance	Rise in hours spent on online education; recorded video tutorials rated most effective; minority inform of online form as non-stimulating and difficult to engage in; less than half enjoyed online medical education; identified positive side was less time consumption
Currat et al. (2022)	The respondents were divided into 2 groups (only online learning, and online learning + live learning)	Performance after knowledge acquisition	Group with combined (e-learning and live) learning scored better
Heitmann et al. (2022)	Presence-based teaching formats with and without patient contact	Performance (students' overall grading of the course); ratings of knowledge and skills by students and lecturers	The teaching format without patient contact- lower grade by students; Students' self-ratings did not differ between the two formats; Practical skills rated better in the group without patient contact by the lecturers
Chang et al. (2022)	Integrating online game-based learning with the watch-summarize-question strategy (experimental group) to improve nursing students' learning in sputum suction skill training; control group used video-based learning	Performance and satisfaction: learning achievement, self-efficacy, learning engagement, and learning satisfaction before and after the intervention	The experimental group - significant higher results in all measured variables
Baumann-Birkbeck et al. (2021)	Simulation intervention (VUMIE™) to improve learning outcomes of pharmacy students, when compared to a traditional wetlab intervention.	Performance (knowledge, skills) and confidence measured. Data was collected at baseline, post-intervention (VUMIE™ or wetlab) and endpoint.	Both interventions improved knowledge, skills and confidence; VUMIE™ outcomes comparable to the wetlab activity.
Thapa et al. (2021)	This study aims to identify the nursing students' attitude towards the practice of e-learning amidst COVID-19	Students' attitude towards e-learning were analysed: advantages and disadvantages, effectiveness, attitude of students regarding e-learning.	The main advantage of e-learning was stated as the ability to stay at home, reduced costs; internet problems was the major disadvantage, followed by technical issues. E-learning evaluated as effective as traditional by minority. Majority still had a favorable attitude regarding e-learning.
Liu et al. (2021)	The goal was to determine whether viewing a 3D hologram with mixed reality techniques can improve medical professionals' understanding of the pulmonary lesions caused by COVID-19	Participants divided into either the 2D CT group or the 3D holographic group; the task involved identifying lung lesions caused by COVID-19; participants' performance was afterwards rated by professional; Educational utility and efficiency of 3D holograms was assessed.	The 3D group - higher results in performance and assessments.
Kong et al. (2021)	The aim of the present study was to evaluate the advantages of the microlecture teaching method on students in standardized residency training	Traditional teaching group (control group) VS. the microlecture teaching group (observation group). Students were assessed on teaching effect, theoretical operation, and clinical practice satisfaction. The students also evaluated the teachers, and the teachers evaluated the students.	All assessed higher in the microlecture teaching group.
Co et al. (2021)	A new web-based surgical skill learning session (WSSL). This case–control study evaluates the surgical skills competency of medical students taught by the WSSL vs conventional tutorials	Independent blinded assessment was performed by a standardized marking scheme.	Surgical skills performance comparable between students in two groups.
Suppan et al. (2020)	The aim was to evaluate the impact of a gamified e-learning module on adequacy of PPE in student paramedics	The control group - guidelines; The e-learning group - gamified e-learning module right after the guidelines	Gamified e-learning module increases the rate of adequate choice of PPE among student paramedics working in an ambulance service.
Ahmed et al. (2020)	This qualitative study aimed to develop a model for utilizing Distance Learning (DL) using The Polarity Approach for Continuity and Transformation (PACT)™	Self-administered assessment based on identified problematic areas.	DL provides a good environment for most students.
Son H. K. (2020)	Traditional maternity clinical practicum VS Simulation problem-based learning (S-PBL)	Self-reported questionnaire (learning attitude, metacognition, and critical thinking).	Learning attitude and critical thinking increased in the S-PBL group.
Christensen et al. (2020)	This study compared live instructor-led training with video-based instruction in personal protective equipment (PPE) donning and doffing	A blind evaluation of performance using checklists was performed.	No significant difference between groups.

Table 1. Aims, methods and evaluation of 15 original studies included in review

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