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**Title:** Virtual Telesimulation for Medical Students During the COVID-19 Pandemic

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Virtual Telesimulation for Medical Students During the COVID-19 Pandemic

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Abstract

Problem
In March 2020, the novel coronavirus 2019 (COVID-19) became a global pandemic. Medical schools around the United States faced difficult decisions, temporarily suspending hospital-based clerkship rotations for medical students due to potential shortages of personal protective equipment and a need to social distance. This decision created a need for innovative, virtual learning opportunities to support undergraduate medical education.

Approach
Educators at Yale School of Medicine developed a novel medical student curriculum converting high-fidelity, mannequin-based simulation into a fully online virtual telesimulation format. By using a virtual videoconferencing platform to deliver remote telesimulation as an immersive educational experience for widely dispersed students, this novel technology retains the experiential strengths of simulation-based learning while complying with needs for social distancing during the pandemic. The curriculum comprises simulated clinical scenarios that include live patient actors, facilitator interactions, and real-time assessment of vital signs, labs, and imaging. Each 90-minute session includes two sets of simulation scenarios and faculty-led teledebriefs. A team of three students performs the first scenario while an additional team of three students observes. Teams reverse roles for the second scenario.

Outcomes
The six-week virtual telesimulation elective enrolled the maximum 48 medical students and covered core clinical clerkship content areas. Communication patterns within the virtual telesimulation format require more deliberate turn-taking than normal conversation. Using the
chat function within the video-conferencing platform allowed teams to complete simultaneous tasks. A nurse confederate provided cues not available in the virtual telesimulation format.

**Next Steps**

Rapid dissemination of this program, including online webinars and live demonstration sessions with student volunteers, support the development of similar programs at other universities.

Evaluation and process improvement efforts include planned qualitative evaluation of this new format to further understand and refine the learning experience. Future work is needed to evaluate clinical skill development in this educational modality.
Problem

In March 2020, the novel coronavirus 2019 (COVID-19) pandemic reached the United States, bringing routine learning experiences at U.S. medical schools to a halt.\textsuperscript{1} Under guidance released by the Association of American Medical Colleges, medical school leaders across the nation began removing undergraduate medical students from the clinical setting given concerns regarding shortages of personal protective equipment, limited COVID-19 testing, and the need for social distancing.\textsuperscript{2} Learning encounters that occur on the hospital wards through direct interactions with patients, families, and the health care team had been a vital component of undergraduate medical education. Medical educators faced the challenge of developing innovative solutions to allow students continued opportunities to gain the critical knowledge, skills, and attitudes necessary to prepare for residency training and caring for ill patients on the frontlines while also respecting stay-at-home mandates.

Before the COVID-19 pandemic, Yale medical students on clinical clerkship rotations routinely participated in immersive simulation scenarios using high-fidelity mannequins at the Yale Center for Medical Simulation (YCMS). During these scenarios, medical students had the opportunity to work in small peer teams to manage acutely ill patients with the assistance of clinical experts and trained debriefers. Research has shown that simulation experiences such as these promote critical thinking and active learning while allowing students to build confidence and practice skills in a supportive environment without risk of consequences to patients.\textsuperscript{3} With the suspension of clerkship rotations, these simulated learning experiences also came to a halt.
Interactive distance learning techniques (e.g., computer-generated virtual patients, videoconferencing) provide rural and remote health care professionals and students with specialized expertise and learning experiences. Simulation educators use similar techniques for telesimulation and teledebriefing, enabling simulated experiences with trained facilitators, in facilities that lack on-site simulation infrastructure. Combining the educational foundations of high-fidelity simulation with features of distance learning platforms, we developed a novel virtual immersive educational experience. Using videoconferencing, we delivered simulation to students in dispersed locations. This provided remote students the opportunity to interact with live patient actors and facilitators in real-time scenarios.

To address limitations in medical education due to the COVID-19 crisis, the faculty at YCMS created a six-week curriculum using this virtual telesimulation format for Yale medical students currently unable to participate in hospital-based clinical training. Here, we describe the educational, curricular, technical, and administrative aspects of our virtual telesimulation elective in an effort to provide other medical schools facing similar challenges with a blueprint for developing active distance learning opportunities for clerkship-level students. Table 1 presents an overall summary of our virtual telesimulation implementation process.

Approach

Educational design

High-fidelity simulation activates students’ emotional or affective state, supporting the development of clinical decision making and reasoning by providing students with opportunities to independently manage critically ill patients beyond the level their current training would allow in real-world clinical settings. To achieve outcomes similar to those resulting from in-person, high-fidelity simulation, we retained as many cognitive and affective learning features of the live
simulation environment as possible while adapting the simulation experience to a virtual videoconferencing platform. Applying David Kolb’s experiential learning model, we designed our curriculum to promote the application of all learning styles in sequence from concrete experience and active experimentation (simulation) to reflective observation and abstract conceptualization (debriefing).  

To build concrete interactions, critical actions in each scenario include communication with patient and team members, assessment of real-time vital signs that are responsive to interventions, and interpretation of relevant laboratory data, electrocardiograms, and radiographic images. To create a simulated experience encompassing both cognitive and procedural skills, we have adopted a “think-aloud” protocol, through which learners verbalize their thoughts out loud in detail while performing targeted tasks. As students verbally describe the individual steps of an exam, a facilitator in a confederate nurse role provides exam findings. For example, during an abdominal exam a student might ask, “I am palpating in the left upper quadrant. Is the abdomen firm? Do I appreciate any guarding or rebound?” The patient provides descriptive answers regarding pain while the nurse supplements exam findings stating, “Left upper quadrant is soft, nontender, with no rebound or guarding.” Additionally, this nurse confederate provides medical students with cues regarding the timing of task (e.g., medication administration) completion. To supplement visual cues, we have incorporated photographic images depicting gross deformities, skin, or key physical exam findings, a practice commonly used in web-based e-learning environments.  

Following each simulation experience, interactive debriefings engage students in a guided reflection on the simulation experience. Learning summaries provide students with opportunities
to generalize concepts from one week to the next and to apply the newly learned skills in future simulation experiences.

**Curriculum**

Yale medical students typically (in non-COVID times) participate in a standard simulation curriculum as part of most rotations during their year-long clinical clerkship. We considered two key aspects related to learner needs in developing a supplemental curriculum for the virtual telesimulation elective: (1) elective students would each have different prior clerkship experiences; and (2) covering new topics was necessary to avoid disrupting the existing curriculum students would encounter when they returned to the clinical wards. To support the range of potential missed clerkship experiences, we developed a curriculum covering topics from six core content areas: neurology, psychiatry, surgical specialties, internal medicine, pediatrics, and obstetrics/gynecology. We reviewed and selected two pre-existing scenarios in our case bank for each of the six clerkship content areas, revising the critical actions within the scenario to an appropriate learner level, and preparing media and facilitators at least one week prior to curriculum implementation.

**Technology and personnel**

In anticipation of stay-at-home directives, we configured laptop computers to allow simulation specialists remote access to the desktop computers situated physically within the simulation center space. We used the Microsoft Remote Desktop application (version 10.3.7, Microsoft, Redmond, Washington) to gain remote access to both the control computer for access to Laerdal LLEAP software (Laerdal Medical, Wappinger Falls, New York) and a second computer to display the vital signs monitor. We used Zoom videoconferencing software (Zoom Video Communications, San Jose, California), which was supported by our university, on the second
computer to display a live vital-signs monitor visible to all participants via the screen sharing function (Supplemental Digital Appendix 1 at http://links.lww.com/ACADMED/B103). As all personnel conducted these simulation sessions from home, we used Google Hangouts (Google LLC, Mountain View, California) instant messaging to communicate “behind the scenes,” prompting vitals changes and role player responses. We preprogrammed cases within the simulation software and embedded appropriate media files to allow live presentation of media within the vital signs monitor screen share.

Each session involved at a minimum one simulation technician, a patient actor, a nurse confederate, and a faculty facilitator/debriefer. We recruited, in addition to YCMS faculty, other educational faculty at the medical school to act as expert consultants in subspecialty areas. By the end of our second week of testing and refining, we were able to streamline remote access, which allowed one simulation specialist to run sessions without more than one technical support expert, thus expanding our operating capacity.

**Implementation**

Students enrolled in one of eight weekly timeslots that ran from late March to early May 2020. Each week’s 90-minute session included two 45-minute segments, each of which, in turn, consisted of a 20-minute simulation and 25-minute debriefing. Teams of three students managed one scenario and observed the other scenario each week for a total of 12 scenarios over six weeks. Students remained within their assigned team and completed all 12 of the same scenarios during the elective. Facilitators created a rotation schedule to ensure that every student had the opportunity to act as team leader for two scenarios and to actively participate in six total scenarios across the elective. Prior to the first session, students viewed an orientation video describing the mechanics of the virtual telesimulation experience.
Each session began with a 2- to 3-minute organizational period during which the team leader assigned roles for specific tasks (e.g., history, physical exam, review of labs and radiology results). Following the organizational period, a confederate nurse presented the initial patient report and chief complaint. Members of the team then interviewed the patient, verbalized the steps of a physical exam, derived diagnoses and treatment interventions, consulted appropriate service(s) for patient disposition, and updated the patient with the care plan. Post-simulation debriefings centered around clinical decision making and communication rather than “textbook knowledge” to supplement training in essential skills that students were deprived of during the cessation of clinical clerkships. For example, during the debriefing of the hyperkalemia scenario, which included delays in treating hyperacute T waves, students recognized the pathologic changes on the electrocardiogram but had difficulty translating their knowledge into management steps. This observation prompted a facilitated dialogue regarding prioritizing intravenous calcium for membrane stabilization.

**Outcomes**

The pilots of our virtual telesimulations with resident physician learners indicated that participant teams larger than three produced too much confusion in communication and less active roles for learning; thus, we limited enrollment to ensure teams were no larger than three. The elective rapidly filled to the 48-student capacity, and we instituted a wait list. Students enrolled in the elective were physically located throughout the continental United States and Canada.

While we have found that the communication patterns innate to videoconferencing technology require more deliberate turn-taking than normal conversation, students have quickly adapted and have fully participated in the scenarios. For example, in a scenario centered around an adolescent female teen presenting with abdominal pain, a team of students decided to split efforts (as they
might in the regular simulation setting) and send one team member “outside” the room to speak with the patient’s mother. This communication occurred through the Zoom chat function while other team members continued interviewing the patient. Upon returning to the patient room, the team huddled to regain shared situational awareness and to synthesize information gained from both the patient and parent. In an early iteration of this elective, we noted that the small-group format allowed all learners to voice their opinion and actively participate.

One limitation of the virtual telesimulation format has been the inability to practice psychomotor and technical skills (e.g., physical exam maneuvers) or procedures (e.g., endotracheal intubation or chest tube placement). Even in-person, mannequin-based interactions entail limitations that require students to verbalize many exam components, including elements of neurological and musculoskeletal systems, and, in turn, receive corresponding findings from a confederate. We used a similar approach for our innovative elective. We incorporated a nurse confederate to address limitations within the virtual telesimulation format, and we asked students to provide detailed verbal descriptions of actions they would typically perform physically during simulations. Further work is needed to optimize these learning features in the virtual telesimulation format.

**Next Steps**

Our experience, rapidly adapting our traditional in-person, mannequin-based simulation to virtual telesimulation, highlights key areas critical for successful learning experiences. These include fully remote delivery of real-time clinical data and live actors in the patient and ancillary staff roles. Using either photos portraying a patient with a live actor voice-over or live video feeds of the patient actor supports real-time interactions and feedback regarding “unseen” actions such as medication administration.
Even as we continue to deliver our virtual medical student elective, we have also begun to share our experience with colleagues from other institutions. For example, we conducted, with the participation of three medical student volunteers, a virtual demonstration of one of our telesimulation scenarios and debriefing sessions. Medical educators from a thirteen-member medical school consortium participated in this telesimulation session as “faculty observers” and received practical advice for scheduling and using virtual simulation technology. Many clerkship directors have contacted us, stating that they intend to provide continuity of clinical experiences through a similar virtual telesimulation curriculum, and we are glad to support shared learning across institutions by offering real-time demonstrations of our novel simulation approach.

In our ongoing refinement process, we consider new ways to better overcome the limitations of the virtual telesimulation format. For example, we have noted that participants sometimes group multiple aspects of exams (“How are the eyes, nose, and mouth?”) rather than go through each one by one, or they request findings too generally (“How is the abdomen?”). We now expend effort to emphasize individual steps and components, and we reinforce developing a systematic and thorough approach to the physical exam. Future work will test the use of audio files of heart and lung sounds to supplement learning. We also hope to try a hybrid simulation format wherein an educator, physically based in the simulation center, demonstrates a procedure on a model based on the student’s verbal cues communicated via video conference. A next steps for evaluating this simulation modality includes collecting qualitative data to guide additional process improvements, to understand learner experiences, and to analyze the effect of our virtual telesimulations. Specifically, we will collect audio-recorded focus-group feedback for qualitative analysis, as well as survey data on the learning experiences, at the end of, respectively, the elective and each clerkship rotation. Further work is also needed to assess whether participants
gain any cognitive and/or interpersonal skills as a result of participating in the virtual telesimulation elective. As in-person experiences resume in the future, further research might examine student preparedness for re-entering the clinical setting and the role of these simulation experiences in maintaining student readiness for their clinical experiences. Given the potential of additional waves of COVID-19, we anticipate that virtual telesimulation education may have an expanded role in the facilitation of undergraduate medical education. Beyond COVID-19, the virtual telesimulation format provides a potentially useful method for situations that require remote delivery of educational content, including rotations in rural locations, institutions with limited access to necessary faculty and personnel, and sessions for training in technology-mediated clinical encounters such as telehealth.
References


## Table 1
### Technical and Educational Components of Virtual Tele-simulation

<table>
<thead>
<tr>
<th>Logistical element</th>
<th>Personnel</th>
<th>Technology</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling</td>
<td>Session host</td>
<td>Zoom</td>
<td>Schedules meeting in Zoom and sends meeting login information to simulation coordinator</td>
</tr>
<tr>
<td></td>
<td>Simulation coordinator</td>
<td>Outlook</td>
<td>Invites students and facilitators to session via Outlook</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Google Hangout</td>
<td></td>
</tr>
<tr>
<td>Technical setup</td>
<td>Simulation specialist(s)</td>
<td>Cisco VPN</td>
<td>Logs into university network</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remote access software (Microsoft)</td>
<td>After accessing the control computer at YCMS remotely, 1. Launches Lleap Simulation home application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cisco VPN</td>
<td>2. Selects appropriate virtual mannequin and loads scenario</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remote access software (Microsoft)</td>
<td>3. Launches Zoom application, joins Zoom call</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LLEAP</td>
<td>4. Launches Lleap Simulation home application</td>
</tr>
<tr>
<td></td>
<td>LLEAP instructor</td>
<td>application</td>
<td>5. Launches patient monitor</td>
</tr>
<tr>
<td></td>
<td>LLEAP instructor</td>
<td>application</td>
<td>6. Shares screen</td>
</tr>
<tr>
<td></td>
<td>LLEAP instructor</td>
<td>application</td>
<td>To share media during the simulation, 1. Clicks “File” and selects “Transfer media files…”</td>
</tr>
<tr>
<td></td>
<td>LLEAP instructor</td>
<td>application</td>
<td>2. Clicks the “Add files” button and browse for the appropriate files</td>
</tr>
<tr>
<td></td>
<td>LLEAP instructor</td>
<td>application</td>
<td>3. Once files are selected, clicks “Transfer to learner’s monitor” to display files on the patient monitor</td>
</tr>
<tr>
<td>Educational</td>
<td>YCMS lead facilitator/faculty</td>
<td>Zoom</td>
<td>1. Welcomes students</td>
</tr>
<tr>
<td>orientation</td>
<td></td>
<td>Zoom</td>
<td>2. Introduces facilitation team (or new members)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zoom</td>
<td>3. Reinforces confidentiality and psychological safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zoom</td>
<td>4. Divides students into teams and assigns team leader</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zoom</td>
<td>5. Has observers and facilitation team turn off video and microphone for scenario</td>
</tr>
<tr>
<td>Simulation process/</td>
<td>Nurse role player (facilitator)</td>
<td>Zoom</td>
<td>Introduces scenario/ patient arrival handoff</td>
</tr>
<tr>
<td>participant interactions</td>
<td></td>
<td>Zoom</td>
<td>Presents photo or live video stream and interacts with students, responding to questions</td>
</tr>
<tr>
<td></td>
<td>Patient role player</td>
<td>Zoom</td>
<td>Speak with the “patient” to obtain the presenting complaint and history and speak with the “nurse” to execute treatment interventions</td>
</tr>
<tr>
<td></td>
<td>Students (in teams of 3)</td>
<td>Zoom</td>
<td></td>
</tr>
<tr>
<td>Debriefing with students</td>
<td>Faculty facilitators</td>
<td>Zoom</td>
<td>1. Announce end of simulation after team updates the patient with the disposition plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zoom</td>
<td>2. Instruct all students and facilitators to turn on their video stream</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zoom</td>
<td>3. Engage students in active reflection of feelings, actions, clinical decision making, and communication during the scenario</td>
</tr>
</tbody>
</table>

Abbreviations: VPN, virtual private network; YCMS, Yale Center for Medical Simulation.

*Company headquarters: Zoom (San Jose, California); Microsoft (Redmond, Washington); Google (Mountain View, California); Cisco (San Jose, California); Laerdal Medical (Stavanger, Norway).