recommendations for RBC transfusion practice in critically ill children from the pediatric critical care transfusion and anemia expertise initiative. *Pediatr Crit Care Med* 2018; 19:884–898

7. Muszynski JA, Guzzetta NA, Hall MW, et al; Pediatric Critical Care Transfusion and Anemia Expertise Initiative (TAXI); Pediatric Critical Care Blood Research Network (Blood Net), and the Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network: Recommendations on RBC transfusions for critically ill children with nonhemorrhagic shock from the pediatric critical care transfusion and anemia expertise initiative. *Pediatr Crit Care Med* 2018; 19:S121–S126
8. Srouji LS, Moore-Clingenpeel M, Hensley J, et al: Shock Severity Modifies Associations Between RBC Transfusion in the First 48 Hours of Sepsis Onset and the Duration of Organ Dysfunction in Critically Ill Septic Children. *Pediatr Crit Care Med* 2020; 21:e475–e484
9. Hébert PC, Wells G, Blajchman MA, et al: A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. Transfusion Requirements in Critical Care Investigators, Canadian Critical Care Trials Group. *N Engl J Med* 1999; 340:409–417
10. Vincent JL, Jaschinski U, Wittebole X, et al; ICON Investigators: Worldwide audit of blood transfusion practice in critically ill patients. *Crit Care* 2018; 22:102
11. Remy KE, Hall MW, Cholette J, et al; Pediatric Critical Care Blood Research Network (Blood Net): Mechanisms of red blood cell transfusion-related immunomodulation. *Transfusion* 2018; 58:804–815
12. Muszynski JA, Spinella PC, Cholette JM, et al; Pediatric Critical Care Blood Research Network (Blood Net): Transfusion-related immunomodulation: Review of the literature and implications for pediatric critical illness. *Transfusion* 2017; 57:195–206

Simulation: Keeping Pace With Pandemics*

Lauren J. Alessi, MD
Melinda Fiedor Hamilton, MD, MSc
Department of Critical Care Medicine
UPMC Children's Hospital of Pittsburgh
Pittsburgh, PA

Spanish Influenza, The Black Death, Hong Kong flu, and even HIV/AIDS are pandemics seemingly distant and unimaginable (1). More recently, however, the worldwide medical community has been faced with H1N1 swine flu, severe acute respiratory syndrome-related coronavirus (SARS-CoV)-1, and Ebola. Each of these pandemics has left an impression on medicine and how we approach infectious disease. The current pandemic, caused by a novel coronavirus leading to severe acute respiratory syndrome, is uncharted territory. It presents its own unique challenges in terms of its infectivity, aerosolized transmissibility, significant morbidity, and its ability to overwhelm our medical systems—including limited resources, nonintensivists providing for the critically ill, and pediatric providers taking care of adult patients (2). In this era of rapid communication, hospitals have had the opportunity to prepare and coordinate responses prior to actual patient cases. Medical simulation, often used for planned medical education experiences, can also be powerful in more urgent and time-sensitive situations. Just-in-time (JIT) training refers to education occurring immediately prior to clinical encounters. JIT simulation has been used to hone procedural, resuscitation, surgical, and decision-making skills in a variety of clinical scenarios (3). A JIT intervention provides real-time guidance and improves skills, especially for those that are high risk and infrequently used (4).

*See also p. e485.

Key Words: airway management; just-in-time training; pandemics; personal protective equipment; simulation

The authors have disclosed that they do not have any potential conflicts of interest.

DOI: 10.1097/PCC.0000000000002509

In studies of disaster preparedness and infectious disease crises, simulation has been used with great success. Simulation was used to test and plan medical responses in a biocontainment center for possible Ebola outbreak, and at a military trauma center preparing for wartime casualties. At the latter center, simulation provided valuable teamwork training including communication and understanding of assigned roles (3). Simulation at each of these places allowed for teams, roles, facilities, and equipment to be developed and refined in an expedited fashion. These findings suggest that simulation could be embraced as equally beneficial to real-time clinical training, especially in wartime, mass casualties, natural disasters, and disease outbreaks (3, 5, 6).

Another successful example of simulation to prepare for an outbreak includes the study by Brazzi et al (7). During the 2009 H1N1 influenza pandemic, Italian health authorities realized the need to rapidly develop a network of extracorporeal membranous oxygenation (ECMO) centers and train physicians, many of whom had no ECMO experience. The training consisted of a two-day simulation course including types of bypass, management of ventilation, set up of the circuit, and complications. Data from the H1N1 pandemic included overall survival to discharge (68.3%) of the 60 critically ill ECMO patients with suspected H1N1, and there was no difference in survival between centers with and without previous ECMO experience. They concluded that this rapidly deployed ECMO simulation prepared the new sites to perform as well as already established centers (7).

In this issue of *Pediatric Critical Care Medicine*, the study by Daly Guris et al (8) is a powerful example of JIT simulation training for patient care and provider safety, extending from the simulation suite to an actual patient scenario. In this feasibility study, a group of experienced providers demonstrated how "work as imagined" via table talks, translated to "work as simulated" in a simulation scenario, and eventually "was as done" via an actual patient experience. The scenario was a pediatric patient with a difficult airway and suspected SARS-CoV-2. Their simulation approach with quality improvement methodology allowed identification of several challenges and strengths during the patient scenario.

The tabletop and simulated scenario uncovered communication challenges secondary to personal protective equipment (PPE) and/or noise-generating powered, air-purifying respirator, difficulty auscultating and confirming endotracheal tube placement, and the challenge in communicating from inside to outside the room. These discoveries led to solutions, including speaking loudly and using closed loop communication, using a Bluetooth stethoscope in addition to waveform capnography and video laryngoscopy/bronchoscopy to confirm ETT placement, and utilization of a tablet for videoconferencing to outside the room. They then had a unique experience given that their simulation session was closely followed by the arrival of an actual patient with suspected SARS-CoV-2 and a difficult airway. Again, lessons were learned in the actual patient encounter, including the need for additional backup equipment, a supraglottic device and bronchoscopy, and the need for additional difficult airway personnel in the room including the time needed for those providers to don PPE. Both the simulation team and actual clinical team of providers recognized the increased difficulty of performing intubation in PPE and PAPR given unfamiliar conditions and an increased cognitive load. The need for heightened concentration and impeccable communication reinforced the need for a checklist and airway bundle to ensure clear directions and roles. The study has its limitations, including its occurrence at a single center, its lack of generalizability given the abundance of resources and advanced airway providers not available at smaller institutions, and it did not address scenarios where a suspected COVID patient cannot be easily ventilated through mask ventilation. However, the benefit of an actual patient encounter immediately after simulation is the ultimate in JIT education (8).

As demonstrated in the case above, JIT simulation training can provide excellent opportunities to rehearse and perfect optimal patient care practices in very complex situations. At the same time, simulation is useful for practicing the simple mastery of a set of skills, such as donning of PPE to ensure safety and improve efficiency. Simulation studies have illustrated the increased time needed for proper donning and doffing of PPE as well as increased time required to obtaining an airway (9). Additional studies show that simulation has provided training, feedback, and familiarity with PPE practices (10–13). This flexibility of simulation, an ability to scale up or down complexity, illustrates simulation's continued role as a dynamic and valuable mode of medical education.

In this era of our current pandemic, we face the immediate need to become quickly prepared for overwhelming patient care and health system needs. Simulation is uniquely effective, allowing us to take what we imagine might happen, practice each possible pathway or outcome, and maybe, just maybe, feel better prepared for these truly daunting times.

REFERENCES

1. Taubenberger JK, Morens DM: The 1918 influenza pandemic and its legacy. *Cold Spring Harb Perspect Med* 2019; a038695
2. Remy KE, Verhoef PA, Malone JR, et al: Caring for critically ill adults with Coronavirus Disease 2019 in a PICU. *Pediatr Crit Care Med* 2020 Apr 29. [online ahead of print]
3. Gardner AK, DeMoya MA, Tinkoff GH, et al: Using simulation for disaster preparedness. *Surgery* 2016; 160:565–570
4. Branzetti JB, Adedipe AA, Gittinger MJ, et al: Randomised controlled trial to assess the effect of a just-in-time training on procedural performance: A proof-of-concept study to address procedural skill decay. *BMJ Qual Saf* 2017; 26:881–891
5. Ingrassia PL, Pigozzi L, Bono M, et al: Use of simulated patients in disaster medicine training: A systematic review. *Disaster Med Public Health Prep* 2020 Jan 13. [online ahead of print]
6. Kneebone RL: Simulation reframed. *Adv Simul (Lond)* 2016; 1:27
7. Brazzi L, Lissoni A, Panigada M, et al: Simulation-based training of extracorporeal membrane oxygenation during H1N1 influenza pandemic: The Italian experience. *Simul Healthc* 2012; 7:32–34
8. Daly Guris RJ, Doshi A, Boyer D, et al: Just-in-Time Simulation to Guide Workflow Design for Coronavirus Disease 2019 Difficult Airway Management. *Pediatr Crit Care Med* 2020; 21:e485–e490
9. Yousif S, Machan JT, Alaska Y, et al: Airway management in disaster response: A Manikin Study Comparing direct and video laryngoscopy for endotracheal intubation by prehospital providers in level C personal protective equipment. *Prehosp Disaster Med* 2017; 32:352–356
10. Adler MD, Krug S, Eiger C, et al: Impact of personal protective equipment on the performance of emergency pediatric tasks. *Pediatr Emerg Care* 2020 Feb 24. [online ahead of print]
11. Francom CR, Javia LR, Wolter NE, et al: Pediatric laryngoscopy and bronchoscopy during the COVID-19 pandemic: A four-center collaborative protocol to improve safety with perioperative management strategies and creation of a surgical tent with disposable drapes. *Int J Pediatr Otorhinolaryngol* 2020; 134:110059
12. Schumacher J, Arlidge J, Dudley D, et al: The impact of respiratory protective equipment on difficult airway management: a A randomised, crossover, simulation study. *Anaesthesia* 2020 Apr 26. [online ahead of print]
13. Feldman O, Meir M, Shavit D, et al: Exposure to a surrogate measure of contamination from simulated patients by emergency department personnel wearing personal protective equipment. *JAMA* 2020; 323:2091–2093