

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

# Resuscitation Plus

journal homepage: [www.journals.elsevier.com/resuscitation-plus](http://www.journals.elsevier.com/resuscitation-plus)EUROPEAN  
RESUSCITATION  
COUNCIL

## Short paper

# Rapid response system adaptations at 40 US hospitals during the COVID-19 pandemic



Oscar J.L. Mitchell<sup>a,b,\*</sup>, Olivia Doran<sup>b,c</sup>, Eugene Yuriditsky<sup>d</sup>, Christopher Root<sup>e</sup>, Felipe Teran<sup>b,c</sup>, Kevin Ma<sup>a</sup>, Michael Shashaty<sup>a,f</sup>, Ari Moskowitz<sup>g</sup>, James Horowitz<sup>h</sup>, Benjamin S. Abella<sup>b,c</sup>

<sup>a</sup> Division of Pulmonary, Allergy, and Critical Care, University of Pennsylvania, United States

<sup>b</sup> Center for Resuscitation Science, University of Pennsylvania, United States

<sup>c</sup> Department of Emergency Medicine, University of Pennsylvania, United States

<sup>d</sup> Division of Pulmonary and Critical Care Medicine, NYU Langone School of Medicine, United States

<sup>e</sup> Department of Emergency Medicine, University of New Mexico Health Sciences Center, United States

<sup>f</sup> Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania, United States

<sup>g</sup> Department of Medicine, Montefiore Medical Center, United States

<sup>h</sup> Department of Cardiology, NYU Langone School of Medicine, United States

## Abstract

**Background:** Management of patients with acute deterioration from novel coronavirus disease of 2019 (COVID-19) has posed a particular challenge for rapid response systems (RRSs) due to increased hospital strain and direct risk of infection to RRS team members.

**Objective:** We sought to characterize RRS structure and protocols adaptations during the COVID-19 pandemic.

**Design, setting, and participants:** Internet-based cross-sectional survey of RRS leaders, physicians, and researchers across the United States.

**Results:** Clinicians from 46 hospitals were surveyed, 40 completed a baseline survey (87%), and 19 also completed a follow-up qualitative survey. Most reported an increase in emergency team resources during the COVID-19 pandemic. The number of sites performing simulation training sessions decreased from 88% before COVID-19 to 53% during the pandemic.

**Conclusions:** Most RRSs reported pandemic-related adjustments, most commonly through increasing resources and implementation of protocol changes. There was a reduction in the number of sites that performed simulation training.

**Keywords:** COVID-19, In-hospital cardiac arrest, Rapid Response Teams, Survey

## Introduction

Rapid Response Systems (RRSs) are important for the detection and early management of inpatient deterioration. As the COVID-19 pandemic spread across the United States (US), hospitals were faced with increased volumes of patients requiring hospitalization and critical care services.<sup>1</sup> The initial and subsequent inpatient surges

posed unique challenges for RRS response to inpatient emergencies. In addition to often severe respiratory dysfunction, patients with acute deterioration or in-hospital cardiac arrest (IHCA) pose a risk of virus transmission to members of the Rapid Response Team (RRT). Professional societies IHCA guidelines have recommended adaptations including delayed cardiopulmonary resuscitation (CPR) until personal protective equipment (PPE) is available, early endotracheal intubation, and the use of viral filters during ventilation.<sup>2</sup>

\* Corresponding author at: Division of Pulmonary, Allergy and Critical Care, Hospital of the University of Pennsylvania, 3400 Spruce Street, Philadelphia, PA, 19104, United States.

E-mail address: [oscar.mitchell@penncare.upenn.edu](mailto:oscar.mitchell@penncare.upenn.edu) (O.J.L. Mitchell).

@OscarJMitchell (O.J.L. Mitchell)

<http://dx.doi.org/10.1016/j.resplu.2021.100121>

Received 26 February 2021; Received in revised form 5 April 2021; Accepted 6 April 2021

2666-5204/© 2021 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

In addition to these clinical challenges, the impact of the COVID-19 pandemic on the quality improvement limb of the RRS has not been established. Traditional approaches such as high-fidelity simulation have historically played an important role in the ongoing training of RRS teams,<sup>3</sup> but it is unclear if and how hospitals have adapted these programs during the pandemic.

We therefore sought to characterize the alterations made to RRS teams at a broad, representative group of U.S. hospitals resulting from response to the COVID-19 pandemic.

## Methods

We conducted an internet-based, cross-sectional survey that was distributed individually to a sample of RRS leaders, physicians, and resuscitation researchers across the US. Participants were identified as professional contacts of study team members and only one individual was contacted from each hospital to avoid duplication. The survey instrument was developed by the lead author (OJLM) and received input from the entire research team. It was further refined based on pilot testing by a sample of clinicians similar to the sampling frame but not participating from the study. The survey consisted of 67 questions, including hospital characteristics, RRS structure before and during the COVID-19 pandemic, adaptations made to IHCA

management, use of simulation, and use of mechanical CPR devices (Supplemental Fig. 1). Free text responses concerning RRS adaptations during the COVID-19 pandemic were reviewed by two of the study team (OJLM and BSA). The study was deemed exempt from review by the University of Pennsylvania Institutional Review Board. The survey was sent individually to survey participants from June to August 2020 and a follow-up survey was distributed in December 2020 only to those who completed the first survey. Study data were collected and managed using an internet-based clinical research tool (REDCap, Vanderbilt University, Nashville TN).<sup>4</sup> Site characteristics were tabulated and summarized using descriptive statistics and presented as number (n) with percentage (%), or median with interquartile range (IQR).

## Results

The survey was sent to forty-six clinicians from 46 hospitals, 40 of which completed a baseline survey (87%). Nineteen of the forty responders (48%) also completed the second follow-up survey. Among the hospitals represented in the survey (Table 1), respondents represented hospitals from eighteen US states, primarily in the Northeast (22/40, 55%), the Midwest (7/40, 18%), and Western USA (7/40, 18%): the majority were academic medical centers (33/40,

**Table 1 – Hospital characteristics of survey respondents, emergency team availability and use of simulation before and during the COVID-19 pandemic.**

	Pre-COVID19 (n = 40)	During COVID-19 (n = 40)
<b>Hospital Classification</b>		
Community Hospital	–	7 (18%)
Academic Hospital	–	33 (83%)
<b>Total Number of COVID-19 IHCA at time of initial survey</b>		
0	–	2 (5%)
1-10	–	11 (28%)
11-20	–	13 (33%)
21-50	–	6 (15%)
>50	–	8 (20%)
<b>Emergency Teams Available</b>		
Rapid Response Team	38 (95%)	38 (95%)
Cardiac Arrest Team	36 (90%)	36 (90%)
Emergency Intubation Team	33 (83%)	36 (90%)
Critical Care Outreach Team	20 (50%)	22 (55%)
<b>In-Hospital Emergency Simulations Performed</b>		
<b>Location of simulations</b>	<b>n = 35</b>	<b>n = 21</b>
Simulation Lab	31 (89%)	11 (52%)
<i>In situ</i>	24 (69%)	12 (57%)
<b>Type of simulation</b>		
IHCA	34 (97%)	18 (86%)
Intubation	17 (49%)	19 (90%)
Patient decompensation	25 (71%)	10 (48%)
<b>mCPR Device Available</b>	<b>23 (58%)</b>	<b>34 (85%)</b>

*Abbreviations:* ECPR: Extracorporeal Membrane Oxygenation Cardiopulmonary Resuscitation; IHCA: In-hospital cardiac arrest; mCPR: Mechanical Cardiopulmonary Resuscitation; RRT: Rapid Response Team.

83%); and 7/40 (18%) were community hospitals. At the time of survey completion, nearly all hospitals surveyed (95%) had at least one COVID-19 patient who experienced IHCA.

### RRS emergency teams

All sites reported having at least one type of emergency team (RRT, Cardiac Arrest Team, or Emergency Intubation Team) that existed before the COVID-19 pandemic. Most hospitals reported an increase in emergency team resources during the COVID-19 pandemic: Eighteen hospitals (45%) increased staffing of existing teams; 18/40 (45%) added teams; 15/40 (56%) provided additional equipment to their teams; and 2/40 (5%) extended the hours of existing in-hospital emergency teams. Prior to COVID-19, 23/40 (58%) had mechanical CPR devices available for inpatient use, and this increased to 85% during the COVID-19 pandemic as 11 hospitals purchased mechanical CPR devices specifically for use during the COVID-19 pandemic.

### IHCA protocols

Most hospitals made multiple adaptations to their IHCA protocols: 38/40 (95%) employed use of viral filters for ventilation, 32/40 (80%) stopped chest compressions during intubation, and 38/40 (95%) used video laryngoscope when possible. All sites required Personal Protective Equipment (PPE) prior to initiating CPR in COVID-19 patients who had suffered IHCA and 24/40 (60%) required PPE during IHCA even when the patient was COVID-19 negative.

### Use of simulation

Prior to the COVID-19 pandemic, clinical simulation training was used in the majority of surveyed hospitals — 35/40 (88%), 31/35 (89%) in

simulation labs and 24/35 (69%) with *in situ* simulations. The number of sites performing simulation training during the COVID-19 pandemic, either in simulation laboratories or *in situ* decreased to 21/40 (53%). During the pandemic, simulations more commonly focused on intubation (19/21, 90%) and IHCA (18/21, 86%), rather than decompensating patients more generally (10/21, 48%). The most commonly cited reason for the decrease in the use of in-laboratory simulation during the pandemic was concern surrounding virus transmission to simulation participants. PPE consumption and lack of instructor and participant availability were also implicated. Several sites developed alternative approaches to simulation during the pandemic, including reductions in class size, development of educational video resources, and use of augmented and virtual reality simulation.

### Adaptations and ongoing focus

Nineteen participants (48%) provided free text responses. Themes identified included minimizing the number of people in rooms during events (11/19 responses, 58%), the use of mechanical CPR during IHCA (11/19 responses, 58%), an emphasis on interventions to protect members of the resuscitation team (11/19 responses, 58%), collaboration with other departments to provide patient care (6/19 responses, 32%) (Table 2).

### Discussion

We have described the adaptations that hospitals have made to emergency teams in the face of the COVID-19, including an increase in resources available to emergency teams and a rapid adoption of American Heart Association IHCA recommendations specific to COVID-19.<sup>2</sup> Interestingly, our surveyed clinicians reported a drop-off in simulation training, both in the laboratory and *in situ* environments.

**Table 2 – Themes extracted from free-text responses to the questions surrounding the lessons learnt whilst adapting to the COVID-19 pandemic and which team adaptations were likely to be carried forward after the pandemic.**

Survey question	Theme	Representative quote(s)
What are the lessons that your RRT or cardiac arrest team learnt while adapting to the pandemic?	Minimizing number of people in the room	“Teams function better with less people in the room but need help with extra outside the room who can grab equipment” “Minimizing persons in the room during RRT/[IHCA] was a philosophical change.”
	Mechanical CPR	“Use of mechanical CPR consistently helps chaotic code situations and reduces need for personnel in the room” “[The mechanical CPR device] was purchased for use in the ED and Critical Care units. This mechanical compressor allows us to limit the exposure of healthcare personnel.”
	Protection of Staff – minimizing exposure and maximizing PPE use	“We have added new roles: PPE officer (Dofficer)”
	Simulation	“Simulation is critical to practice new workflows and new communication issues”
What adaptations made to your RRT or cardiac arrest teams will be carried forward after COVID?	Crowd Control	“We are hoping to continue with a focus on minimizing [providers] within the room to reduce the amount of noise and improve communication during events.”
	Education	“Hopefully the residents will continue to be the team leaders of RRTs moving forward.” “The smaller/leaner team may be an adaption that continues after, but it does limit learning opportunities.”
	Mechanical CPR	“Use of mechanical CPR will continue and simulation exercises for team building will be organized routinely.”

CPR: cardiopulmonary resuscitation; IHCA: in-hospital cardiac arrest; PPE: personal protective equipment; RRT: rapid response team.

The management of deteriorating patients with COVID-19 poses a particular challenge due to the risk of virus transmission to the responding team. Given the large number of hospitalizations seen during surges of COVID-19, the increased resources made available seem to be a logical step to ensure the continued ability to respond to inpatient emergencies. However, the accompanying decrease in simulation suggests a potential area of future concern surrounding team functioning and communication. For the most part, RRSs at responding institutions adapted the guidance of professional societies such as the AHA for management of IHCA including measures to protect the resuscitation team, although we did not determine whether these were standard-of-care prior to the COVID-19 pandemic.<sup>2</sup> It is unclear whether such changes will impact outcomes from IHCA.

High-fidelity or *in situ* simulation provides an ideal opportunity to identify areas for quality improvement during the RRS's response to deteriorating patients.<sup>5,6</sup> Simulation carries many potential benefits when adapting to such a pandemic, allowing for testing of new protocols and just-in-time learning, but requires groups of in-person learners with risk of infection, consumes PPE, and places additional workload on already fatigued clinical staff required to participate in and supervise simulation sessions.<sup>7</sup> We found that many hospitals that had previously performed simulation training were no longer using this approach during the pandemic, with a marked reduction in laboratory simulations. The impact of this reduction in simulation during COVID-19 is unclear and is deserving of further study.

Two themes that emerged were the adoption of two interventions: active crowd control at events and the use of mechanical CPR devices. Although both were likely implemented to reduce team members exposure during inpatient emergencies, it is possible that these interventions could impact team functioning. Crowd size has frequently been identified as a barrier to effective team functioning and, although it is best studied in out-of-hospital cardiac arrest, mechanical CPR has been associated with improved survival after IHCA.<sup>8–11</sup> More studies will be required to evaluate the consequences, intended and unintended, on changes made to the structure and function of IHCA and RRT teams during the COVID-19 pandemic.

Our study has several limitations that must be considered. First, due to the small sample size of the study and non-random sampling methods, responses may not be representative of protocol modifications implemented by most hospitals in the U.S. Although a large number of states were represented, most of the survey respondents were from academic medical centers that may have very different resources compared to community hospitals. As we did not collect detailed hospital-level information, we were unable to determine whether our sample was representative of the range of hospitals across the country. This is especially pertinent given the wide variation in emergency team structure in the United States.<sup>12</sup> The second round of the survey also had a lower response rate than the first, which may further impact the generalizability of our findings. Additionally, we only captured adaptations that had been made at the time of the initial survey, which took place during the initial wave of COVID-19 in the United States and not subsequent adaptations to team structure or function.

## Conclusion

The COVID-19 pandemic continues to present challenges to in-hospital emergency teams. Most hospitals in our study increased

resources and implemented protocol changes to minimize exposure of the resuscitation team to transmissible virus as recommended by national societies. A particularly notable change was the decrease in simulation training, especially modeling patient decompensation.

## Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## CRedit authorship contribution statement

**Oscar J.L. Mitchell:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - original draft. **Olivia Doran:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing - review & editing. **Eugene Yuriditsky:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing - review & editing. **Christopher Root:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing - review & editing. **Felipe Teran:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing - review & editing. **Kevin Ma:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing - review & editing. **Michael Shashaty:** Conceptualization, Methodology, Formal analysis, Writing - review & editing, Supervision. **Ari Moskowitz:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing - review & editing. **James Horowitz:** Conceptualization, Methodology, Formal analysis, Writing - review & editing, Supervision. **Benjamin S. Abella:** Conceptualization, Methodology, Formal analysis, Writing - review & editing, Supervision.

## Acknowledgement

OJLM is supported by an NIH T32 grant 5T32HL007891-22.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.resplu.2021.100121>.

## REFERENCES

1. Griffin KM, Karas MG, Ivascu NS, Lief L. Hospital preparedness for COVID-19: a practical guide from a critical care perspective. *Am J Respir Crit Care Med* 2020;201:1337–44, doi:<http://dx.doi.org/10.1164/rccm.202004-1037CP>.
2. Edelson Dana P, Comilla Sasson, Chan Paul S, et al. Interim guidance for basic and advanced life support in adults, children, and neonates with suspected or confirmed COVID-19. *Circulation* 2020;141:e933–43, doi:<http://dx.doi.org/10.1161/CIRCULATIONAHA.120.047463>.
3. Wheeler DS, Geis G, Mack EH, LeMaster T, Patterson MD. High-reliability emergency response teams in the hospital: improving quality and safety using in situ simulation training. *BMJ Qual Saf* 2013;22:507–14, doi:<http://dx.doi.org/10.1136/bmjqs-2012-000931>.

4. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform* 2019;95:103208, doi:<http://dx.doi.org/10.1016/j.jbi.2019.103208>.
5. Daly Guris RJ, Doshi A, Boyer DL, et al. Just-in-time simulation to guide workflow design for coronavirus disease 2019 difficult airway management. *Pediatr Crit Care Med* 2020;21:e485–90, doi:<http://dx.doi.org/10.1097/PCC.0000000000002435>.
6. Yuriditsky E, Horowitz JM, Nair S, Kaufman BS. Simulation-based uptraining improves provider comfort in the management of critically ill patients with COVID-19. *J Crit Care* 2021;61:14–7, doi:<http://dx.doi.org/10.1016/j.jcrc.2020.09.035>.
7. Aldekhyl SS, Arabi YM. Simulation role in preparing for COVID-19. *Ann Thorac Med* 2020;15:134–7, doi:[http://dx.doi.org/10.4103/atm.ATM\\_114\\_20](http://dx.doi.org/10.4103/atm.ATM_114_20).
8. Nallamothu Brahmajee K, Guetterman Timothy C, Molly Harrod, et al. How do resuscitation teams at top-performing hospitals for in-hospital cardiac arrest succeed? *Circulation* 2018;138:154–63, doi:<http://dx.doi.org/10.1161/CIRCULATIONAHA.118.033674>.
9. Mullangi S, Bhandari R, Thanaporn P, Christensen M, Kronick S, Nallamothu BK. Perceptions of resuscitation care among in-hospital cardiac arrest responders: a qualitative analysis. *BMC Health Serv Res* 2020;20:145, doi:<http://dx.doi.org/10.1186/s12913-020-4990-4>.
10. Azzopardi P, Kinney S, Moulden A, Tibballs J. Attitudes and barriers to a Medical Emergency Team system at a tertiary paediatric hospital. *Resuscitation* 2011;82:167–74, doi:<http://dx.doi.org/10.1016/j.resuscitation.2010.10.013>.
11. Crowley CP, Wan ES, Saliccioli JD, Kim E. The use of mechanical cardiopulmonary resuscitation may be associated with improved outcomes over manual cardiopulmonary resuscitation during in-hospital cardiac arrests. *Crit Care Explor* 2020;., doi:<http://dx.doi.org/10.1097/CCE.0000000000000261>.
12. Mitchell OJL, Motschwiller CW, Horowitz JM, et al. Rapid response and cardiac arrest teams: a descriptive analysis of 103 American hospitals. *Crit Care Explor* 2019;1:e0031, doi:<http://dx.doi.org/10.1097/CCE.0000000000000031>.