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## Impact of COVID-19 on inpatient clinical emergencies: A single-center experience

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### Abstract

**Aim:** Determine changes in rapid response team (RRT) activations and describe institutional adaptations made during a surge in hospitalizations for coronavirus disease 2019 (COVID-19).

**Methods:** Using prospectively collected data, we compared characteristics of RRT calls at our academic hospital from March 7 through May 31, 2020 (COVID-19 era) versus those from January 1 through March 6, 2020 (pre-COVID-19 era). We used negative binomial regression to test differences in RRT activation rates normalized to floor (non-ICU) inpatient census between pre-COVID-19 and COVID-19 eras, including the sub-era of rapid COVID-19 census surge and plateau (March 28 through May 2, 2020).

**Results:** RRT activations for respiratory distress rose substantially during the rapid COVID-19 surge and plateau (2.38 (95% CI 1.39–3.36) activations per 1000 floor patient-days v. 1.27 (0.82–1.71) during the pre-COVID-19 era;  $p=0.02$ ); all-cause RRT rates were not significantly different (5.40 (95% CI 3.94–6.85) v. 4.83 (3.86–5.80) activations per 1000 floor patient-days, respectively;  $p=0.52$ ). Throughout the COVID-19 era, respiratory distress accounted for a higher percentage of RRT activations in COVID-19 versus non-COVID-19 patients (57% vs. 28%, respectively;  $p=0.001$ ). During the surge, we adapted RRT guidelines to reduce in-room personnel and standardize personal protective equipment based on COVID-19 status and risk to providers, created decision-support pathways for respiratory emergencies that accounted for COVID-19 status uncertainty, and expanded critical care consultative support to floor teams.

**Conclusion:** Increased frequency and complexity of RRT activations for respiratory distress during the COVID-19 surge prompted the creation of clinical tools and strategies that could be applied to other hospitals.

**Keywords:** Coronavirus, COVID-19, Rapid response team, Medical emergency response team, Clinical emergencies, Patient safety

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## Introduction

The worldwide spread of SARS-CoV-2 has resulted in surges of hospitalizations in patients with COVID-19 respiratory illness.<sup>1</sup> Despite pandemic control efforts, the United States continues to see such hospitalization waves.<sup>2</sup> Non-ICU COVID-19 patients are at risk for respiratory and cardiac decompensations that may occur quickly, triggering in-hospital rapid response systems. Providing care to such patients to meet the urgency of their clinical deterioration while simultaneously maintaining appropriate infection control is challenging and requires adaptation of existing protocols concerning personal protective equipment (PPE), provision of aerosol-generating interventions, and provider communication. Inpatient clinical emergencies may be further complicated by uncertainty of COVID-19 status. Specifically, clinical decompensation may prompt reconsideration of a COVID-19 diagnosis in patients in whom infection was not previously suspected. To date, published data on the impact of COVID-19 on inpatient rapid response systems are limited.

The first admission of a COVID-19+ patient to the Hospital of the University of Pennsylvania (HUP) occurred on March 7, 2020, one day after the first COVID-19 case was confirmed in the state of Pennsylvania. The clinical emergencies team was engaged early—March 11, 2020 marked the first rapid response team (RRT) call, for the 2nd COVID-19+ patient admitted—and numerous challenges emerged. In response, our hospital clinical emergencies leadership team launched a series of efforts to rapidly adapt existing guidelines, generate simple clinical tools for guideline application, and disseminate such tools to clinical personnel. In this study, we aimed to determine differences in rates and characteristics of RRT activations during the spring 2020 surge of COVID-19 patient admissions compared with the pre-COVID time period. Further, we sought to describe our hospital's early COVID-19 clinical emergencies experience and the systems adapted to permit delivery of emergent, safe treatment to rapidly deteriorating non-ICU inpatients.

## Methods

### Study design

We performed a retrospective analysis of all inpatient RRT activations at HUP from January 1 through May 31, 2020. This time period included a "COVID era" starting with the first COVID-19 inpatient admission on March 7, 2020 and a "pre-COVID era" from January 1 through March 6, 2020. The COVID era included the surge, plateau, and initial decline of COVID-19 inpatient census at HUP.

### Setting and data collection

HUP is an academic 791-bed hospital that serves a diverse population of medical and surgical patients from the local West Philadelphia neighborhood and as a referral center for the greater Philadelphia region. The HUP rapid response system was established in July 2006 with a principal goal of providing timely, coordinated, multidisciplinary care to clinically deteriorating floor (non-ICU) inpatients. The afferent limb can be activated by hospital staff or family.<sup>3</sup> The efferent limb, staffed at all times, includes medical and surgical RRTs as well as a range of specialist teams for critical care consultation, emergency intubation, surgical airway, and extracorporeal membrane

oxygenation. Core RRT personnel include a critical care nurse, respiratory therapist, pharmacist, patient transporter, security personnel, and providers specific to RRT type: internal medicine residents and a medical critical care attending physician for medical RRT, surgical residents and a surgical critical care fellow for surgical RRT. These teams are alerted through dedicated pager and overhead announcements. Clinical details of each RRT activation are entered immediately after the event into a clinical emergencies quality improvement database by the RRT's critical care nurse. All COVID-19 diagnoses during the study period were made using a polymerase chain reaction (PCR) assay for SARS CoV-2. Multiple PCR test kits and reagents were used across the study period since no single assay had supply to meet testing needs.

### Statistical analyses

We used  $\chi^2$ , Fisher's exact, and t-tests, as appropriate, to compare RRT patient, treatment, and outcome characteristics both by COVID era versus pre-COVID era and, within the COVID era, by COVID-19 status. We tested differences in RRT activation rates by era using negative binomial regression models to account for non-normal distribution. Stata/IC v. 16.0 (College Station, TX) and Microsoft Excel (Microsoft Office Professional Plus 2016) were used for statistical analyses. The study was deemed exempt by the University of Pennsylvania's Institutional Review Board.

## Results

During the COVID era, the RRT was activated for 165 floor inpatient emergencies: 147 medical and 18 surgical. Of note, during this timeframe all COVID-19-positive floor patients were cohorted and managed by internal medicine teams. Patient demographic and clinical characteristics, interventions during the RRT call, and disposition immediately after the RRT call and on hospital discharge are shown in Table 1. The median RRT event duration was slightly longer during the COVID era than the pre-COVID era (38 v. 34 min, respectively,  $p=0.03$ ), and was longer for COVID-19/PUI patients (those with a positive SARS-CoV-2 test or persons under investigation with a pending test) than those without COVID-19 (46 v. 35 min, respectively,  $p=0.04$ ). Respiratory distress prompted 36% of RRT activations during the COVID era, compared with 26% during the pre-COVID era. Correspondingly, endotracheal intubation during RRT activations was more than twice as common during the COVID era, though we did not detect a significant difference by COVID-19 status. Among COVID era patients, RRT calls for respiratory distress were significantly more common in COVID-19/PUI patients than non-COVID-19 patients (57% v. 28%,  $p<0.01$ ).

Fig. 1 shows RRT activation rates throughout the study period, overlaid on COVID-19 floor hospital census. There was a steep rise in COVID-19 census beginning March 28, 2020 that peaked at 98 patients (56 floor, 42 ICU) on April 23. RRT activations for respiratory distress rose modestly from a pre-COVID era rate of 1.27 (95% confidence interval 0.82–1.71) per 1000 floor patient-days to 1.69 (95% CI 1.20–2.19) per 1000 floor patient-days during the COVID era ( $p=0.212$ ). This rise was pronounced during the period of rapid surge and plateau of COVID floor census (March 28 – May 2) with 2.38 (95% 1.39–3.36) respiratory RRT activations per 1000 floor patient-days ( $p=0.02$  compared with pre-COVID era). In contrast, the pre-surge

**Table 1 – Characteristics of, interventions for, and disposition of patients for whom the rapid response team was activated, by era and COVID-19 status.**

	Comparison by era			Comparison by COVID-19 status (COVID era only)		
	Pre-COVID era (n=172)	COVID era (n=165)	p	COVID-19/PUI (n=42)	Non-COVID-19 (n=123)	p
<b>Demographics</b>						
Male sex	100 (58%)	98 (59%)	0.82	27 (64%)	71 (58%)	0.45
Age (years)	59.9 ± 16.7	60.7 ± 14.6	0.62	62.7 ± 15.3	60.1 ± 14.4	0.31
<b>RRT duration (min)</b>	33 (20–50)	38 (25–56)	0.03	46 (33–59)	35 (23–54)	0.04
<b>Reason for RRT activation</b>			0.18			0.003
Cardiovascular instability	65 (38%)	47 (28%)		7 (17%)	40 (33%)	
Respiratory distress or hypoxia	45 (26%)	59 (36%)		24 (57%)	35 (28%)	
Concern for stroke	6 (3%)	7 (4%)		3 (7%)	4 (3%)	
Other indication	56 (33%)	52 (32%)		8 (19%)	44 (36%)	
<b>Interventions during RRT</b>						
NIV or HFNC	40 (23%)	42 (25%)	0.64	14 (33%)	28 (23%)	0.18
Endotracheal intubation	16 (9%)	32 (19%)	0.008	11 (26%)	21 (17%)	0.20
Vasopressors	41 (24%)	26 (16%)	0.06	4 (10%)	22 (18%)	0.20
<b>Events during RRT</b>						
Anesthesia team called	23 (13%)	36 (22%)	0.04	13 (31%)	23 (19%)	0.10
Advanced airway team called	2 (1%)	9 (5%)	0.03	2 (5%)	7 (6%)	0.82
Cardiac arrest	4 (2%)	9 (5%)	0.14	1 (2%)	8 (7%)	0.31
ECMO	0	0	—	0	0	—
<b>Disposition at RRT conclusion</b>			0.47			0.06
ICU	87 (51%)	86 (52%)		27 (64%)	59 (48%)	
Non-ICU	80 (47%)	75 (45%)		14 (33%)	61 (50%)	
Emergency surgery	4 (2%)	1 (1%)		1 (1%)	0	
Expired	1 (1%)	3 (2%)		0	3 (2%)	
<b>Hospital discharge disposition</b>			0.56			0.35
Home	86 (50%)	88 (53%)		18 (43%)	70 (57%)	
Healthcare facility	40 (23%)	43 (26%)		14 (33%)	29 (24%)	
Expired or Hospice	40 (23%)	32 (19%)		9 (21%)	23 (19%)	
Against medical advice	2 (1%)	2 (1%)		1 (2%)	1 (2%)	

Comparison by era divides patients into Pre-COVID era (1-1-2020 through 3-6-2020) and COVID era (3-7-2020, the date of first patient hospitalized with COVID-19, through 5-31-2020). Comparison by COVID-19 status divides patients from the COVID era only into COVID-19/PUI (patients with positive SARS-COV-2 test, or persons under investigation due to clinical symptoms with SARS-COV-2 test result pending) and Non-COVID-19 (patients without a COVID-19 diagnosis and not under investigation at the time of RRT activation). Data are presented as n (%) for categorical variables and mean ± standard deviation for continuous variables.  $\chi^2$  and Fisher's exact tests (categorical variables) and t-tests (continuous variables) were used to determine p-values for each comparison. Definition of terms: RRT=rapid response team. Other indication=uncontrolled hemorrhage, non-stroke neurological condition, hypoglycemia, fall, allergic reaction, pain, and abnormal laboratory results. NIV=non-invasive ventilation (including bag-valve mask ventilation and non-invasive positive pressure ventilation). HFNC=high flow nasal cannula oxygen. Advanced airway team=anesthesiologist, otolaryngologist, and emergency surgeon. ECMO=extracorporeal membrane oxygenation. ICU=intensive care unit. Healthcare facility=skilled nursing facility, acute rehabilitation facility, or long-term acute care hospital. pressure ventilation.

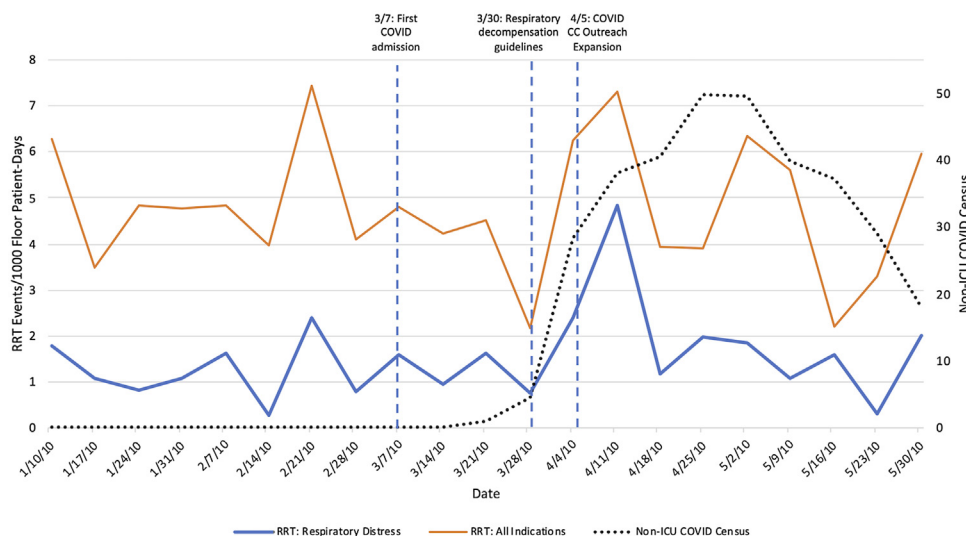
(March 7–27) and post-plateau (May 3–31) time periods during the COVID era had rates similar to the pre-COVID era: 1.11 (95% CI 0.42–1.79) per 1000 floor patient-days ( $p=0.71$ ), and 1.27 (95% CI 0.62–1.92) per 1000 floor patient-days ( $p=0.99$ ), respectively. We did not detect a difference in the rate of total RRT activations even when comparing the pre-COVID era (4.83 (95% CI 3.86–5.80) per 1000 patient-days) and the COVID era surge and plateau (5.40 (95% CI 3.94–6.85) per 1000 patient-days;  $p=0.52$ ). Of note, with temporary suspension of elective admissions the total hospital floor census was lower during the COVID era than the pre-COVID era: median 403 (interquartile range 369–472) versus 539 (IQR 521–545), respectively ( $p<0.01$ ). The timing of several relevant institutional interventions, including dissemination of a COVID-19 respiratory decompensation guideline summary and the expansion of COVID-19 critical care outreach, is noted in Fig. 1 and described further below.

In 18 of 35 RRT calls for respiratory distress in non-COVID-19 patients during the COVID era, new testing for SARS-COV-2 was prompted by the clinical emergency. Of these, two tests (11%) were positive and the patients were diagnosed with COVID-19. Both of

these patients had a prior negative test for SARS-COV-2 during their hospitalizations. We did not detect significant differences in hospital discharge disposition for RRT patients between the COVID era versus the pre-COVID era, or between COVID-19/PUI versus non-COVID-19 patients during the COVID era (Table 1).

## Discussion

COVID-19 had a significant impact on the nature of inpatient floor clinical emergencies at our institution, particularly during the surge and plateau of COVID-19 hospitalizations from late March to early May 2020. RRT call rates for respiratory decompensation were significantly more common during this time, driven by events in COVID-19/PUI patients. We think that these findings, and our efforts to create comprehensive and accessible management guides described in the following sections, are informative for hospital rapid response systems adapting to periods of rising or persistently elevated COVID-19 census.



**Fig. 1 – Hospital of the University of Pennsylvania (HUP) rates of rapid response team (RRT) activation per 1000 floor (non-ICU) patient-days (left-hand vertical axis), averaged over the prior 7 days, between January and May 2020. Activation rates for all indications (orange line) and specifically for respiratory distress (blue line) are shown. Also shown is total non-ICU inpatient COVID-19 patient census (right-hand vertical axis), similarly averaged over the prior 7 days. Vertical dashed lines denote key dates: the first COVID-19+ patient admission at HUP (March 7, 2020), dissemination of a new respiratory decompensation management guideline (March 30, 2020, guideline shown in Supplemental Fig. 1), and COVID-specific expansion of critical care (CC) outreach services (April 5, 2020).**

We found that new testing for SARS-COV-2 was prompted in over half of non-COVID-19 patients with respiratory-related clinical emergencies and was positive in a small number of cases. With multiple COVID-19 case rate surges since the onset of the pandemic, recognizing the potential for previously uninfected inpatients to acquire infection, whether from visitors or hospital personnel, takes on added importance when multiple providers emergently respond and may need to employ aerosol-generating interventions. Although our study was not designed to track rates of healthcare worker SARS-COV-2 exposure and conversion, our findings suggest that inpatient clinical emergencies, particularly with new respiratory decompensation, may be the first indication of new COVID-19 that could put personnel at risk. We therefore suggest a systematic approach to infection control, PPE, and clinical decision making that accounts for uncertainties in COVID-19 status, outlined below. Such an approach can be tailored to an individual hospital based on PPE availability, local COVID-19 prevalence, and center-specific SARS-COV-2 testing protocols and turnaround time.

#### **Initial response: infection control, room logistics, and communication**

Many of our initial modifications to clinical emergencies protocols were based on the limited data available at the time and iterative change informed by clinician feedback. Adapting procedures to limit transmission of infection to healthcare workers providing emergency care was of paramount concern.

We considered a spectrum of risk based on COVID-19 status and likelihood of aerosol-generating procedures for each emergency type (Fig. 2, section on PPE and Infection Control). After several early experiences that highlighted the challenge of definitively

establishing risk to providers at RRT onset, we adopted aggressive infection control guidelines particularly for patients with respiratory decompensation or cardiac arrest. We applied this approach even in patients not known to have COVID-19, though RRT personnel could de-escalate during events if an alternative diagnosis were established clearly enough that a new diagnosis of COVID-19 would not be entertained. We also reduced in-room personnel to only those essential for delivering emergency care ( $n=4$  for RRT call, 7 for cardiac arrest, with the option to call in additional personnel as needed; Fig. 3), though no changes were made to the overall make-up of the responding team.

Reducing in-room personnel and routinely keeping the patient's door closed had significant impact on RRT communication. Some providers noted that the quieter, less crowded environment facilitated team communication within the patient's room. We did, however, have to institute procedures to enable communication with key team members, such as the pharmacist and additional nursing and physician staff, who stayed outside the patient room. The simplest measure, effective regardless of whether the room was visible from the outside via window or glass door, was to use an in-room phone on speaker setting connected to the lead nurse stationed just outside of the room. This nurse served as the communication hub for patient status updates and requests for equipment and additional personnel.

#### **Respiratory decompensations**

As noted, respiratory clinical emergencies surged during the initial increase in patients hospitalized with COVID-19. Recommendations regarding allowable levels of non-invasive respiratory support, thresholds for intubation, and risks to both patient and personnel of

## Clinical Emergencies Guide: PPE and Respiratory Management

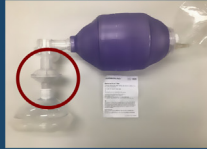
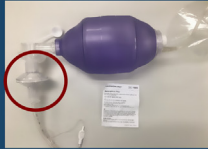
(see accompanying [Clinical Emergencies Guide: Logistics and Layout](#) for additional details)

PPE and Infection Control				Initial Respiratory Management		
COVID status	Emergency	PPE	Risk minimization	Airway	Respirations	Management
Non-PUI	RRT (non-respiratory)	Surgical Mask + Gloves + Eye Shield	Standard	Native	Spontaneous	O <sub>2</sub> by nasal cannula or NRB
	RRT (respiratory)	Single use N95 or PAPR† + Gown/Gloves + Eye Shield	Minimize in-room personnel† + Close door / cell phone communication†		Poor ventilation -or- No respirations -or- Persistent ↓SpO <sub>2</sub>	Bag ventilate Place viral filter (picture) Use 2 providers (mask + bag)
	Code or Intubation					
PUI	RRT (any)	Single use N95 or PAPR + Gown/Gloves + Eye Shield	Minimize in-room personnel + Close door / cell phone communication	Trach	Trach collar -or- Ventilated	Follow trach card algorithm‡ If bag ventilation indicated Place viral filter (picture) Use 2 providers (mask + bag)
	Code or Intubation					
Confirmed COVID-19 +	RRT (any)	Single use N95 or PAPR + Gown/Gloves + Eye Shield	Minimize in-room personnel + Close door / cell phone communication	ETT	Ventilated	Use ventilator (adjust alarms) If unable to ventilate Place viral filter (picture) Bag ventilate
	Code or Intubation					

Notes	
†	Initial approach for non-PUI given: - Possible aerosolizing interventions (O <sub>2</sub> mask, bag, CPR) - Possible reconsideration of COVID testing De-escalation to pre-emergency level of precautions if: - Aerosolizing interventions not needed, OR - New testing for COVID-19 deemed unnecessary
‡	Card posted on door/window of all tracheostomy patients

Viral filter placement for bag ventilation	
Mask	ETT
	

Updated mm/dd/yyyy – Recommendations may evolve: check UPHS COVID-19 SharePoint for most updated version.  
Email Michael Shashaty ([shashatm@pennmedicine.upenn.edu](mailto:shashatm@pennmedicine.upenn.edu)) for corrections.

**Fig. 2 – Page 1 of the Clinical Emergencies Guide for the Hospital of the University of Pennsylvania showing adaptations of the rapid response system to the surge of inpatients with confirmed or possible COVID-19 infection. This page gives guidance on PPE and respiratory management and was distributed with page 2 (see Fig. 3) as a single, two-page tip sheet. Actual dates in versions distributed to hospital personnel are replaced here with a non-specific designation (mm/dd/yyyy). Abbreviations: PPE=personal protective equipment; PUI=person under investigation for COVID-19; RRT=rapid response team activation; PAPR=powered air purifying respirator; CPR=cardiopulmonary resuscitation; NRB=non-rebreather mask; ETT=endotracheal tube.**

such interventions changed during the early months and differed substantially from routine pre-COVID practice.<sup>4</sup> Of particular concern was the balance of risks— aerosolizing viral particles, patient instability—considered when deciding to intubate known or suspected COVID-19 patients in non-negative pressure rooms versus delaying intubation and transferring spontaneously breathing critically ill patients through hospital hallways to a negative pressure room in the ICU.

In response, we created a clinical decision support tool for respiratory decompensations that accounted for the urgency of intubation, the likelihood of COVID-19 infection, and competing infection control considerations (Supplemental Fig. 1A and B). Anticipating that recommendations would likely evolve, we embedded a hyperlink within the tool that brought the user to the most updated version which was maintained on a secure cloud storage server.

Given early reports of unusually rapid respiratory decompensation in COVID-19 pneumonia patients,<sup>5</sup> our Department of Anesthesiology created a dedicated intubation team with no competing operating room or other responsibilities. This allowed for early anesthesia team involvement in decision-making for floor patients with respiratory emergencies and provided additional time flexibility for the team to don

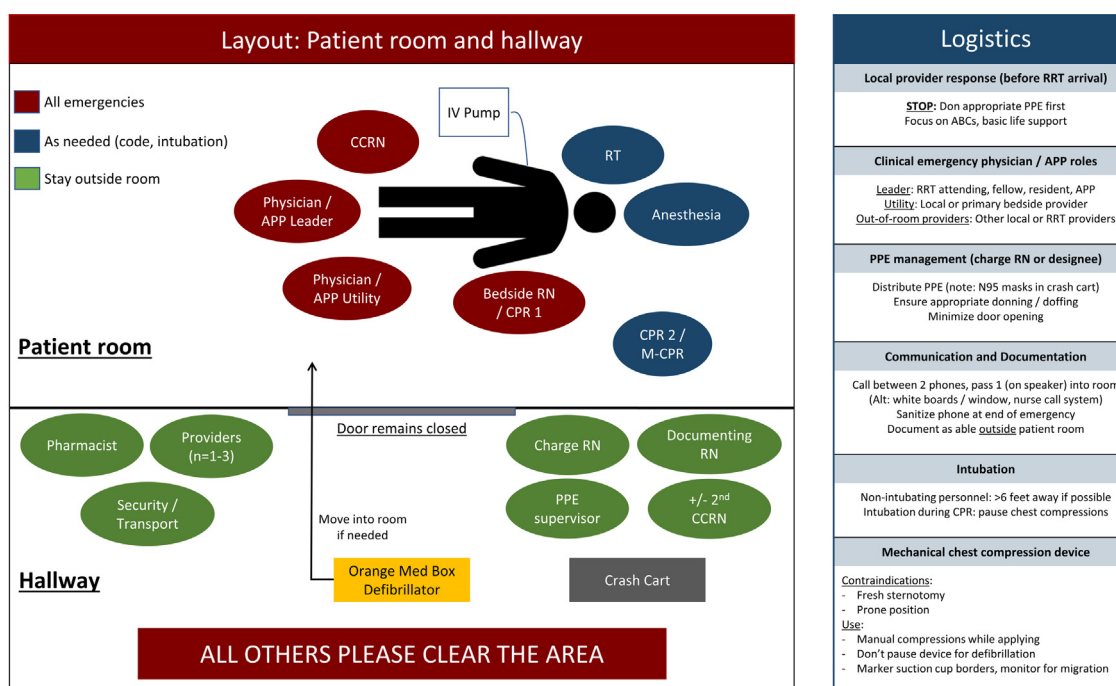
airborne PPE to protect against viral particle dissemination during intubation.<sup>6</sup> Further, we rapidly expanded and restructured our existing critical care outreach service, staffed by the RRT intensivist, to offer early engagement and integrated support for COVID-19 floor patients with concerning respiratory trajectories that had not yet prompted a RRT call. This adaptation also facilitated dissemination of emerging, novel therapies such as awake proning, ensured contingency planning for high-risk COVID-19 patients, and promoted timely goals of care discussions to guide further escalation of care if needed.

### Respiratory and cardiac arrest management

RRT and primary teams had substantial concern about viral spread from aerosol-generating procedures during cardiopulmonary resuscitation. Interim guidance from the American Heart Association, issued in April 2020, allowed for modification of resuscitation protocols in patients with COVID-19, such as replacing bag-valve-mask ventilation with application of oxygen without ventilation.<sup>7</sup> Because clinical decompensations often raised the possibility of COVID-19 diagnosis even in those previously considered low risk,

## Clinical Emergencies Guide: Layout and Logistics

(Use when Clinical Emergencies Guide: PPE and Respiratory Management dictates minimizing in-room personnel and closing door)



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Email Michael Shashaty ([shashatm@penmedicine.upenn.edu](mailto:shashatm@penmedicine.upenn.edu)) for corrections.

**Fig. 3 – Page 2 of the Clinical Emergencies Guide for the Hospital of the University of Pennsylvania showing adaptations of the rapid response system to the surge of inpatients with confirmed or possible COVID-19 infection. This page shows the layout of responding providers in the patient room and adjacent hallway as well as a summary of logistical considerations during management of patients with known or possible COVID-19 infection. It was distributed with page 1 (see Fig. 2) as a single, two-page tip sheet. Actual dates in versions distributed to hospital personnel are replaced here with a non-specific designation (mm/dd/yyyy). Abbreviations: PPE=personal protective equipment; PUI=person under investigation for COVID-19; CCRN=critical care nurse; APP=advanced practice provider; RN=registered nurse; CPR=cardiopulmonary resuscitation; M-CPR=mechanical chest compression device operator; RT=respiratory therapist; RRT=rapid response team.**

however, we were concerned that such a guideline change would lead to unnecessarily broad withholding of potentially lifesaving positive pressure ventilation. Further, our clinical experience with decompensating COVID-19 patients frequently involved rapidly worsening hypoxemia and hypercapnia requiring immediate positive pressure ventilation via bag-valve-mask to prevent respiratory or cardiac arrest.

We therefore focused heavily on PPE use and required use of high-efficiency particle air (HEPA) filters and two-provider technique to minimize the risk of aerosolization during bag-valve-mask ventilation (Fig. 2). HEPA filters were kept with bag-valve masks on all hospital code carts and carried by all respiratory therapists and RRT nurses. We also purchased several mechanical compression devices early in our COVID-19 surge to reduce both the number of in-room personnel needed for cardiopulmonary resuscitation and the exposure of those assigned to chest compressions. These devices were deployed in areas of the hospital with the greatest density of COVID-19 patients.

### Guideline dissemination and implementation

Rapidly modifying and communicating our RRT protocols proved challenging given the complexity of clinical emergencies management. For example, implementing stricter infection control measures created barriers to rapid patient assessment as well as communication between in-room personnel and support staff. We overcame such hurdles by actively seeking real-time feedback from RRT providers across disciplines, which, combined with the use of links to updated versions embedded within posted guideline summaries, allowed for rapid incorporation and dissemination of evolving recommendations.

With a stretched hospital workforce and multiple simultaneous patient management changes during the COVID-19 surge, we were unable to discretely and formally test the impact of our clinical emergencies interventions. Even if we were able to demonstrate specific benefit of summary tip sheets and additional layers of critical care and anesthesia support for floor teams, applying similar

interventions more broadly would require customization to each hospital's rapid response system structure.

## Conclusions

We identified significant changes in floor inpatient clinical emergencies during the spring 2020 COVID-19 admission surge and plateau at our hospital. Our team's efforts provide one example of how the challenge of clinical emergencies amidst the COVID-19 pandemic can be addressed in a way that promotes patient and provider safety during events that involve expedited, multidisciplinary, highly coordinated care. Such an approach may also be applicable to future scenarios that prompt precipitous hospital-wide management changes.

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## Conflicts of interest statement

None.

## CRedit authorship contribution statement

**Oscar J.L. Mitchell:** Conceptualization, Methodology, Formal analysis, Data curation, Visualization, Writing - original draft. **Stacie Neefe:** Conceptualization, Data curation, Visualization, Writing - review & editing. **Jennifer C. Ginestra:** Visualization, Writing - review & editing. **Cameron M. Baston:** Visualization, Writing - review & editing. **Michael J. Frazer:** Visualization, Writing - review & editing. **Steven Gudowski:** Visualization, Writing - review & editing. **Jeff Min:** Visualization, Writing - review & editing. **Nahreen H. Ahmed:** Visualization, Writing - review & editing. **Jose L. Pascual:** Conceptualization, Writing - review & editing. **William D. Schweickert:** Visualization, Writing - review & editing. **Brian J. Anderson:** Visualization, Writing - review & editing. **George L. Anesi:** Visualization, Writing - review & editing. **Scott A. Falk:** Conceptualization, Visualization, Writing - review & editing. **Michael G.S. Shashaty:** Conceptualization, Methodology, Formal analysis, Data curation, Visualization, Writing - original draft.

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## 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.2021.100135>.

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