A California Hospital's **Response to COVID-19:** From a Ripple to a Tsunami Warning

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BACKGROUND The outbreak of coronavirus disease 2019 (COVID-19) rippled across the world from Wuhan, China, to the shores of the United States within a few months. Hospitals and intensive care units were suddenly faced with a "tsunami" warning requiring instantaneous implementation and escalation of disaster plans.

EVIDENCE REVIEW An evidence-based question was developed and an extensive review of the literature was completed, resulting in a structured plan for the intensive care units to manage a surge of patients critically ill with COVID-19 in March 2020. Twenty-five sources of evidence focusing on pandemic intensive care unit and COVID-19 management laid the foundation for the team to navigate the crisis.

IMPLEMENTATION The Critical Care Services task force adopted recommendations from the *CHEST* consensus statement on surge capacity principles and other sources, which served as the framework for the organized response. The 4 S's became the focus: space, staff, supplies, and systems. Development of algorithms, workflows, and new processes related to treating patients, staffing shortages, and limited supplies. New intensive care unit staffing solutions were adopted.

EVALUATION Using a framework based on the literature reviewed, the Critical Care Services task force controlled the surge of patients with COVID-19 in March through May 2020. Patients received excellent care, and the mortality rate was 0.008%. The intensive care unit team had the needed respiratory and general supplies but had to continually adapt to shortages of personal protective equipment, cleaning products, and some medications.

SUSTAINABILITY The intensive care unit pandemic response plan has been established and the team is prepared for the next wave of COVID-19. (*Critical Care Nurse*. 2020;40[6]:e1-e16)

The coronavirus disease 2019 (COVID-19) pandemic began during the closing months of 2019 in Wuhan, China.[1] The ripple effect of the outbreak in China reached the state of Washington on January 19, 2020.[2] By late February 2020, the COVID-19 virus was spreading rapidly. Hospitals across the world were suddenly faced with a "tsunami" warning. The wave of patients with COVID-19

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began to enter US hospitals, requiring rapid escalations in preparing for and managing the spreading pandemic. Hospitals began to review and implement infectious-disease disaster plans. The rapid deterioration of some of the patients with suspected COVID-19 infections led to a dramatic increase in intensive care unit (ICU) admissions.[3] The impact was significant.

The survival of patients with COVID-19 has depended on a plan to manage the crisis. During March through May 2020, at Mission Hospital, Mission Viejo, California, we used the hospital's evidence-based practice model to develop a question to assist the team in planning and managing the crisis: How does a nonacademic hospital ICU apply pandemic and COVID-19 disease management guidelines to optimize readiness, maximize resources, and treat patients during the peak surge of the crisis? In this article, we detail an evidence-based approach to the deployment, management, and evaluation of Mission Hospital's disaster plan for the COVID-19 pandemic in March through May 2020, with an emphasis on critical care services. Recommendations from the literature, including the *CHEST* consensus statement on surge capacity principles,[4] served as the framework for the coordinated critical care response to the COVID-19 tsunami during March through May 2020.

The model defined conventional, contingency, and crisis care as it relates to space, staff, supplies (stuff), and system strategies (known as the 4 S's) for care.

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Review of Evidence

As the pandemic began to affect the United States, published reports and literature on managing pandemics and COVID-19 began appearing in numerous publications and on professional societies' websites. Hospitals worldwide were affected as the viral illness spread rapidly. With the admission to Mission Hospital of the first patients infected with COVID-19 in March 2020, the multidisciplinary team reviewed the hospital disaster plan. The Executive Leader Team (ELT) and physician and nurse leaders focused on implementing the Hospital Incident Command Structure (HICS), while the Critical Care Services (CCS) team focused on the literature to gather additional information on managing the COVID-19 pandemic. The CCS clinical nurse specialist (CNS) used the hospital's evidence-based practice model to prepare an evidence grid with pertinent summaries on managing COVID-19. The hospital had adopted the Johns Hopkins Nursing Evidence-Based Practice Model[5] for clinical decision-making. This model applies a structured process to evaluate and integrate the best available evidence. The process involves 3 components: (1) P: develop a focused practice question; (2) E: search, review, and appraise evidence; and (3) T: translate the evidence review into practice.[5] The PET model provided the CNS a systematic approach for compiling evidence-based information about COVID-19.

Development of a practice question used the PICO format (P: population, patient, or problem; I: intervention; C: comparison; and O: outcomes): How does a nonacademic hospital ICU apply pandemic and COVID-19 management guidelines to optimize readiness, maximize resources, and treat patients during the peak surge of the COVID-19 pandemic? The CNS conducted an evidence search and reviewed relevant sources of literature[6-21] on managing the COVID-19 process and pandemic. As new information was published, sources were added to the grid. Each source was reviewed using the Johns Hopkins Nursing Evidence-Based Practice Model, and a level of evidence (I to V) was assigned according to the model: I (experimental, systematic reviews of randomized

controlled trials); II (quasi-experimental study, systematic review of a combination of randomized controlled trials); III (nonexperimental study, qualitative, metasynthesis); IV (opinion of respected authorities, nationally recognized expert committees, clinical practice or consensus guidelines); and V (integrated literature reviews, quality improvement, case reports, opinion of nationally recognized experts based on experimental evidence). All the sources of evidence[6-21] were compiled (Table 1) and used by the CCS team when developing and managing the plan for the influx of patients with COVID-19. The sources of evidence were related to pandemic principles and specific disease-related issues.

Pandemic management principles focused on mitigating the impact of the pandemic through prevention guidelines, including social distancing and environmental cleaning measures, developing widespread testing, creating specific vaccine and treatment measures, and maintaining adequate stockpiles of critical supplies such as ventilators, medications, and personal protective equipment (PPE).[6,18] Hospitals were advised to plan for the 4 phases of disaster management, with an emphasis on planning (Table 1).[17] Conducting a hazard-vulnerability analysis was key to preparing hospitals and CCS for dealing with the pandemic.[17,20] Important hospital-wide practices included establishing a HICS, communication systems, a security strategy, decontamination facilities, a personnel pool, and critical care infrastructure and involving all services and professionals in the process.[4,8,10,17,20] The Centers for Disease Control and Prevention (CDC) provided guidelines and recommendations for managing COVID-19 and the pandemic.[6] The recommendations were updated numerous times from March through May 2020.

The critical care planning and management guidelines provided numerous critical recommendations and frameworks.[4,10,13,15-17,19-21] Key to managing a pandemic is preplanning.[4,6,10,12,13,16,17,20] Intensive care unit practitioners are identified as key contributors to planning for and managing pandemics, especially the COVID-19 outbreak.[4,17,20,21] Hick et al[4] provided a framework for managing an ICU surge during a pandemic or disaster. The model defined conventional, contingency, and crisis care modes as they relate to space, staff, supplies (stuff), and system strategies (the 4 S's) (Table 2).[4] The key components identified in the *CHEST* guidelines[4] were identified repeatedly in many articles, with the 4 S's emerging as a universal model to frame the ICU response.[13,16,20,21]

Space involved identifying usual areas for ICU care but expanded the concept to delivering ICU level of care in units not traditionally used as an ICU, including postanesthesia care units, step-down units, and endoscopy areas. Triaging patients into the ICU space was emphasized and detailed.[6,7,9,12,15,16,19] Staff models for treating patients in the ICU presented contingency and crisis models that included augmenting ICU practitioners (eg, using a 2-tiered staffing model; Figure 1).[4,13,16,20,21] Supplies and equipment were critical to managing an ICU surge during the pandemic. Essential supplies included respiratory equipment, pharmaceuticals, PPE, intravenous fluid pumps, and monitors.[6,10,11,13-15,20,21] The need for airborne-infection isolation rooms (AIIRs) was identified to reduce viral transmission.[6,11] System strategy or standard of care explored the treatment of patients when in conventional (usual care), contingency (minimal impact on usual care practices), and crisis modes (not consistent with usual standards).[4,13,16,20,21]

The literature specifically related to the COVID-19 pandemic provided guidance on managing the surge of patients, providing adequate PPE during extreme shortages, and understanding disease-specific characteristics that would influence transmission and care practice.[6-12] According to reports published from China and Italy, the practices for treating patients suspected of having or positive for COVID-19 affected how care was delivered in managing the specific disease as well as procedures such as intubation, aerosol-generating procedures, and cardiopulmonary resuscitation.[1,7,9,11,22] The relevant literature reviewed and the hospital disaster-management plan provided the CCS team with a strategic game plan for managing the surge of patients with COVID-19 in March through May 2020.

The HICS was based on the incident command system, which assists hospitals with management planning and response and recovery capabilities for unplanned and planned disaster events.

Implementation

Hospital Response

Mission Hospital, part of the Providence St. Joseph Health System, is a 523-bed, nonacademic, acute-care

Table 1 Applying pandemic guidelines: findings identified on literature review

Source	Design, rating[a]	Key findings
CDC,[6] 2020	Guidelines, level III	Real-time recommendations for health care settings to manage COVID-19 and address transmission of disease; screening of patients, visitors, and staff; strategies to mitigate staffing shortages; infection control guidance; patient placement; PPE and precautions with aerosol-generating procedures; specimen collection; engineering controls; HCP management; environmental infection control; and reporting guidelines between facilities and public health authorities.
Hick et al,[4] 2014	Consensus, level IV	A suggested framework for expanding critical care surge capacity and extending critical care services during pandemics or disasters. Twenty-three questions were developed related to system issues, equipment, supplies and pharmaceuticals, staffing, and informatics. Surge continuum taxonomy defined as conventional care (expand by 20% above baseline), contingency care (expand by 100% above baseline), and crisis care (expand 200% above baseline). Adapt the hospital's space, staff, supplies, and standard of care to the conventional, contingency, and crisis phases of the pandemic or disaster. Mitigate impact on ICU through prevention, screening, and early treatment, triage, and risk communication; support and protect medically fragile patients; and work within region for specialty critical care.
Ranney et al,[7] 2020	Prospective, level V	Between 60 000 and 160 000 ventilators are available in the United States, which is estimated to be inadequate for a national surge in COVID-19 cases. Lack of PPE experienced across the country. Problems with global supply chain due to the pandemic. Before the outbreak, China produced 50% of the world's face masks. CDC-altered guidelines for PPE include limiting N95 respirator use to aerosol-generating procedures and reusing the masks. DPA enacted to increase production of ventilators. US government should coordinate efforts to ensure supplies are going to hardest hit areas. Coordinated response by government in partnership with technology companies would increase needed supplies.
Hick and Biddinger,[8] 2020	Prospective, level V	Need for population-based public health interventions and use of foundations for preparedness in health systems to deal with the pandemic. Organizations must implement incident action planning. Provide access to testing. HCP need to determine patients' end-of-life wishes. Expand inpatient critical care. Plan for a regional process for the triage of resources. Establish a regional plan for critical care referrals. Prepare for long-term care of patients with COVID-19. Hospitals must have a staged plan to meet or exceed the 200% increase in critical care beds. Conserve PPE, and protect HCP with adequate PPE.
Grasselli et al,[9] 2020	Editorial, level V	A critical care response in Italy: Priorities were to increase surge ICU capacity and implement measures for containment. Created a cohort of first-responder hub hospitals with expertise in infectious disease. Separated patients with COVID-19 from other critically ill patients in designated areas. A triage area was created for patients receiving ventilation. Established local protocols for triage, testing, and management. Ensured adequate PPE for HCP. Dramatic increase in patients within 14 days of outbreak led to overwhelming ICU surge. Proportion of ICU admissions was 12% of all positive cases and 16% of all hospitalized patients.
Adalja et al,[10] 2020	Viewpoint, level V	Hospitals should review, update, and prepare disaster and pandemic plans. Provide protocols for triage of patients into and out of hospitals. Train staff on PPE use and managing crisis. Increase ICU capacity by augmenting ICU space with PACUs and other areas with access to ventilators. Clinicians should develop and update patient management guidelines. Need for rapid expansion of diagnostic testing. Public health must slow the spread of the pandemic.
Liu et al,[11] 2020	Editorial, level V	Key challenges: early identification of the outbreak, rapid expansion of patients, high risk of nosocomial transmission, unpredictability of size affected, and lack of backup resources. Recommended a coordinated response with hospital, community, and government. Admit patients to single, negative-pressure rooms with ICU monitoring and externally exhausted HEPA filters. Suspend general surgeries and procedures. Increase ICU bed capacity. Ensure adequate PPE supplies. Virus contained high viral load and aerosol-generating procedures magnified exposure and transmission risk; enforce strict isolation (contact, droplet, and airborne precautions) with N95 respirators. Prolonged virus shedding >3 weeks. Manage stress and evaluate HCP. Aggressive management of pulmonary status is required. Provide intubation, early prone positioning, neuromuscular blockade, and extracorporeal membrane oxygenation, as necessary.

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Table 1 *Continued*

Source	Design, rating[a]	Key findings
Toner and Waldhorn,[12] 2020	Expert synopsis, level V	Presented projections for pandemic planning: moderate scenario (200 000 patients requiring ICU care) vs very severe scenario (2.9 million patients requiring ICU care). Comprehensive planning based on CDC flu surge projections. Limit the spread of the virus to HCP and others. Maintain workforce by augmenting ICU-level practitioners with non-ICU–level staff via buddy teaming.
Maves et al,[13] 2019	Expert opinion, level V	Emphasizes hospital preparedness with early planning to manage epidemics/pandemics. Identifies infection prevention controls to reduce risk to staff and patients. Strategies for managing a pandemic include stuff (ie, supplies such as disposable items, pharmaceuticals, mechanical ventilators/respiratory equipment, PPE, laboratory equipment for testing), staff (plan for staff shortages, assess skill level of HCP, develop a plan to supplement ICU staff), space (assess current ICU space and examine potential other areas such as PACUs, endoscopy, and monitored step-down units), and system (cancel elective surgeries, discharge patients, and develop disease-specific strategies to treat patients and complications).
Kain and Fowler,[14] 2019	Review, level V	Review of timeline of the 1918 pandemic and recent outbreaks in from 1900 to 2019. Preparation for next pandemic must include careful surveillance to recognize and mitigate the pandemic. Emergency response system that responds adequately to surge capacity. Prepare equipment, physical space, human resources, and system issues. Mass produce vaccines. Communication must be timely and be coordinated within organizations. Establish coordinated research plans.
Daugherty Biddison et al,[15] 2019	Review, level V	Two scoring systems were used to predict short-term mortality: the Sequential Organ Failure Assessment score and the Pediatric Logistic Organ Dysfunction 2 score. The process had inclusion/exclusion criteria and an assignment of priority scoring for allocating ventilators during a disaster. Process requires a triage team, staffing and oversight, and a statewide review process that emphasize bidirectional communication with local hospital triage committees.
Seda and Parrish,[16] 2019	Review, level V	Preparation is essential. Key priorities include staff (critical care physicians and nurses, respiratory therapists; ancillary staff may be limited; augment staff by developing a 2-tiered model [eg, 1 ICU nurse and 3 non-ICU nurses caring for 6 ICU patients]; staff should use preprinted order sets and protocols), supplies (respiratory equipment such as ventilators and noninvasive ventilation; medications such as vasopressors, bronchodilators, sedation/analgesic agents, crystalloids, and antimicrobials; pumps, monitors, and PPE may be in short supply), space (quantify available ICU beds and convert acuity adaptable units such as PACUs, step-down units, and endoscopy areas), and structure (paradigm shift away from comprehensive care to predetermined strict ICU admission criteria to handle surge; use virtual critical care to support bedside physicians and nurses).
Wax,[17] 2019	Review, level V	Four phases of disaster management: mitigation, preparedness, response, and recovery. Conduct hazard-vulnerability analysis (risk of event = probability × severity). Disaster planning should include critical care physicians and nurses; respiratory therapists; pharmacists; laboratory, facilities, security, and finance staff; administrators; clinical ethicists; and trauma and emergency services and perioperative services staff.
Jester et al,[18] 2018	Review, level V	The 1918 influenza pandemic infected 50% of world population and caused ≥50 million deaths. Several recent viral outbreaks have occurred (particularly in Asia). Readiness efforts for a severe pandemic: World Health Organization and other agencies conduct surveillance around the globe. Gaps are present because of limited influenza virus testing and test reagents. Prevention guidelines include social distancing and environmental cleaning measures. Treatments depend on the organism. Mitigating the impact of emerging pandemics relies on available treatment, clinical support, and vaccines. Stockpiles of ventilators, PPE, and antiviral drugs are needed.
Blanch et al,[19] 2016	Consensus guidelines, level V	Intensivists should involve emergency medicine professionals, hospitalists, surgeons, nurses, and allied health professionals when making triage decisions about ICU placement. Use triage systems for mass casualty incidents. Make ICU beds available by triaging patients out of ICU to intermediate-level care units. Allocation of resources needs broader discussions with ethics committees, government bodies, and society.

Continued

Table 1 *Continued*

Source	Design, rating[a]	Key findings
Farmer et al,[20] 2012	Guidebook and toolkit, level V	Guidelines and tools for hospitals to assess ICU preparedness and resources for implementing a standing plan for disasters. Establish a control process using a hospital incident command center structure; establish a robust communication system using landlines, radios, cell phones, and computer technology; develop a security strategy for crowd control and patient flow, parking, and triage; determine if decontamination facilities are needed; establish a personnel pool and strategy for human resources; build a critical care infrastructure with the ability to surge in capacity and response; and build an ICU disaster response plan: establish the multidisciplinary team; assess current ICU capabilities and outline contingency and crisis capacities; complete a hazard vulnerability analysis, ICU equipment and staff inventory; organize ICU management using space, staff, and stuff; ensure interface relationships (other departments); establish flow algorithm (triage, flow, transport, and admission in ICU vs non-ICU); communicate, train with drills, and evaluate; consider 4 phases of disaster response: plan/prepare, before disaster, during disaster, and recovery; and anticipate ethical issues and establish a plan for scarce resources.
SCCM,[21] 2013	Interactive videos, level V	Videos that augment information on managing disasters: "Augmenting Critical Care Capacity During a Disaster": Reviews care modification principles when disaster occurs; identifies essential interventions for emergency mass critical care; identifies a plan to increase staffing for emergency mass critical care; and discovers locations outside of ICUs most appropriate for delivery of emergency mass critical care. "Disaster Triage and Allocation of Scarce Resources": Describes triage goals, patient resource requirements; presents conflicting ethical principles that occur during mass casualty incidents; and evaluates current protocols for ethical triage of critical care resources during a disaster. "ICU Microcosm Within Disaster Medical Response": Details US preparedness and response system; reviews all-hazards preparedness; details communication strategies in disasters; and identifies the structure of the incident command structure.

Abbreviations: CDC, Centers for Disease Control and Prevention; COVID-19, coronavirus disease 2019; DPA, Defense Production Act; HCP, health care personnel; HEPA, high-efficiency particular air; ICU, intensive care unit; PACU, postanesthesia care unit; PPE, personal protective equipment; SCCM, Society of Critical Care Medicine.

[a] Evidence hierarchy from Johns Hopkins Nursing Evidence Based Practice Model,[5] levels I to V.

tertiary hospital and operates 2 facilities on campuses that are 8.8 miles apart. The hospital is a Joint Commission–certified Comprehensive Stroke Center and American College of Surgeons–accredited level II trauma center, serving approximately 645 000 people. The hospital had prepared to manage emergency situation needs through the traditional HICS.[20] The HICS was based on the incident command system, which assists hospitals with management planning and response and recovery capabilities for unplanned and planned disaster events.[20] Key members of the ELT, physicians, and staff had previously completed the Federal Emergency Management Agency Disaster Training Program. Disaster drills held before this pandemic had necessitated partial command center operations because of power failures, loss of water, and information technology outages. This prior command center use only touched the surface of the needs that a community hospital may encounter in a disaster.

On March 10, 2020, the ELT opened a modified HICS to manage key issues such as supplies and space. The incident commander, an operations section chief and a safety officer, per the HICS organizational structure (Table 3), deployed resources and kept key stakeholders informed of the plan to manage the pandemic. Within a few days of the arrival of patients infected with COVID-19, the hospital team realized the scope of the global disaster was beyond any prior disaster experience. A full HICS (Table 3) was needed to manage the escalation in cases. The command center structure was refined for long-term stability to support infrastructure, operations, finance, logistics, planning, and other key roles needed for structure and sustainment. The HICS made various decisions such as determining COVID-19 units and establishing cohorts of patients positive for COVID-19 and those who could be ruled out in a defined geographic location. The HICS halted elective surgeries, restricted

Table 2 Model for care of critically ill and injured patients during pandemics and disaster[a]

	Conventional: Expansion of resources by 20%	Contingency: Expansion of resources by 100%	Crisis: Expansion of resources by 200%
Space	Usual patient care and spaces maximized: 51 ICU beds Converted COVID-19 units: intermediate ICU and non-ICUs	ICU space expansion: 17 IICU beds; 20 PACU areas repurposed to ICU; 10 ICU beds at second campus Converted COVID-19 units: for ICUs, first intermediate ICU and second CICU; for non-ICUs, same-day care unit, surgical unit, and acute rehabilitation unit	Nontraditional areas used for critical care: DSU and cardiac telemetry unit (33 beds), IR hold room (6 beds), OR (50%, 6 beds) Converted COVID-19 units: for ICUs, third SICU; for non-ICUs, cardiac telemetry, medical unit, and PCSU
Staff	Additional staff called in as needed: physicians, nurses, and respiratory therapists	Staff extension (supervision of larger number of patients, changes in responsibilities): anesthesiologists, hospitalists, trauma physicians, and advance practice providers; PACU and IR nurses, as well as other nurses with previous ICU experience. Staffing model deployed 1 ICU nurse and 1 non-ICU nurse to 3 ICU patients Examine shared job responsibilities with nursing	Insufficient ICU trained staff available/unable to care for volume of patients: intensivists shared staffing model with nonintensivists. 2-tiered staffing model required and expanded scope: 1 ICU nurse and 3 non-ICU nurses to 6 ICU patients Shared staffing model
Supplies	Cached/on-hand supplies Respiratory equipment: ventilators, 40 Servo and 25 HHCOPD oxygen; intubation equipment adequate, 6 video laryngoscope and proning beds Material supplies: PPE adequate, cleaning wipes and equipment adequate Pharmacy supplies: adequate IV pumps and monitors: adequate	Conservation, adaptation, and substitution of supplies with selected reuse of supplies when safe Respiratory equipment: ventilators, 14 LTV 1100 and 10 BIPAP conversion to ventilators, and 20 HHCOPD oxygen; 2 video laryngoscope; manual proning (shortage of proning beds) Material supplies: PPE inadequate; shortage of gowns and masks; repurposing; modification in required use by the CDC; cleaning wipes shortage—alternative solutions used Pharmacy supplies: shortages of sedation, analgesics, NMB, antibiotics, bronchodilators, and antiviral agents; alternative medications added to formulary IV pumps and monitors: adequate	Critical supplies lacking, possible allocation/reallocation of lifesaving resources Respiratory equipment: ventilators, 23 LTV 1200 ventilators, and 15 anesthesia machines; call to surgery centers for anesthesia machines; rationing of ventilators Material supplies: inadequate/shortages; PPE inadequate; shortage reuse and rationing Pharmacy supplies: inadequate/shortages; rationing of medications IV pumps and monitors: inadequate/shortages; remove all IV catheters from pumps; use dial-a-flow devices to regulate drips
System strategies	Usual care: implement ICU guidelines/protocols (eg, ventilator/sedation protocols, proning in critically ill, PPE guidelines) Created disease-specific protocols for COVID-19: physician and nurse treatment guidelines	Minimal impact on usual patient care practices Expanded disease-specific protocols for COVID-19: altered PPE guidelines based on CDC changes during pandemic; cardiac arrest algorithms for emergency and in-house patients; PPE boxes/visual cards for cardiac arrest; transmission-based precaution guidelines for testing and discontinuing isolation; discharge checklist/guidelines; proning guidelines for non-ICU patients; new ketamine sedation protocol; updated protocols for NMB and sedation; and screening surgical/procedural patients Documentation remains in computer	Not consistent with usual standards of care Disease-specific protocols for COVID-19: triage and ethical guidelines for patients during the pandemic in the presence of scarce resources Implement altered staffing guidelines Documentation is limited and on paper

Abbreviations: BIPAP, bilevel, positive airway pressure; CDC, Centers for Disease Control and Prevention; CICU, cardiac intensive care unit; COVID-19, coronavirus disease 2019; DSU, designated step-down unit; HHCOPD, high-flow heated humidification; ICU, intensive care unit; IICU, interventional intensive care unit; IR, interventional radiology; IV, intravenous; NMB, neuromuscular blocker; OR, operating room; PACU, postanesthesia care unit; PCSU, progressive care stroke unit; PPE, personal protective equipment; SICU, surgical intensive care unit.

[a] This table represents how Mission Hospital planned and executed the 4 S's model, adapted from Hick et al,[4] Seda and Parrish,[16] and Farmer et al.[20]

Figure 1 Intensive care unit staffing models in contingency versus crisis modes.[4,13,16,20,21]

Abbreviations: ICU, intensive care unit; RN, registered nurse.

Table 3 Hospital incident command structure

Title	Defined role
Incident commander	Responsible for the organization of the Command Center and well as strategic direction for the hospital with input from the Command Center officers and section chiefs
Safety officer	Monitors safety of staff, patients, and visitors; oversees IP team
Liaison officer	Contact for external agencies; oversees case management and community benefit
Public information officer	Conduit for information for internal and external sources
Medical technical specialist	Manages leaders representing physicians, radiology, laboratory, legal/risk, medical staff, ICU, pediatric hospital
Operations section	Oversees the clinical branch (all clinical areas), medical care branch, casualty care, behavioral health, and patient registration
Security branch	Coordinates access control and traffic or crowd control, as needed, and law enforcement
Patient family assistance branch	Oversees social services, patient family connection unit
Planning chief	Oversees resources (personnel, facilities, and supply tracking leads), Situational Unit lead, Documentation Unit lead, and Demobilization Unit lead, business continuity
Situation Unit lead	Oversees patient notification process for COVID-19 results
Business continuity/demobilization	Responsible for developing a plan for resuming services in surgical and procedural areas
Logistics section lead	Oversees hazmat branch (mask recycling and environmental services workflow), IT/IS, service branch lead (employee health, labor pool, credentialing, caregiver/visitor screening)
Finance section lead	Oversees contracts, materials acquisition; major liaison to testing facilities

Abbreviations: COVID-19, coronavirus disease 2019; hazmat, hazardous material; ICU, intensive care unit; IP, infection prevention; IS, information systems; IT, information technology.

visitors to the hospitals, established a labor pool, provided daily updates to key stakeholders and all personnel via conference calls and written communication, and provided emergency support of all units by staffing the center 24-7.

Critical Care Response: Preparing and Dealing With the Tsunami

After the implementation of the HICS and the declaration of a code triage, the medical director of critical care and the critical care CNS met to establish a CCS task force to focus on the evidence obtained from the evidence-based practice review. The CCS task force comprised members of multiple disciplines (Table 4). In the beginning of the pandemic, the task force focused on ICU COVID-19 priorities. After the first week, the task force rapidly expanded its scope and purpose, adding other key leaders from multiple areas. Meetings were held 3 times per week for the first 4 weeks, then decreased to

Table 4 Critical care services task force for the COVID-19 pandemic

Initial membership: week 1	Expanded membership: week 2
All intensivists	All hospitalists on service
Hospitalist medical directors	Emergency services medical directors/nurse leaders
Infectious disease physicians	Trauma services medical director/nurse leader
Chief Medical Officer	Non-ICU COVID-19 nurse leaders
Chief Nursing Officer	Nutritional care dietitian
ICU nurse directors, managers, and CNSs	Director of Quality
Pharmacy director/manager	Nurse Epidemiology Director
Respiratory therapy lead	Children's Hospital nurse leader
	Palliative care physician/nurse

Abbreviations: CNS, clinical nurse specialist; COVID-19, coronavirus disease 2019; ICU, intensive care unit.

twice per week, then weekly by week 8. The *CHEST* consensus statement[4] and recommendations from other disaster models provided the framework for Mission Hospital's plan, described in Table 2.[4,13,16,20,21] The CNS and medical director of critical care created agendas, focusing each meeting on the 4 S's model.

Space. In early March 2020, the CCS team examined the hospital's ICU bed capacity. The total 51-bed capacity in 3 units had served both campuses well during previous high-census seasons in the conventional mode. Planning commenced for managing the ICU capacity at contingency and crisis levels. A multidisciplinary team toured the ICUs as well as the interventional intensive care unit (IICU), used as a procedural area since 2009. One of the main priorities in managing space and the surge of patients with infectious disease was isolating this population to a single geographic space where ICU-level and non-ICU–level care would be delivered. The team examined the IICU space and the adjacent non-ICU nursing units and decided to convert the procedural area into a functioning 16-bed ICU and admit all ICU patients under investigation for COVID-19 and/or patients positive for COVID-19 to this unit. All non-ICU patients were admitted to the 2 non-ICUs adjacent to the IICU; semiprivate rooms were converted to private rooms. Temporary isolation walls, negative-pressure rooms, and isolation anterooms were constructed to create individual AIIRs, as recommended by the CDC.[6]

Planning space for the contingency and crisis mode required the CCS team to identify the sequence of ICUs converting to COVID-19 units, followed by repurposing areas from procedural and/or non-ICUs into functional ICUs.[10,13,16] Within 2 weeks, the number of critically ill patients with COVID-19 exceeded the IICU capacity, and the 27-bed cardiac ICU was converted into a COVID-19 ICU. This change resulted in moving patients without COVID-19 to the surgical ICU. The postanesthesia care units were repurposed to serve as ICUs to increase available ICU beds. During the pandemic, the hospital remained in the contingency phase for space, avoiding the conversion of other non-ICU spaces (Table 2).

Staff. Assessment of staffing capabilities related to ICU providers focused on intensivists, nurses, and respiratory therapists. Because the hospital was adequately staffed in the conventional mode, team discussions at the CCS task force meetings focused on contingency and crisis modes. At each meeting, the CCS team reviewed staffing levels and needs. The intensivists had an adequate supply of staff to manage the conventional and contingency modes. Staffing nurses in the ICUs became an intense area of focus. As the ICU occupancy reached beyond 51 beds, contingency staffing was implemented. Nurses with ICU experience in the previous 2 years were shifted to the ICU resource pool. After 2 orientation shifts in the ICU and an assessment of skills, these nurses were scheduled to work in the ICU. Nurses with prior ICU experience (>2 years) underwent orientation shifts and focused education modules to retrain to work in the ICU.

Suggestions from non-ICU units, physicians, and nurses for early proning of non-ICU patients with COVID-19 were investigated by the CCS CNS, who found literature supporting early proning.

Looking ahead to the crisis mode, the chief nursing officer asked the CCS nurse leaders to formalize a model for ICU staffing if staffing ratios could not be maintained during the pandemic (state-mandated ratio was 1 ICU nurse to 1 or 2 ICU patients). On the basis of recommendations in the literature, the CCS CNS adapted the 2-tiered model into the staffing plan.[4,13,16,20,21] If patient

Table 5 ICU versus non-ICU nurse duties in contingency and crisis modes (1:3 staffing)

ICU patient care by nurses	ICU documentation in EMR	Non-ICU patient care by nurses	Non-ICU documentation in EMR
Go through safety checklist[a]	Initial assessment results	Go through safety checklist[a]	Safety checks
Perform initial physical assessment[a]	Pupillometry results	Perform physical assessment every 4 h after initial assessment	Ongoing assessment
Perform pupillometry	MOVEN assess mobility[a]	Measure Braden score/Morse Fall Scale score	Braden score/Morse Fall Scale score
MOVEN assess mobility[a]	CAM-ICU score	Measure vital signs (patient not receiving vasopressors)	Vital signs
Monitor delirium using the CAM-ICU	Vital signs (patient receiving vasopressors)	Provide meals/tube feeding	Meals
Measure vital signs (patient receiving vasopressors)	NIHSS/stroke parameters	Measure intake and output	Intake and output
Administer the NIHSS for stroke care	IV drips	Medications[a] and IV main catheter and antibiotics: Provide by mouth, feeding tube, or suppository Provide subcutaneous insulin Provide anticoagulants Set up PCA	Record in EMR medications given
Medications[a]: Titrate all IV drugs Administer IV push medications Assess RASS/BIS	All IV medications	Perform oral care (CHG)/brush	Oral care
Ventilator management and chest tubes: Suction ETT Move ETT side to side Perform oral care (CHG) Provide sedation vacation	RASS/BIS scores	Change dressings for catheters and wounds	Dressings/wounds
Manage arterial/hemodynamic catheters	Ventilator screenings	Monitor activity, provide mobility exercises,[a] and turn patient as needed	Activity/turning
Manage lumbar drains	Oral care/CHG	Provide sequential compression devices	Sequential compression devices
Assess acuity	Sedation vacation	Measure blood glucose using Accu-Chek meter	Blood glucose results
	Hemodynamic parameters and catheters	Provide CHG baths/patient handwashing	CHG baths/handwash
	Lumbar drains	Screen for sepsis	Sepsis screening results
	Acuity assessment	Assess lift team	Lift-team assessment
	Care plan and shift event	Educate patient	Education
		Apply restraints (if used)	Restraints (if used)

Abbreviations: BIS, bispectral index score; CAM-ICU, Confusion Assessment Method for the Intensive Care Unit; CHG, chlorhexidine; EMR, electronic medical record; ETT, endotracheal tube; ICU, intensive care unit; IV, intravenous; NIHSS, National Institutes of Health Stroke Scale; PCA, patient-controlled analgesia; RASS, Richmond Agitation-Sedation Scale.

[a] Shared duties of both ICU and non-ICU nurses.

capacity was greater than the number of available ICU nurses, 3 different levels of the 2-tiered model were adopted (Figure 1).[4,13,16,20,21] In the contingency mode, a 1:3 model (ie, 1 ICU nurse paired with 1 non-ICU nurse to care for 3 critically ill patients) would be implemented. In the crisis mode, either a 1:4 (ie, 1 ICU nurse paired with 2 non-ICU nurses to care for 4 critically ill patients) or 1:6 (ie, 1 ICU nurse paired with 3 non-ICU nurses to care for 6 critically ill patients) model would be implemented. A conceptual mapping was created to identify ICU nurse versus non-ICU nurse duties on the basis of competency (Tables 5 and 6).

Supplies (Stuff). Managing supplies has been challenging during the COVID-19 pandemic. Typical supplies, including respiratory equipment, medications, pumps and monitors, and materials (eg, PPE, cleaning wipes), were adequate in the conventional mode but

Table 6 ICU versus non-ICU nurse duties in crisis modes (1:4 or 1:6 staffing ratio)

ICU patient care by nurses	ICU documentation on paper	Non-ICU patient care by nurses	Non-ICU documentation on paper
Go through safety checklist[a]	Initial assessment	Go through safety checklist[a]	Safety checks
Perform physical assessment[a]	Pupillometry results	Perform physical assessment every 4 h after initial assessment	Ongoing assessment
Perform pupillometry	NIHSS/stroke parameters	Measure Morse Fall Scale score	Morse Fall Scale score
Administer the NIHSS for stroke care	IV drips	Measure Braden score, if skin/pressure issue	Braden score
Medications[a]: Titrate all IV drugs Administer IV push medications Assess RASS/BIS scores	Scan IV medications into EMR and administer to patient	Measure vital signs	Vital signs
Ventilator management and chest tubes: Suction ETT Move ETT side to side Manage hemodynamic catheters Collect blood sample from arterial catheter for laboratory analysis Assess FloTrac	RASS/BIS scores	Provide meals/tube feeding	Meals/tube feeding
Manage lumbar drains	Ventilator care	Measure intake and output	Intake and output
	Hemodynamic parameters and catheter care	Medications[a] and IV main catheter and antibiotics: By mouth/feeding tube/suppositories Provide subcutanous insulin Provide anticoagulants Set up PCA	Record IV-administered and other medications in EMR
	Lumbar drains	Perform oral care (CHG)/brush	Oral care
		Change dressings for catheters and wounds	Dressings/wounds
		Monitor activity, provide mobility exercises,[a] and turn patient as needed	Activity/turning/mobility
		Provide sequential compression devices	Sequential compression devices
		Measure blood glucose using Accu-Chek meter	Blood glucose results
		Provide CHG baths	CHG baths
		Educate patient	Education
		Apply restraints (if used)	Restraints (if used)

Abbreviations: BIS, bispectral index score; CHG, chlorhexidine; EMR, electronic medical record; ETT, endotracheal tube; ICU, intensive care unit; IV, intravenous; NIHSS, National Institutes of Health Stroke Scale; PCA, patient-controlled analgesia; RASS, Richmond Agitation-Sedation Scale.

[a] Shared duties of both ICU and non-ICU nurses.

quickly changed in the contingency mode (Table 2). The supply of respiratory equipment concerned the ICU team. A total of 45 heated, humidified, high-flow oxygen units supported patients before mechanical ventilation. The hospital's original 40 ventilators were adequate in the conventional mode. An additional 37 ventilators were provided by the county and state, and have been adequate during the pandemic. Ten bilevel positive airway pressure machines could have been converted to ventilators, if needed. Having intubation bags available allowed for rapid access to needed equipment. Medications were in short supply, requiring physicians to alter prescribed agents in all patients hospitalized in the ICU. Some days supplies of propofol, midazolam, fentanyl, and cisatracurium became depleted, necessitating conversions to other medications. Pumps and monitors for administering intravenous fluids and medications have been in adequate supply during the pandemic.

The biggest challenge was the shortage of PPE and germicidal cleansing wipes used to clean surfaces and equipment. As the entire world experienced a shortage of PPE, managing supplies became a priority for the entire organization. The reuse of N95 masks, face shields, and powered air-purifying respirators was mandatory in all

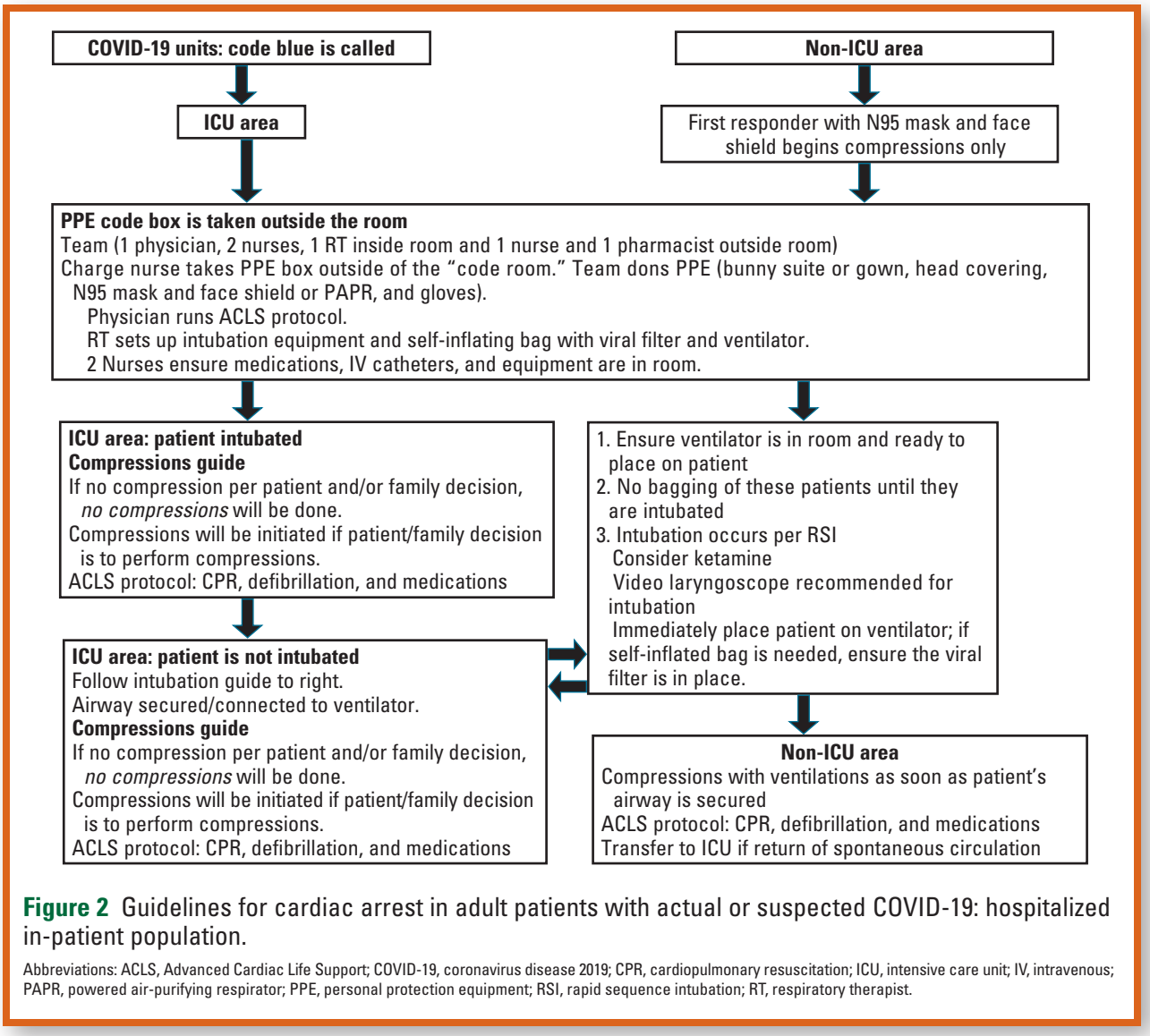

Figure 2 Guidelines for cardiac arrest in adult patients with actual or suspected COVID-19: hospitalized in-patient population.

Abbreviations: ACLS, Advanced Cardiac Life Support; COVID-19, coronavirus disease 2019; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; IV, intravenous; PAPR, powered air-purifying respirator; PPE, personal protection equipment; RSI, rapid sequence intubation; RT, respiratory therapist.

areas. Gowns and gloves were in short supply. Processes were developed by the Infection Prevention Department to manage the scarce supply of PPE, on the basis of CDC recommendations.[6] The lack of PPE has remained a significant challenge. The shortage of wipes led to the purchase of myriad products to clean equipment and the environment.

System Strategies. Treating patients daily in the ICU provided the CCS team with a strong foundation of critical care practice. Modifications to current practice were necessary to target specific COVID-19 interventions. A series of new guidelines and protocols was created, enabling a consistent approach among practitioners (Table 2). As an example, managing cardiac or respiratory arrest required specific alterations in bagging and compressions, because of the increased risk with aerosol-generating procedures associated with COVID-19.[22] Algorithms were created to guide the staff on code blue responses (Figures 2 and 3). Special PPE boxes were placed on every COVID-19 unit, which provided the team with immediate access to needed PPE. Laminated cards were created for use by the team inside the room to communicate needed supplies to practitioners outside the room.

The shortage of PPE had a major impact on delivering care in the ICU. Although the COVID-19 ICUs had constructed negative-pressure rooms and anterooms for donning and doffing PPE, infection control measures were a priority. Staff in the ICU were evaluated while donning

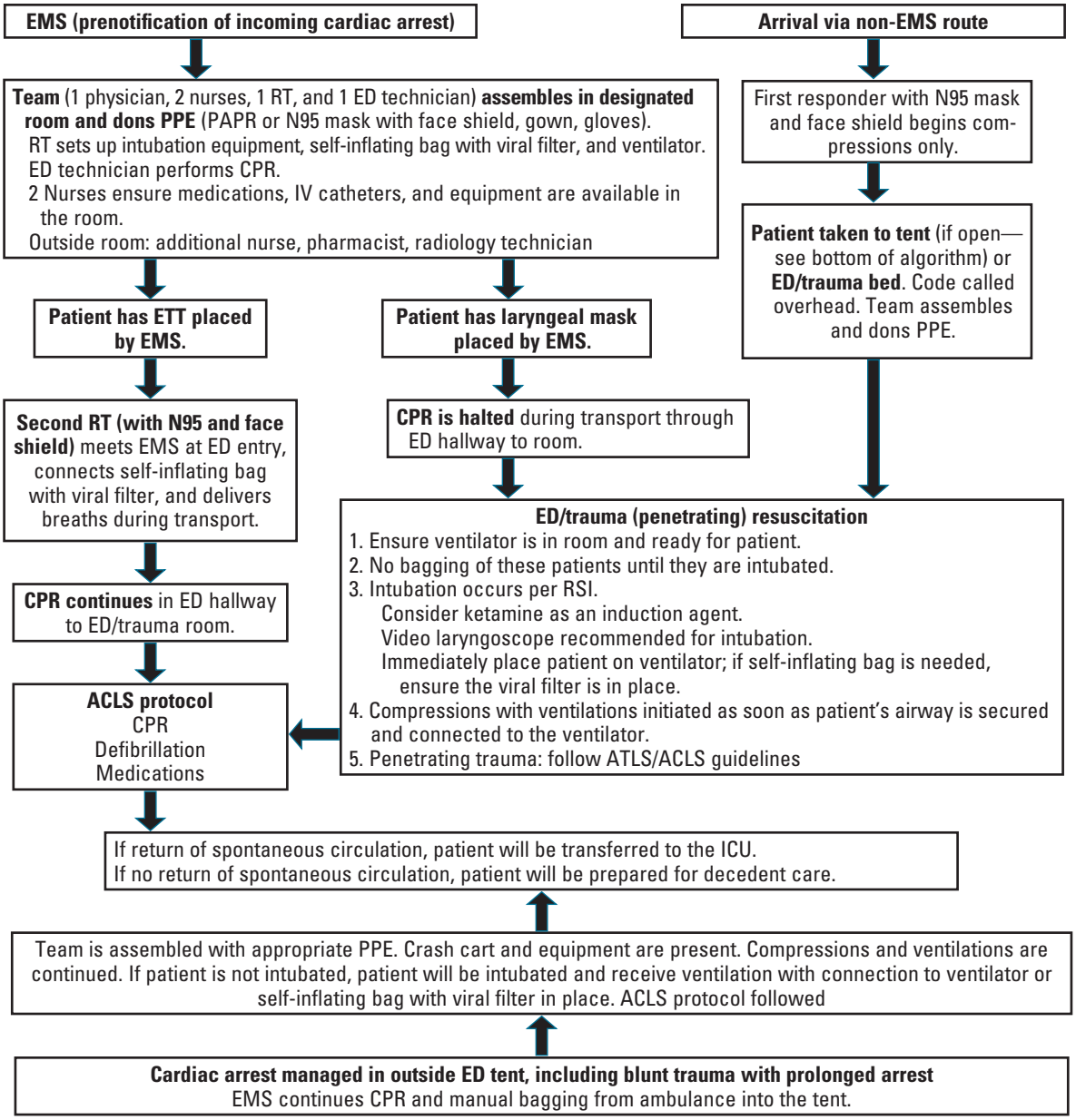

Figure 3 Guidelines for cardiac arrest in adult patients with actual or suspected COVID-19 in the emergency department.

Abbreviations: ACLS, Advanced Cardiac Life Support; ATLS, Advanced Trauma Life Support; COVID-19, coronavirus disease 2019; CPR, cardiopulmonary resuscitation; ED, emergency department; EMS, emergency medical services; ETT, endotracheal tube; ICU, intensive care unit; IV, intravenous; PAPR, powered, air-purifying respirator; PPE, personal protection equipment; RSI, rapid sequence intubation; RT, respiratory therapist.

and doffing PPE to ensure compliance with guidelines. Education and infection prevention teams educated staff 24-7 to reinforce proper techniques to minimize contamination and spread of the virus.

One of the biggest challenges in the first 4 weeks of the pandemic was testing for COVID-19. Whether it was a limited number of test swabs or the timing of the results, testing posed challenges and created delays in moving patients under suspicion out of COVID-19 areas to non-COVID-19 areas. During mid-April through early May, the situation eased when the hospital acquired a COVID-19 testing machine. This machine enabled in-hospital

COVID-19 testing instead of having to send swabs to an outside facility. Testing will remain an issue as the hospital begins to reopen the surgery and procedural areas. The limiting factor has continued to be the number of swabs and testing reagents available for use.

Cardiopulmonary treatment of patients with COVID-19 was comparable to managing critical hemodynamically unstable patients with adult respiratory distress syndrome (ARDS). Hemodynamic monitoring was required, and vasopressor support was initiated. Many patients not requiring mechanical ventilatory support received heated, humidified, high-flow oxygen with continual monitoring of pulse oximetry. Once the flow was greater than 50 L/min, the intensivists electively intubated the patients. Ventilator management and bundle adherence (head of bed at 30 °, oral care, suctioning, turning from side to side) were done. Even with standard care, the pulmonary status and ARDS worsened in many patients with COVID-19.

Proning critically ill patients with ARDS has been cited to improve the oxygenation-perfusion mismatch.[23] Pronation of patients receiving ventilatory support in the ICU resulted in improved gas exchange in the most critical of the patients with COVID-19. Although a proning procedure with a special bed had existed, the shortage of these specialty beds required manual proning guidelines for patients in the ICU to be developed. Nurses in non–COVID-19 ICUs conducted simulations to determine the minimum number of providers required to prone. With real-time education, the ICU nurses were able to manually prone with 4 personnel in the room managing the ventilator, intravenous and/or arterial catheters, and rotation. Suggestions from non-ICU units, physicians, and nurses for early proning of non-ICU patients with COVID-19 were investigated by the CCS CNS, who found literature supporting early proning.[24,25] A new proning protocol for non-ICU patients was developed from the evidence and included input from physical therapists on properly positioning an awake patent. The proning protocol was approved and nurses in the non-ICU COVID-19 unit were educated. When the non-ICU nurses' assessment revealed worsening oxygenation, they would contact the physician for orders to prone. Oxygenation was reassessment during the process by monitoring the pulse oximeter.

To continue to support patients with COVID-19 in the ICU setting, the translation and implementation of evidence-based care during pandemic-related surge capacity must be relied on in relation to space, staffing, supplies, and system strategies.

Pharmacological protocols were either created or updated to include alternative medications used during the pandemic. Physicians were encouraged to order alternatives to propofol and midazolam because these medications reached critical shortages. Expansion of sedation agents included using lorazepam or ketamine as alternatives. When the shortage of fentanyl reached critical levels, physicians were asked to change analgesics to others in more abundant supply, such as hydromorphone or morphine sulfate. Faced with the possibility of a crisis mode in which patients in the ICU required ventilatory support, pharmacological agents, or other interventions in limited supply, the ICU team collaborated with practitioners from the ethics and palliative care team to create the Ethical Guidelines Related to ICU Triage in Adult Patients During a Pandemic or Disaster Crisis Mode. These guidelines provided definitions of ethics-based considerations, identified criteria associated with an ICU crisis mode and assumptions of use, and provided physicians with key guidelines for ICU triage criteria while in ICU crisis mode. The guidelines were sent to the system legal and ethics groups for approval.

Evaluation: The Wave Subsides

As the team evaluated the deployment of the disaster plan, the HICS underwent a metamorphosis, adapting and reorganizing to meet the needs of the hospital services and personnel affected by a large pandemic. The ELT and HICS staff developed a more advanced management strategy with focused teams managing the issues. The ability of the facilities staff to convert rooms and entire units into negative-airflow spaces with anterooms for donning and doffing PPE enhanced the placement and management of patients. As units were converted into COVID-19 areas and traditional specialty ICUs were blended, creative staffing strategies allowed the team to match patient-care needs with the competency of nurses. At the peak of the surge in April 2020, ICU nurses were deployed to the ICU, where their unique skill and competency were needed. The team had the needed respiratory and general supplies except PPE, cleaning products, and some medications. The short supply of medications necessitated the development of alternative

sedation (eg, ketamine), analgesic, and neuromuscular blocker protocols. The team viewed their ability to rapidly adapt system strategies to patients with COVID-19 as a strength. The entire hospital and the ICU team working synergistically together allowed the organization to manage this disaster, and will help them do the same for future disasters.

Mission Hospital serves 645 000 people of the county's 3.22 million total population. In early May 2020, at the time of writing, the county's health department reported that a total 45 674 tests had been done and 2348 individuals had contracted COVID-19; there had been 52 deaths attributed to COVID-19 county-wide.[26] During the same time, 1154 patients were tested for COVID-19 at our hospital, 119 patients were confirmed positive for infection, and 37 required ICU care. Of those treated in the facility, only 1 patient died as a result of complications from COVID-19. By May 10, at the end of the 2 months, 7 patients positive for COVID-19 and 6 patients under investigation for COVID-19 remained hospitalized, while the county reported a total of 228 hospitalized in 26 hospitals. As the numbers decreased, the CCS task force developed a plan for de-escalation and consolidating ICU spaces opened in March 2020. Additionally, by May 10, the HICS command center was closed, and leaders worked virtually to manage any issues.

Sustainability

To continue to support patients with COVID-19 in the ICU setting, the translation and implementation of evidence-based care during pandemic-related surge capacity must be relied on in relation to space, staffing, supplies, and system strategies. The concept of space remains a top priority as hospitals de-escalate and potentially manage a new surge of COVID-19. Our organization designated a quarantined area to admit patients positive for COVID-19 and patients under investigation for infection. This area was in alignment with the recommendations to allocate a specific number of beds for an influx of patients who may require advanced therapies.[6,9] The hospital adapted space into AIIRs and areas to cordon off regions for caring for infected patients.

Staffing for the surge required the hospital to consider 2 possible trajectories: (1) an increased shortage of ICU nurses and thus the inability to provide an ICU level of care; or (2) a great influx of nursing into this specialty area by supplementing ICU nurses with non-ICU nurses in specific roles. To fill the gap of the nursing shortage during this pandemic, the institution introduced alternative staffing model phases to supplement existing ICU nursing staff (Figure 1). This model, with the division of roles between ICU and non-ICU staff, enhanced the flexibility of the organization to meet current and future ICU staffing needs.

Supplies have been bolstered since April 2020. Respiratory equipment has been determined to be adequate for contingency and crisis modes, after more mechanical ventilators were purchased. Pharmacological supplies of ICU medications commonly used with patients receiving mechanical ventilation have improved, but there is ongoing concern that new drug shortages will develop if another surge of the pandemic occurs. The organization created an interdisciplinary task force to address supply and demand of PPE. The Infection Prevention Department developed an internal tracking system for caregivers and units to reprocess N95 masks. Reprocessing has been done in-house with sterile processing. Increasing the supply of PPE for disaster use has become a top priority moving forward. The CCS task force has continued to meet monthly. System strategies for COVID-19 included updating disease management guidelines as new information has been published, refining infection control practices and testing, revising pharmacotherapy support as research studies revealed results from clinical trials, and revising hospital disaster-response systems in preparation for another wave of patients.

A multidisciplinary critical care team using an evidence-based framework for managing an infectious pandemic can optimize the hospital's response and management during the crisis.

The geographic disparities of the COVID-19 pandemic in the United States led to some areas of the country moving into the crisis mode of pandemic operations. Those institutions experienced significant capacity issues at the beginning of the COVID-19 pandemic that this hospital did not experience. Issues included exhausting all available ICU beds, staffing shortages in the crisis mode necessitating use of nurses or physicians from specialty procedural and perioperative areas, and sustaining a high mortality rate that overwhelmed existing morgue capacity. Hospital-based plans should address these potential issues before the next surge or new pandemic.

Conclusion

The CCS multidisciplinary task force used an evidence-based approach to assess and manage the COVID-19 pandemic in our hospital. Proactively addressing key pandemic strategies before the next surge or disaster will assist ICU teams to mitigate threats, build processes to manage the crisis, and optimize patient outcomes. CCN

Financial Disclosures
None reported.

See also

To learn more about caring for patients with COVID-19, read "COVID-19 Therapeutics: Making Sense of It All" by Bakare and Allen in *AACN Advanced Critical Care.* https://doi.org/ 10.4037/aacnacc2020792

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