Configuring ICUs in the COVID-19 Era
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Contents
Authors and Acknowledgements ........................................................................................................... 2
Introduction ............................................................................................................................................. 4
Clinical Management Strategy ............................................................................................................. 4
Overarching Principles of COVID-19 ICU Management ...................................................................... 5
Increasing ICU Capacity ....................................................................................................................... 5
Managing Expanded ICU Capacity ...................................................................................................... 10
Infusion Pumps ...................................................................................................................................... 12
Physiologic Monitoring ......................................................................................................................... 15
Respiratory Care ..................................................................................................................................... 16
Pharmacy and Medication Management .............................................................................................. 19
Room Environment .............................................................................................................................. 23
Patient Communication ........................................................................................................................ 25
Emotional Support for Staff .................................................................................................................. 26
Ramping Up Hospital Operations While Maintaining or Ramping Down Expanded ICU Capacity .......... 26
Moving Forward ....................................................................................................................................... 27
References ............................................................................................................................................... 29
Additional Resources ............................................................................................................................ 32
Contributing Medical Centers .............................................................................................................. 34
Introduction
The continually changing landscape of the novel coronavirus 2019 (COVID-19) pandemic makes it clear that hospitals and healthcare professionals can no longer rely on their previous approaches to managing their intensive care units (ICUs). The rapid escalation and need for ICU bed capacity, new staffing models incorporating additional staffing, and delivery of acute respiratory support, all in the setting of a highly contagious pathogen with rapidly evolving—and sometimes contradictory—pathophysiologic and therapeutic understandings is quite challenging. The interplay of these domains has been already introduced in the Society of Critical Care Medicine’s (SCCM) article “United States Resource Availability for COVID-19.” To ensure that the best possible care is delivered to critically ill or injured patients while reducing the risk to healthcare workers (HCWs), hospitals and clinicians must be nimble and able to quickly adjust all aspects of their care models.2,3

In response to ongoing requests for a body of knowledge from which to draw, SCCM created this living document to provide insight into configuring ICUs in the COVID-19 era. While this guidance has evolved during the COVID-19 pandemic, it is also intended to be relevant for other large-scale infectious disease crises. This document is based on a collection of experiences from 16 hospitals and their clinicians and other staff members (physicians, nurses, advanced practice providers [APPs], pharmacists, respiratory therapists, biomedical engineers, and environmental staff) who provide frontline COVID-19 care. We have also integrated information from current reports that deal with these issues. It is SCCM’s intent to regularly update this document as informed by lessons learned during COVID-19 patient care.

This document addresses rapidly creating and staffing new ICUs; developing new processes of care, such as moving monitoring and medication delivery outside the patient’s room to minimize HCW exposure by limiting room entry; rethinking the delivery of respiratory care, pharmacy, and medication management; and emplacing new processes to protect staff from aerosolized virus contact.

Clinical Management Strategy
Recommendations for guiding COVID-19 patient care are offered rapidly and frequently, and earlier reports may be contradicted by later ones as guidance shifts in response to clinical experiences or trial outcomes. It is therefore highly recommended that each hospital develop its own principles and protocols for COVID-19 patient care. This approach is enabled by appointing a critical care leader responsible for coordinating clinical care through the creation of small and agile multidisciplinary workgroups to address specific issues that have continuously evolved (e.g., anticoagulation, renal support, ventilator management, pharmacy response, supply and capital equipment management). The workgroups may initially—or continually—meet several times a week to revise protocols and best practices based on experiences, new reports, and emerging research data. The output of these workgroups will need to be coordinated with inpatient care and the hospital's command structure.
Overarching Principles of COVID-19 ICU Management

The ICU team must determine how to minimize entry into ICU rooms for all HCWs to decrease their risk of viral load exposure while still providing excellent patient care that to date requires staff at the bedside. This is a challenging goal because of competing priorities exemplified by staff safety versus patient care. Nonetheless, a variety of tasks and activities that typically occur inside the patient’s room can be shifted outside the room. However, some tasks and activities must still be performed at the bedside. In performing these tasks, all appropriate safety precautions must be taken to ensure HCW safety.

Increasing ICU Capacity

Hospitals that are inundated with COVID-19 patients have been forced to expand their ICU capacity and care delivery capabilities.4 Hospitals that are not in hot spots should plan to do so in the event COVID-19 cases spike in their area.

Converting ICUs to COVID-19 ICUs. The first step most hospitals take to acutely increase ICU bed numbers is to convert many existing nonmedical ICUs into COVID-19 ICUs. This change reflects the acute decrease in surgical case volume that follows in the wake of rescheduling elective surgical procedures. Some surgical ICU capacity will need to remain to care for patients with urgent or emergent surgical conditions such as injury, intestinal obstruction, or acute limb-threatening ischemia. Thus, unique specialty ICUs, and even pediatric ICUs, may become COVID-19 ICUs. As ICU space is taken over by COVID-19 patients, a hospital might consider designating a clean ICU for non-COVID-19 patients. This practice is known as cohorting and may be critical in maintaining isolation practice efficacy.

The typical ICU already has the supportive infrastructure for care of critically ill patients inclusive of several airborne infection isolation rooms (AIIRs) or negative-pressure rooms. However, negative pressure, necessary to protect staff both inside and outside the patient room in the setting of an aerosolized infection such as COVID-19, may not be available in all ICU rooms. Several steps will be required to move the ICU forward. The first is enabling negative pressure in each patient room. We have learned that patient rooms—or entire ICUs—may be converted to negative pressure with minimal work, depending on the capability of the heating, ventilation, and air conditioning system and the need for concomitant air conditioning.5 If this option is not available, then pressure should be at least neutral, with high-efficiency particulate air (HEPA) purifiers placed in each room. The hospital facilities teams must be engaged to address this process early on. Additionally, infusion pumps, control and view of physiologic monitors, and alarm management are shifted outside the room. Computer workstations on wheels are also added outside the room if there are no computers outside the room. One last point: Although ICUs typically have one patient per room, some hospitals have placed two patients in each ICU room to increase bed capacity.

Converting non-ICUs to COVID-19 ICUs. Hospitals may initiate a second step that includes the conversion of step-down units or regular acute care in patient wards into novel or pop-up ICUs. These areas may be able to support ICU care because the core infrastructure (i.e., gas access, power, and possibly physiologic monitors, as in a step-down unit) of an ICU room is already in place. The patient rooms should be converted to negative pressure or have HEPA purifiers installed. Another issue to be addressed is the use of patient double-occupancy rooms.
Hospitals need to decide whether to maintain single-patient occupancy across all rooms or to cohort two patients of similar COVID-19 status in double-occupancy rooms, space permitting.

At a minimum, there should be direct line of sight to patients from outside the room (Figure 1). This may require installing windows if the doors are solid. Indirect monitoring will require the installation of webcams. Physiologic monitors need to be placed in each patient room as well as mechanical ventilators as required. Computers should be in all rooms for electronic medical record (EMR) use. Device integrators will help merge data generated by the various medical devices into the EMR.

Figure 1. Nursing workstation directly outside a patient room in the corridor of a pop-up or novel ICU. A window was placed into a solid wood door to provide direct patient visibility (A). Webcams (not shown) were also installed in the rooms. To the right of the door is the IV pole with infusion pumps (B), and IV tubing (C) snakes under the door to the patient. A power strip on the wall (D) provides electricity for all devices. An iPad displays a mirror view of the physiologic monitor and is attached to the wall (E). The nurse sits at a computer workstation on wheels (F). A bar code scanner is also on the computer cart (G). PPE hangs in bags on the computer cart (H) and to the left of the door (I). (Courtesy of © MSKCC, 2020, Memorial Sloan Kettering Cancer Center, New York, New York)

To decrease nursing exposure to the room, nursing stations, if they do not already exist, should be set up outside each room. These stations will need electrical power, chairs, computer workstations on wheels, an informatics solution to locally display the physiologic monitor data so it is readily visible, infusion pumps, whiteboard, and hand sanitizer dispensers, either wall mounted or on temporary stands. Alarm transmission for monitors and ventilators will also need
to be addressed. Procedure carts for airway management, bronchoscopy, and catheter insertion should be created and labeled for each novel unit. Depending on the prior level of pharmacy infrastructure, keycard- or password-protected medication dispensers may also be required.

Converting operating rooms (ORs) into COVID-19 ICU rooms. ORs have the requisite physiologic monitor and ventilator (i.e., anesthesia machine) and space and therefore lend themselves to ICU conversion.\textsuperscript{6,8} The OR bed will need to be replaced with a hospital or ICU bed, and computer workstations on wheels may need to be inserted into the OR. ORs also often have highly purified air and, commonly, negative pressure can be activated in individual rooms. If negative pressure is not possible, HEPA filtration should be installed. Designed as self-enclosed spaces to care for one patient at a time, ORs may be quite large; some hospitals, because of extreme need, have cohorted multiple patients within single OR rooms—a paradigm shift from traditional OR and ICU care of one patient per room. In this multipatient and possibly crowded scenario, additional oxygen, suction, and electrical capabilities will need to be added to accommodate the extra patients. Moreover, extreme diligence is required to identify each patient (e.g., whiteboards) and associate their medical needs, devices, and medications with them to minimize the possibility of errors. Privacy screens should be available for patients who are extubated to prevent anxiety in this disconcerting environment.

In the novel OR-ICUs, webcams may need to be installed to visualize the patient outside the room. Depending on the OR corridors, it may or may not be practical to create local nursing stations outside each OR room, especially if multiple patients are in the OR. Thus, minimizing nursing entry into the room may not be feasible, and almost all aspects of care will have to be delivered within the individual OR room. This circumstance may mandate that OR caregivers remain in the OR space for long periods of time with layered gowns, so that the top layer can be shed after examining and caring for each patient in order to avoid cross-contamination. Heat mitigation is a serious concern with gown layering. Typically, several ORs are connected by a sterile core where the scrub sinks and surgical supplies are stored. This core can be turned into a nursing station with central monitoring and whiteboards (or electronic boards) to identify each ICU patient with their medication infusions and ventilator settings. This space also can be used for storage of supplies and medications.

Hospitals with large numbers of critically ill COVID-19 patients have also used cardiac catherization or other similarly equipped procedural suites as COVID-19 ICUs. The discussion above regarding ORs applies.

Converting postanesthesia care units (PACUs) into ICUs. Most PACUs are open spaces with a few single-occupancy or isolation rooms. Each PACU bed location has all the requisite infrastructure to care for a critically ill patient. Some hospitals used PACU space for COVID-19-negative patients because PACUs are predominantly open spaces and are not usually designed to achieve negative pressure either in the open spaces or within individual rooms. However, some hospitals prepared the PACU for COVID-19-positive patients by installing negative pressure or HEPA filtration systems in the area of the PACU beds. Two approaches were observed. In the first, transparent enclosures were built around groups of PACU beds to maintain the negative pressure. In the second, core nursing and other staff areas were enclosed with transparent acrylic glass with neutral or positive pressure, and the bed areas themselves were not enclosed. In the latter scenario, staff can monitor the patients continuously without wearing full personal protective equipment (PPE). Curtains, usually between patient beds in open PACUs, provide privacy for patients.
Converting open spaces into COVID-19 ICUs. Constructing novel or pop-up ICUs within a large empty “shell” space offers the opportunity to use imagination to design and build ICUs that are needed (possibly taking advantage of federal waivers) rather than adjusting or retrofitting existing ICUs, wards, or ORs. For expediency, this type of shell ICU may be constructed without standard architect drawings and may use the open space’s existing walls and ceiling (similar to converting an OR into an ICU but on a larger scale). Alternatively, one or more ICUs may be constructed de novo as modular self-enclosed environments within the open space (Figures 2 and 3).

**Figure 2.** One of three negative pressure, shell space ICUs constructed from scratch over two weeks in an empty auditorium. Each ICU can handle approximately 20 patients. All patient beds are positioned with their heads toward the outer walls. Monitoring cables, ventilator circuits, and IV infusion tubing pass through conduits to nursing stations located directly on the other side of the lateral walls and equipped with physiological monitors, mechanical ventilators, and infusion pumps. (*Courtesy of Holy Name Medical Center, Teaneck, New Jersey*).

To meet standard ICU and specialized COVID-19 needs, the design must incorporate the complete ICU supportive infrastructure (i.e., power, gases, wired and wireless communication, data ports, temperature control, water, and drainage), as well as negative pressure and/or HEPA filtration. The design must include spaces for corridors, staff work, central oversight, donning and doffing, pharmacy, logistics, and restrooms. Patient beds must be situated in a logical manner (whether many beds in an open space or as single-patient rooms) to both allow for patient care and minimize staff exposure. **Figure 3** shows an example of a nursing station built in a shell space. As in the OR or when ICU patients are doubled up in one bed space, the hospital must assign patient locations within the hospital’s admission, discharge, and transfer system or registration and billing systems to allow for proper patient assignments and designations in the EMR.
Figure 3. A nursing workstation is situated immediately outside the self-enclosed shell space ICU. Patient beds are placed along the perimeter of the unit with the head of the bed abutting the outside walls. The base (A) of the wall houses the ICU infrastructure (i.e., power, gases, suction, data port) at the head of the bed both inside (not shown) and outside (B). There is a bidirectional pass-through conduit (C) for monitoring leads, ventilator circuits, and infusion pump tubing; there is also a flip-up door in the acrylic glass (not shown) to pass medical items in and out of the ICU. The top portion of the wall (D) is transparent acrylic glass, permitting direct patient visibility. The external nursing station includes infusion pumps (E), mechanical ventilator (F), physiologic monitor (G), and computer workstation on wheels (not shown). A mirror mounted over the patient's bed (not shown) helps the nurse view the patient's face. (Courtesy of Holy Name Medical Center, Teaneck, New Jersey).

An alternative approach to fully constructing an ICU in an empty space or on outdoor grounds next to a hospital, is to install prefabricated ICU patient rooms in these areas. Prefabricated ICU rooms are available as custom-built modules (Figure 4) or as renovated shipping containers. Either type requires that the ICU rooms be “knitted” together with prefabricated shared spaces and corridors to establish complete ICUs. Prefabricated ICU rooms usually have built-in AIIR systems and may be purchased with other infrastructure systems (e.g., electricity and water management) to be fully self-sufficient. Commonly, however, these ICUs are connected to the hospital’s supportive services. In contrast, military-type hospitals or ICUs may have their own complete infrastructure.
Optimal conversion of non-ICU space to ICU space. Our comments above regarding the optimal conversion of non-ICU space to ICU space include several key elements to protect staff and maximize patient care. The first is that negative pressure or HEPA filtration will be applied in the novel ICU patient rooms, thereby providing a layer of protection for staff both inside and outside the room. The second is that staff can both directly and indirectly observe each patient. The third is that nursing stations will be erected outside each room, if possible, to minimize staff exposure within the room. The fourth, as will be discussed in detail below, includes the transmission of data and alarms outside the patient room. Without implementing these core measures, the bedside area may not be safe for staff or the patient and would necessitate continuous monitoring of the patient by staff remaining in the patient room in full PPE for many hours or frequently going in and out of the room; this at a time when PPE may be in short supply. While costly and challenging, creating a novel ICU means creating similar functionality to a standard ICU regardless of the original utilization of the space.

Managing Expanded ICU Capacity

ICU bed triage. ICU bed triage before the pandemic was commonly managed using local ICU resources (e.g., ICU charge nurse, intensivist, ICU medical director), a centralized critical care bed management system, or a hospital-based patient flow or admission center. Other triage structures may exist as well. As ICU spaces rapidly expanded, the need for an increasingly centralized hospital-supported approach to space designation, resource distribution, and patient
allocation arose. Given the diversity of hospitals and their novel ICU spaces, as well as their patient load, centralized model configuration is anticipated to be diverse and to reflect local dynamics, including staffing models.

In hospitals with only a few ICUs (traditional plus novel), establishing a single 24/7 triage clinician position supported by an ICU dashboard, local ICU leaders, and the hospital’s patient flow center may be enough to manage and balance patient allocation among ICUs. In contrast, a tertiary or quaternary medical center that serves as the hub of a healthcare network would require a different type of 24/7 command structure even if a critical care triage center existed before the pandemic-driven expansion of ICU beds. For example, a major medical center may have had 15% to 20% of hospital beds designated as ICU beds and housed 8 to 10 adult and pediatric ICUs before COVID-19. In a pandemic, ICU bed capacity may more than double, placing beds in locations that no longer conform to pre-pandemic naming and location conventions. Similar bed naming and location issues will have occurred in smaller facilities as well. Without a global ICU command center overseeing critical care activities across the hospital or network, it would be impossible to safely manage the flow of incoming critically ill patients from the emergency department, decompensating patients on wards, and transfers from the emergency departments and ICUs of affiliated network facilities as well as unaffiliated hospitals.

A network ICU command center manages patient flow with the primary goal of matching patient needs with available ICU resources, including space, staff, staff skill sets, and clinical devices and resources. This matching process is complicated, as critical care clinicians or redeployed non-critical care clinicians ICUs may be managing and delivering care, and each area may offer divergent clinical resources, especially the pop-up ICUs. The command center houses critical care resources in a dedicated logistics space, directing resource allocation (e.g., managing both the inventory and distribution of mechanical ventilators and high-flow oxygen systems) and personnel deployment (e.g., rapid response and acute point-of-care ultrasound teams) to the patient. Similarly, the center shifts patients toward resources (e.g., transferring a patient to an ICU that has extracorporeal membrane oxygenation capability from one that does not).

One way of helping the network command center view the breadth of spaces, patients, and resources is to use tele-critical care technology as a tracking and management tool. In this way, center staff can monitor all ICU patients using an array of data streams (EMR, bedside physiology, ventilator, alarm, laboratory, and radiology) to render informed decisions. Moreover, the center should also enable a critical care hotline for the local novel ICUs as well as satellite hospital ICUs to link clinicians across sites. The hotline signals a willingness to field questions from throughout the system and may be key to establishing a sense of confidence for non-ICU clinicians. Finally, the center, working in combination with investigative teams and the pharmacy, could also serve as a clearinghouse for entry of patients into clinical trials and to receive experimental medications.

**Governance.** Existing ICUs have local governance that includes ICU directors and nurse leaders or managers. Similar management structures will be required for novel ICUs. Since ICU governance requires leaders to interface with a vast number of departments and services within the hospital, it is perhaps easiest to extend the responsibilities of current ICU directors and nurse managers. In facilities that establish many novel ICUs, utilizing existing ICU leaders will readily exceed their capacities. Therefore, introducing new individuals to ICU leadership roles in the novel ICUs will become a necessity. Ideally, new ICU leaders should also provide care in the ICUs they direct, visibly tying them to the location, staff, resources, and patients. The novel
ICU leaders must learn and manage staffing and scheduling, as well as coordinating education, privileging, technology influx, pharmacy services, and respiratory support, to support staff and promote safe, effective, and quality care. New leaders will find that there are a variety of other daily tasks that will compete for their time at the bedside or in administration. Therefore, new leaders will benefit from having regular and structured guidance from existing leaders to provide support, assess effectiveness, and ensure that the new leaders are not overwhelmed.

**Staffing:** The staff of novel ICUs may include a mixture of existing staff already working in the converted space as well as redeployed hospital staff (physicians, APPs, nurses, and pharmacists) from areas that have decreased their day-to-day functions (e.g., ORs, perioperative care, PACUs, clinics) or from outside the hospital. Non-ICU staff are also supported through the redeployment of ICU staff to novel ICU spaces. An educational program addressing critical care for the non-ICU clinician must be developed and actualized. Privileging must also be expanded for staff to perform tasks they do not typically perform (e.g., inserting arterial catheters, titrating continuous infusions, and ventilator management), ideally with supervision of ICU-experienced or procedurally experienced clinicians. The novel ICU staff may be unfamiliar with specific hospital protocols, emergency procedures, or leadership and will need an efficient orientation approach.

The **tiered staffing strategy** described in the SCCM article “United States Resource Availability for COVID-19” is an ideal method of engaging and merging ICU skilled and relevant staff and non-ICU staff.¹ This strategy has been adopted during COVID-19 and adjusted as locally applicable.⁹,¹⁰ The tiered strategy sets up pyramids, with the most experienced critical care clinicians at the apex of the triangle of care or, depending on the number of available intensivists, across several care pyramids. These physicians do not usually have direct patient care responsibilities, but instead supervise and support care rendered by groups of redeployed non-critical care physicians who are assigned to lead and participate in teams caring for defined groups of ICU patients. ICU nurses, for example, may also be teamed with nurses who do not typically work in the ICU. The ICU nurses may also have no direct care responsibilities; instead, through their experience and presence, they supervise and provide support to the non-ICU-experienced nursing staff. This continues with each group of clinicians including APPs, respiratory therapists, pharmacists, and the rest of the new ICU team. Similarly, redeployed staff may also be inserted into existing ICU teams to backfill for ICU staff sent to the novel ICUs.

One of the greatest challenges of maintaining staff satisfaction in both the existing and novel ICUs is creating a scheduling system that is embraced as fair by all parties. This is difficult even when there is no pandemic; challenges in achieving scheduling equity are significantly amplified by the unique stressors driven by COVID-19 care. Thus, ICU and novel ICU leadership must be attuned to the emotional and physical stresses clearly or subtly expressed by their staff members. This is another important reason that new ICU leaders are ideally geographically fixed in the ICUs they have newly come to lead.

**Infusion Pumps**

The first step to minimizing bedside nursing exposures requires the shifting of infusion pumps from inside to outside the patient room (Figure 5).¹¹-¹³

*Physical setup.* Infusion pumps are usually mounted on rolling stands, facilitating relocation. If no outlets are readily available, hospital-grade, special-purpose relocatable power strips can be
installed to provide power to pumps outside the rooms. Tubing may be passed under the doors; in some hospitals, conduits were inserted through the walls to create a safe passage for IV tubing and electrical power. Whatever the arrangement, the tubing will need to be secured to maintain the most direct route to the patient and to minimize the chances of unintentional interference. The placement of IV infusion pumps outside the patient room may not be practical when patients are in a very large ward or in ORs because of the extreme length of tubing required to reach from the pump outside the room to the patient. Similarly, if multiple patients are in each room, there may not be enough space outside each room to accommodate all the pumps, and there is likely to be difficulty associating each pump and channel with the correct patient.

Figure 5. IV infusion pumps outside ICU room. Multiple infusion pumps are mounted on an IV pole (A) outside the patient room in a traditional ICU. The extension tubing snakes under the sliding doors from the outside (B) to the inside (C). Power strip and cords (D) cross on the floor. A remote control for the physiologic monitor (E) hangs on the right side of the lower pumps. Note the writing on the glass doors: “GOOD JOB” and “WE ♥️ U” messages on the left (F) and ventilator settings on the right (G). There is a nursing station to the left (H) and a nurse server (bidirectional cabinet with doors outside and inside the room) (I) on the right. An electronic display is attached to the nurse server (J). (Courtesy of © MSKCC, 2020, Memorial Sloan Kettering Cancer Center, New York, New York)

Pump function. The use of extension tubing will increase the downstream resistance within the tubing, which will in turn impact the accuracy of the infusion rate. Therefore, it is important to minimize the use of extension sets as much as possible and eliminate any environmental
factors, such as extraneous loops of tubing, that could add to this resistance. It is expected that with a higher downstream resistance, alarms associated with occlusion pressure will be activated. However, occlusion pressure alarms may be delayed due to the increased time associated with the pressure buildup within the extended tubing. Some infusion pumps have specialized displays that show the pressure in the line in real time. A focus on monitoring this pressure may be necessary, depending on the quantity of occlusion alarms that are received. It is also possible, for certain infusion pumps, to manually adjust the occlusion pressure alarm threshold. It is advisable to consult with the infusion pump vendor to determine the safest and most efficacious approach.

**Clinical considerations.** Placing the pumps outside the rooms allows the nurses to titrate continuous infusions and administer IV push and intermittent IV piggyback medications without entering the room. When possible, bolus doses are administered via the pump from a continuous infusion bag rather than via IV push at the bedside. Extra flush volume will be needed for the medication to reach the patient if rapid delivery and effect are desired. Also, it might be necessary to place a larger-gauge IV access catheter to decrease downstream resistance, especially when using a singular IV line for multiple infusions.

### Outside-the-Room Infusion Pump Tips

- Label each IV line inside and outside the room with different colors for each unique line.
- Secure tubing and electrical cords to floor (e.g., use tape or floor wire track for protection and to prevent tripping).
- Use hospital-grade special-purpose relocatable power strips if outlets are not available right outside the room.
- Suspend IV tubing inside the room to prevent damage from radiograph machines or ultrasound machines running over tubing.
- Extra precaution is necessary to avoid accidentally dislodging tubing from the patient’s IV access or concomitantly dislodging the IV access.

Despite the obvious benefits of pumps outside the room, some concerns have been raised. The first focuses on inadvertently dislodging catheters from patients when the tubing is tripped over or pulled on by accident. Tubing must be well secured, and close observation is required to maintain the integrity and organization of the tubing, especially if tubing from multiple pump channels and pumps is being used.\(^\text{13}\) The second focuses on infection prevention and diligence to avoid increased central line-associated bloodstream infection (CLABSI) rates due to changes in workflow and potential colonization of tubing from outside the room. The third addresses alarm recognition. When nurses are in the room, they may not hear a pump alarm because the pump is outside the room. This is especially true when the nurse is wearing a powered air-purifying respirator (PAPR) or when a HEPA filter device in the patient room is generating noise. Therefore, each ICU must put a system in place (e.g., other nursing personnel outside the room) to aid in pump alarm surveillance.

An alternative to moving the infusion pumps is to use wired or wireless remote control of the increasingly prevalent smart pumps as they remain at the bedside. However, we are not aware of any commercially available solutions to remotely manage smart pumps. Furthermore, even if
such a control system were available, the nurse would still need to enter the room to load medications for infusion, perhaps rendering this approach less robust than desired.

**Physiologic Monitoring**

Physiologic monitoring is a core element of critical care. Since data from physiologic monitors often drive management of therapeutic agents such as vasopressors or inotropes, data flow from these monitors must be ensured with fidelity when relocating nurses and pumps outside the patient room.

*Visualizing and interacting with the physiologic monitor.* As with infusion pumps, some aspects of physiologic monitoring can be performed without entry into the patient’s room. The key elements include visualization of the monitoring display outside the patient room as well as indirectly controlling the monitor.

In ICUs with large glass doors, the physiological display may be easily visible from outside the room. Alternatively, if the monitor display cannot be visualized, especially in novel ICUs, some have moved the monitor display outside the room. This technique has a drawback in that the bedside team may not be able to see physiologic data when caring for the patient inside the room. A more sophisticated approach relies on electronically mirroring the bedside display through the use of vendor-based mirror image displays or vendor agnostic web-based systems that allow viewing of monitoring data on personal computers or tablets. Some have also used webcams installed in the patient rooms of the ICU or novel ICU to remotely view the monitor. Viewing of monitoring data can be supplemented by the use of a tele-critical care suite if the ICU is so equipped.

Remote management of the physiological monitor is facilitated by a remote controller, if available. These devices are attached by an extended cable to the monitor in the room and allow the nurse to remotely perform the full range of monitoring functions without entering the room, including obtaining on-demand blood pressure, adjusting alarm settings, responding to alarms, and securing a 12-lead ECG.

*Alarms.* Physiologic monitors are equipped with software to program alarm profiles (e.g., age, weight, acuity). As monitors are placed into novel ICUs, alarm profiles may need to be adjusted to meet the specific ICU need. Successfully transmitting alarms outside the room is critical in this environment because the nurses are primarily located outside the patient room. Moreover, some COVID-19-related therapeutic agents may prolong the QTc interval and frequently trigger the QTc alarm if it is enabled. Nurses are accustomed to hearing alarms directly from the bedside physiologic monitor, at a central station, or through third-party transmission (e.g., nurse call or alarm middleware) to overhead systems, alarm boards, or handheld devices. If bedside alarms are not audible outside the room, one solution is the enabling of audio settings on webcams, if present in the patient room. Installing additional central station monitors might be necessary if staff cannot hear the alarms because of the physical layout of the floor. Some have experimented with placing a baby monitor in the room that relays the alarm to a receiver outside. This solution is inexpensive and easy to implement but is not thought to be valuable because the receivers may not be loud enough to be heard and the alarms may all sound the same if multiple baby monitors are located adjacent to one another. Regardless of the approach adopted, it is imperative that the nurses outside the room be notified of alarms.
Respiratory Care

To minimize exposure of respiratory therapists, nurses, and other clinicians to COVID-19 contagion, it is important to decrease aerosol generation and adjust respiratory care practices to minimize clinicians’ entry into patient rooms. Accomplishing these goals primarily requires adjusting oxygen delivery systems, mechanical ventilation protocols, and medication delivery approaches. The very large number of patients who require both noninvasive and invasive support has necessitated the use of a large number of mechanical ventilators. A certain percentage of these may come from existing, but infrequently used, hospital inventory or from the national stockpile. However, the influx and variety of ventilators and their associated supplies can be challenging to staff who are mostly familiar with their commonly used devices. Therefore, respiratory therapy departments should provide education to ensure competency. A cheat sheet comparing ventilator terminology can help users synchronize their understanding of the various settings and data across multiple devices. Further, education sessions featuring images and videos of new devices and their operation should be provided to clinical staff when new devices are introduced. Multiple free teaching programs are available online. Anesthesia machines may also be used to expand ventilator capacity not only in the OR-ICUs but also in ICUs, PACUs, and other novel ICU spaces. It is critical that anesthesia staff expert in managing these devices oversee their operations as respiratory therapists have no experience with them.

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<th>Mechanical Ventilation: Teaching Tools</th>
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Managing ventilator circuits and medications. Before COVID-19, the common respiratory therapy practice was to use active humidity (auto-fed water-based humidification chamber and heated wire in-circuit tubing) for ventilator circuits. Nebulized medications were administered within the ventilator circuit via an in-line gas-driven nebulizer or preferably via an electrically powered, vibrating mesh nebulizer that enhances medication delivery within the tracheobronchial tree. Once the vibrating mesh nebulizer is in the circuit, the circuit need not be broken to instill the medication. Nebulization of medication by either approach can produce obstruction of the ventilator-based expiratory limb filter; this filter cannot be easily replaced while the patient is on the ventilator. For this reason, an easily removed secondary filter may be inserted directly within the expiratory limb of the ventilator circuit to protect the ventilator. Some hospitals place the secondary filter only during nebulizer treatments and remove it after each treatment, while others leave the secondary filter in line all the time and routinely change it to avoid having it become saturated with water and medications. Thus, nebulized medications may necessitate breaking of the ventilator circuits and exposure of aerosols within the room.

If anesthesia machines are being used, a filter also needs to be placed on the expiratory limb to protect the machine from contamination. However, anesthesia machines differ greatly from standard ventilators because they include modules for inhalation agents. Commonly, these modules are removed; however, if the OR ventilators are used in ORs or PACUs by experienced anesthesiology staff, inhalation agents may be considered in lieu of muscle...
relaxants. Of note, if inhalational agents are used in a PACU, gas scavenger systems must be installed.

At the onset of the COVID-19 pandemic, there was a push to shift from active humidity circuits with nebulized liquid medications and associated circuit breaks to passive humidity using dry circuits (heat and moisture exchangers [HMEs] and wireless circuits) and metered dose inhalers (MDIs). The primary goals of these changes were to decrease the number of times a circuit is broken to address expiratory limb filters saturated with water or nebulized medications and subsequent exposure of staff to aerosols.

However, there have been misgivings about these changes, especially with dry circuits because HMEs and endotracheal tubes (ETTs) have become clogged with inspissated debris. Acutely, obstructions have required emergency circuit disconnection, ETT exchange (using a tube exchange device) or reinsetion and bronchoscopy. Concomitant airway edema makes the latter practice dangerous and may require rescue with a surgical airway at the bedside, further increasing exposure risk during a life-threatening emergency. Each of these events can lead to staff exposure during emergent aerosol-generating procedures (AGPs) such as these. Shifting back to heated humidity seems to help mitigate ETT obstruction by thick secretions and avoid emergent AGPs. The planned circuit disconnections required to change filters when using heated humidity may be safer than the emergent disconnections sometimes necessitated by dry circuits. Some hospitals may deliberately, but briefly, occlude the ETT during these disconnections to reduce aerosolization during filter exchange.

MDIs continue to be used as availability permits. However, when nebulizers must be delivered in line, staff should consider set times for changing ventilator circuit filters and should also use appropriate precautions to mitigate aerosol spread. Medications not available as MDIs include inhaled antibiotics (e.g., tobramycin, amikacin, colistin, amphotericin B), continuous bronchodilators (e.g., albuterol), mucolytics (e.g., acetylcysteine, dornase alfa), and prostaglandins (e.g., epoprostenol, iloprost).

### Ventilator Circuits: Addressing Humidity and Aerosolization

- Consider the benefits and downsides of using active humidity (i.e., heated circuits versus dry circuits with HME).
- Change ventilator circuits or filters according to patient need rather than by protocol.
- Use MDIs instead of nebulizers when possible.
- Consider vibrating mesh nebulizer rather than in-line gas-driven nebulizer when nebulized medication must be given.

*Invasive ventilator and alarm management.* Unlike physiologic monitors that may have remote controllers, ventilator settings are commonly adjusted and alarms acknowledged directly at the ventilator. This requires respiratory therapists or nurses to enter the patient room. Although some ventilators allow the display that controls the device to be physically disconnected from the base (the display remains tethered by a cable and placed outside the patient room as is an infusion pump for remote ventilator management), this is not recommended. The ventilator display can fall and be damaged or the cable can be dislodged or broken. Rolling devices (e.g., portable radiograph machines or dialysis machines) may become tangled on the suspended cable, also leading to damage. Either circumstance would remove the ventilator from use at a time when the maximum number of available ventilators may be needed for patient care, or
worse, dislodge the ETT or tracheostomy tube. To our knowledge, ventilator vendors are currently working on remote management capability by smartphone or PC.

Many hospitals use device integrators with appropriate middleware and wireless transmitters to send ventilator alarms to handheld devices or through the nurse call system (e.g., alarming overhead at central nurse call stations or through annunciators) to reliably alert respiratory therapists and nurses of alarm situations. However, transmitting ventilator alarms through traditional methods becomes challenging when deploying nonstandard ventilators, such as older ventilators from hospital storage or the national stockpile. These ventilators are often unsophisticated and equipped with only minimal informatics, precluding their incorporation into alarm transmission systems. Various integration solutions may need to be tested and tailored to fit the particular ventilator and middleware combinations available to the institution. If the ventilators will not mesh with existing systems to broadcast alarm alerts, there is a risk of being unable to hear the alarm behind closed isolation doors. Some hospitals have used webcams enabled with audio to transmit ventilator alarms out of the rooms of novel ICUs. Furthermore, nonstandard ventilators may not communicate with the EMR, necessitating manual flow sheet documentation.

Regardless of ventilator fleet composition, hospitals have adopted a variety of approaches to decrease the need for staff to enter the room. These include reconfiguring alarm settings to broaden alarm trigger limits (widen the range), shifting from multiple, in-room ventilator checks to fewer checks per shift, and reconfiguring the ventilator circuits.

**Oxygen supply.** A rapid increase in the use of ventilators may stress the hospital’s oxygen storage and delivery systems. The hospital’s liquid oxygen vendor should be contacted to make sure that its support of the hospital’s supply is stable and can match current and anticipated needs. The hospital should also monitor its oxygen supply level in a proactive fashion. During the height of the metropolitan New York COVID-19 pandemic, oxygen supply pipes froze in several hospitals. In one hospital, many patients had to be emergently transported to other medical centers because oxygen could not be delivered. It is imperative to collaborate with the facility’s oxygen supply management team to ensure safe and uninterrupted support of critical care units.

**Noninvasive ventilation.** Although early intubation and invasive ventilation comprised the dominant approach at the beginning of the COVID-19 pandemic, hospitals have increasingly shifted to noninvasive oxygen support. At the most basic level, noninvasive oxygen support includes low-flow oxygen by nasal cannula and non-rebreathing face mask. The next level includes high-flow nasal cannula (HFNC) oxygen, continuous positive airway pressure (CPAP), and bilevel positive airway pressure (BiPAP). HFNC oxygen systems were initially avoided because of concerns about aerosolization during spontaneous exhalation. However, such concerns currently seem unsupported and HFNC oxygen support is increasingly being used, with occasional restrictions on maximal flow rates, a face mask requirement, and exclusive use in a negative-pressure room. A minority of hospitals have permitted BiPAP devices while embracing negative pressure. CPAP is also being used in some centers, with the patient wearing a helmet device that uses oxygen support, positive end-expiratory pressure valves, and filters, instead of a ventilator or BiPAP machine.

**Managing medications for nonintubated patients.** For nonintubated COVID-19 patients requiring aerosolized medications, the preferred delivery method is MDI with a valved holding chamber (spacer) rather than a standard nebulizer. The valved holding chamber holds the medication until the patient breathes in, giving the patient time to take a slow deep breath and thereby
improve medication delivery into the tracheobronchial tree. If a patient cannot create a seal around the mouthpiece, an alternative is to attach the valved holding chamber to a face mask held tightly against the face. A valved holding chamber can also be adapted to connect directly to a tracheostomy tube. For medications not available in MDI form, gas-powered nebulizers with a bacterial/viral filter attached to the expiratory limb to reduce environmental contamination during aerosol treatment may be used. These devices were used before COVID-19 since the filters protected the environment and HCWs from toxic medications (e.g., pentamidine). They may similarly prove useful with COVID-19 patients.

Respiratory procedures. To reduce exposure to the patient’s respiratory gases and potentially COVID-19 during intubation, the ETT should be inserted by the most experienced clinician. Disposable airway management devices are being used. Exposure to aerosols should be minimized by performing intubation in a negative-pressure room if possible. Some hospitals have developed special intubation boxes as well. All clinicians involved in the intubation should wear PAPRs or, at a minimum, N95 masks and eye protection. Documentation for airway procedures can be simplified or performed by others in attendance to free the experienced proceduralist to focus on patient care in a dedicated manner. Use of manual resuscitator bags should be avoided if possible. When they are necessary, they should be fitted with antiviral filters for expired air. Similarly, tracheostomies and gastrostomies, whether open or percutaneous, need to be performed with techniques designed to minimize aerosolization.19-21

Prone positioning. Prone positioning therapy has emerged as a powerful tool in the care of COVID-19 patients with hypoxemia, whether critically ill or spontaneously breathing. Hospitals have created prone positioning teams and protocols to support the staff during complex patient care. Many hospitals have staffed these teams with clinicians who routinely use prone positioning in the OR or procedural suite. Such teams coordinate initiating and terminating prone positioning therapy with the respiratory therapist and the bedside nurse.

Commonly used ETT securing devices are not intended for use during prone positioning because they may cause adverse effects, including pressure ulceration and skin breakdown.22,23 A protocol should be developed for prone positioning that addresses both securing the ETT with tape and the best way to position the patient to prevent these adverse effects. This may include working with colleagues from the OR who have more experience with prone positioning. Special pillows for the head may also be used to relieve pressure from the face and to protect the airway and nasogastric tubes.

Vascular access, including central venous, arterial, and dialysis catheters should be obtained on the same side to facilitate prone positioning by having all the device pumps and connections remain aligned. The right side is easiest with regard to placing devices. It also minimizes the potential for prone position-associated flow impedance in the internal jugular position if the left side is used; kinking appears to be less likely with catheters placed in the subclavian position, although this position is optimally avoided in those with acute kidney injury who require renal replacement therapy.

Pharmacy and Medication Management

ICU Pharmacy Operations
• ICU pharmacy operations and staffing should be expanded and bolstered to accommodate the increase in COVID-19 patients and ensure around-the-clock coverage for COVID-19 units. Staffing can be expanded by reallocating and cross-training pharmacists and pharmacy technicians from non-critical care areas to provide clinical and operational support in the ICU. Additional surge support can be provided through remote medication order review and verification as well as remote critical care pharmacy specialist services.

• Critical care and COVID-19-specific training opportunities and resources should be developed for pharmacy staff. These may include dosing cards and a critical care pharmacy reference guide to keep all pharmacists abreast of rapidly evolving drug management strategies.

• Critical care pharmacy specialists should provide medication management education for nurses, APPs, and physician staff who have been redeployed to critical care areas.

• Critical care pharmacists should actively participate in multidisciplinary teams in the rapid development of COVID-19-specific care management guidelines. Pharmacists should coordinate care with intensivists to implement these guidelines.

• Automated dispensing cabinets (ADCs) should be available in surge ICU areas, including ORs. ADCs should be optimized and reconfigured to ensure the prompt availability of medications to critically ill patients. This may include preassembled intubation and cardiopulmonary resuscitation kits made available on override, which can be easily removed and disposed of once brought into COVID-19-positive patient rooms to support infection control. This minimizes the contamination and waste of entire code cart medication trays. Periodic automatic replenishment levels should be frequently reevaluated and set to meet changing surge needs.

• Pharmacy departments should expand and optimize IV compounding operations to meet increased demand and reduce waste of critical medications on shortage. Specifically, batching services should be increased for sedation and analgesia medications and vasopressors.

• Critical care pharmacy specialists should collaborate with informatics departments to expedite development and implementation of order sets to meet evolving patient needs and promote medication safety. The implementation of order-specific questions and restrictions prompts prescribers and encourages appropriate drug utilization.

**Drug Shortage Management**

The COVID-19 pandemic has highlighted the deficiencies surrounding the durable drug shortages present for many years in the U.S. healthcare system. It is critical for the pharmacy to have a highly functional infrastructure to effectively respond to drug shortages. To minimize supply disruptions, the pharmacy should have a drug shortage team and a committee that oversees, approves, communicates, and implements the reallocation of resources and the implementation of conservation strategies. These teams should proactively identify medications and support supplies required for the management of COVID-19 patients. They should promptly
recognize and anticipate shortages, routinely assess current stores and daily usage, and extrapolate current usage to anticipated increased patient volume. Daily status reporting within the pharmacy and a process for clear communication to prescribers are key.

### Drug Shortage Mitigation Strategies

- Include a pharmacist as part of the ICU team to help guide medication selection and dosing.
- Create and implement local guidelines outlining patient-specific drug shortage mitigation strategies.
  - Use alternative formulations.
    - Use enteric opioids or topical patches to spare IV formulation.
      - Be aware of prolonged opioid effect with topical patches.
    - Conserve MDIs for intubated patients by using nebulizers in non-COVID-19 patients.
  - Use alternative agents within the same drug class.
    - Use rocuronium or vecuronium during cisatracurium shortages.
    - Use IV hydromorphone in place of IV fentanyl.
  - Use adjunctive agents.
    - Routinely use non-opioid analgesics to spare IV opioids and minimize delirium.
    - Use antipsychotics to optimize sedation to spare IV opioids and sedatives.

### Pharmacy-Nurse Coordination to Help Minimize Exposure Risk

Relocation of Infusion Pump and Nuances of Medication Management

- Placing the infusion pump outside the room can minimize the number of in-room visits the nurse must make. Policies should be developed, and nurses trained, on how pump relocation will influence routine tasks such as priming and flushing of long extension tubing whose volume is approximately 50 mL. Knowing the volume required to flush the line enables successful bolus dosing of therapeutic agents in a timely fashion and will help avoid inadvertent bolus administration as well.
- The pharmacy should consider the ramifications of widespread use of extended tubing, including drug waste due to volume loss during priming and the risk of medication administration error. Nursing education should be provided to minimize premature or excessive titration of continuous infusions administered
via extended tubing that occur in response to delays in medication reaching the patient.

- The pharmacy should identify medications that preclude the use of infusion pumps outside the patient room due to administration logistics. They should be aware of the composition of the extension tubing. If it contains PVC, medications requiring low-sorbing tubing (polyethylene-lined tubing with PVC-free fluid path), such as nitroglycerin, insulin, continuous-infusion tacrolimus, and cyclosporine, should not be administered from infusion pumps placed outside the room. Certain medications may bind to PVC material. The use of longer lines containing PVC may sequester these medications and cause patients to receive a drug at a different dose than intended.

- In hospitals using bar-code-assisted medication administration, nurses cannot scan patients’ wristbands when administering medications through long extension tubing outside the room. One solution is to place a second scanner outside the room with the patient’s bar code wristband attached to the IV tubing. Scrupulous line labeling is required to mitigate potential errors.

- Pharmacists can help minimize the number of times nurses must enter patient rooms for medication administration by choosing medications that require only once- or twice-daily dosing and facilitating the consolidation of dosing times. When appropriate, and in accordance with local regulatory guidance, the pharmacy can compound larger volume or more concentrated continuous-infusion bags with extended dating to reduce the number of times the bags need to be changed.

Storage of patient-specific medication

- In ICUs that store patient-specific medications inside patient rooms or in built-in pass-through cabinets, the pharmacy can help support infection control by relocating patient-specific medications to medication rooms or ADCs to prevent contamination. Pharmacists should proactively work with nurses to identify and dispose of unused or discontinued medications that have been stored inside patient rooms.

Safely minimizing patient monitoring

- Decreasing blood sampling for glucose monitoring
  - For patients with hyperglycemia requiring an insulin infusion, glucose sampling is required every hour during active titration, which increases nurses’ exposure risk. Several approaches have been described to minimize the need to frequently obtain blood samples directly. One is to use glucose monitoring devices that attach to the patient and transmit glucose values wirelessly to a receiver or mobile device outside the room. This approach supports infrequent and perhaps complete elimination of standard blood glucose sampling but is not a realistic solution for most institutions. Other options include decreasing the frequency of routine sampling by de-escalating insulin infusion protocols and loosening blood
glucose targets and by using the basic metabolic panel result to eliminate at least one sampling event. Additionally, optimizing blood glucose management by proactive initiation of short- and long-acting insulin may minimize the need for continuous-infusion insulin and the associated need for frequent glucose monitoring. When clinically appropriate, some institutions have avoided insulin infusions in favor of more aggressive subcutaneous long-acting and sliding-scale insulin strategies.

- Using a clinical end point to monitor neuromuscular blockade
  - Instead of using train-of-four goals to titrate neuromuscular blockade, some institutions have moved toward titrating for ventilator dyssynchrony as the primary end point.

**Room Environment**

The ICU patient's room, wherever it is located, is the epicenter of potential infection and should be configured to reduce risk to clinicians while ensuring optimal patient care. Both room equipment and care execution are key for successful space and patient management while caring for a patient with a highly transmissible pathogen such as COVID-19.

**Donning and doffing.** Zones and protocols should be developed for donning and doffing PPE. These critical actions should be initially trained, assessed, and periodically surveilled. Fatigue may lead to inadvertent error. Donning and doffing should occur as much as possible with a trained observer to ensure safety; doffing represents the highest risk for contamination of the environment and the clinician. Protocols to preserve PPE supplies (e.g., sterilization of N95 masks for safe reuse) may need to be developed and should be periodically assessed for efficacy. Facial injuries have been described with N95 masks, so care should be taken to prevent injury from pressure; previously undisclosed latex sensitivity or allergy has been reported as well after contact with securing straps.24,25

**Communications.** A communications system should be installed, especially in novel ICUs where it may not exist, to ensure that nurses and other staff inside the patient's room can easily communicate with those outside the room. Staffing should be adjusted to provide resource nurses outside the room while the primary nurse in full PPE is in the room with the patient. Nurses outside the room should perform tasks that support the in-room nurse, including supply gathering, laboratory request scanning, and medication preparation. This teamwork reduces the number of room exits and reentries during a patient care episode.

**Split ICUs.** Some ICUs may split their spaces into two areas using barrier doors. COVID-19-positive patients and patients under investigation are cohorted on one side of the doors, while COVID-19-negative patients are cohorted on the other side. These ICUs should have duplicate equipment, procedure carts, and other supports—including code carts—on each side of the barrier to avoid cross-contamination.

**Sanitizer dispensers.** Most modern U.S. ICUs already have nursing stations with computers, charting areas, and sinks outside and inside the room. If there are no nursing stations outside the room, ICUs and acute care areas functioning as novel ICUs should set up local stations. Alcohol-based hand sanitizer dispensers must not be positioned directly above electrical outlets or connections.
Room cleaning and disinfection. A protocol should be developed for room cleaning and disinfection, both when the room is occupied and between patients. Hospitals commonly have room cleaning and disinfection protocols that address patient care areas with aerosol or droplet precautions. The U.S. Environmental Protection Agency (EPA) website lists EPA-registered disinfectants that have qualified under the EPA’s emerging viral pathogens program for use against COVID-19. Some hospitals are also using an ultraviolet light generator for additional disinfection for terminal cleaning. Environmental services workers should wear the recommended PPE for airborne and eye protection, which includes a disposable fluid-impervious gown, gloves, face shield or goggles, and N95 respirator. Safe waste handling and transport to a suitable collection and disposal site should be developed, trained, and reinforced.

Suggestions for Safe Practices: Room Equipment
The following list of key supplies will reduce the need for avoidable room exit and reentry and decrease the risk of COVID-19 virus transmission on HCW exit.

1. Position waste receptacle close to the door for shoe cover and other PPE disposal.
2. Place a whiteboard and markers or other means of communication (e.g., erasable markers for writing on glass doors) with HCWs outside the room to limit the need for door opening for communication.
3. Enable a pressure monitoring system for standard ICUs and novel ICUs when negative pressure is specially applied.
4. Set up door opening or closure failure alarms to help maintain door security and limit the potential for viral dispersal, especially when the room does not have negative pressure.
5. Place equipment decontamination wipes in the room so that contaminated equipment can be cleaned before being transported out of the room.
6. Position an in-room computer so that nursing care may be documented while in the room when care is protracted and requires a bedside nurse to remain in the room.
Suggestions for Safe Practices: Care Execution

The following practices will decrease the risk of HCW environment viral pathogen exposure.

1. Have an observer for PPE donning and doffing to reduce errors in donning and especially doffing.
2. Secure IV tubing to the floor out of the path of care equipment, especially radiograph machines, so that IV lines remain free flowing and are not damaged.
3. Provide a communication method besides walkie-talkies in the room for when HCWs must wear PAPRs. HCWs may not be able to hear while wearing a PAPR. Having more than one method of communication reduces HCW room exit and reentry to secure aid or additional supplies that can be brought to the door by other clinical staff if there is a means of effective communication.
4. Position a hand hygiene station immediately outside the room to facilitate rapid hand decontamination and reduce the likelihood of inadvertent surface contamination.
5. Practice a method to transport laboratory specimens to ensure safety and avoid contamination of tube systems. Alternatively, establish and practice a method and alternate route for hand-carrying specimens to the laboratory.
6. Cell phones are to be left outside the room to avoid reflex answering of the phone in a COVID-19 room and to prevent contamination of the phone in the room. A start-of-shift or care period checklist helps ensure that personal devices are secured. Practices such as wearing patient care-only shoes (as opposed to street shoes) are undertaken as well.
7. Ensure that HCWs remove PAPRs on room exit. PAPR doffing helps reduce the likelihood of the PAPR coming into contact with other contaminated spaces (including non-COVID-19 pathogens such as methicillin-resistant *Staphylococcus aureus* or extended-spectrum beta-lactamase-producing gram-negative bacteria) that can then be transmitted to a COVID-19 patient.
8. Ensure that room doors close rapidly and completely between room exit and entry, especially in rooms without negative pressure capability to help limit the potential for virus spread.
9. Establish a designated PAPR drying station between cleanings so that there is a single location for PAPR care and supplies.

Patient Communication

Visitors are not currently permitted in most hospitals except under pilot programs and very specific circumstances such as birth and the end of life. This safety practice has generated tremendous anxiety for both family members and ICU staff and renders the usual approaches to patient- and family-centered care difficult. It is vital that the ICU develop a communications
system to ensure that family members can obtain information about their loved one that does not overwhelm bedside nurses and other clinicians. Some solutions involve enlisting dedicated social workers, patient representatives, and pastoral care providers to aid in facilitating communication with family members. It is helpful to identify one family spokesperson who will serve as the ICU point of contact and who can then inform the rest of the family. The ICU team must also be prepared to address an unusual element in their conversations with the family members of COVID-19 patients, notably the outsized role played by the media in relation to all things COVID.27

Verbal information from clinicians is unlikely to be sufficient to assuage family concerns. The family also benefits from having contact with the patient, whether the patient can communicate or not. At a minimum, ICU rooms are equipped with telephones that can be put on speaker so that the family can talk to the patient even if the patient is unable to respond. It may be ideal to encourage families to speak to the patient in a positive manner. Offering families audio or video communication via video chat programs at least once each day or more, if feasible, will help support family members. Such contact may also reduce anxiety-driven repeated inbound telephone calls that can disrupt workflow at a time when focused attention to PPE donning and doffing permeates care.

**Emotional Support for Staff**

Serving on the front lines of critical care is physically exhausting and emotionally draining. Many clinicians experience depression, anxiety, and feelings of being overworked and overwhelmed while being disconnected from their family, friends, and community. These feelings may be magnified during the enforced absence of the usual support systems under lockdown measures for virus containment and mitigation. Those who are not HCWs may be unable to understand the stressors HCWs face while delivering critical care during a pandemic. Additionally, even with optimal PPE, ICU clinicians recognize that they are putting themselves in harm’s way daily and worry about inadvertently exposing family members to COVID-19 when they return home after their shift.

It is vital that hospitals recognize the mental health challenges faced by their workers—from physicians to cleaning staff—and provide psychological and emotional support from social workers, psychologists, and psychiatrists. Moreover, HCWs can be queried to determine what they believe would be most helpful for them besides therapies provided during individual or group therapy sessions. A variety of complementary approaches include at-work recreation activities (at a distance), mindfulness training, guided book clubs, and therapy animal visits. The latter are particularly popular and appear to be effective. The visibility of hospital administrative and clinical leadership in the clinical space is similarly tremendously supportive. Leaders walking through the ICU offer opportunities for bedside clinicians to share concerns, identify successful interventions, and view themselves as part of a larger team. It also provides leaders with time to directly assess the needs of frontline staff and may help inform their decision-making regarding logistical support, staffing, and other key aspects of care.

**Ramping Up Hospital Operations While Maintaining or Ramping Down Expanded ICU Capacity**

Even as the pandemic continues across the country, hospitals that have seen a significant decrease in COVID-19 cases have received permission from state authorities to ramp up
outpatient and inpatient operations. Staff deployed to traditional and pop-up ICUs are being returned to their original spaces and positions. While these staff members look forward to returning to their “home” spaces, they are worn out emotionally and physically. They may need some respite from the accelerated pace and personal risk encountered while working in the ICU setting. Additionally, these staff may feel unfairly “used” in comparison to other staff members who were not redeployed to care for patients with such a contagious illness. Locum tenens-type staff and volunteers are also leaving to resume their usual employment, workflow, and activities.

Ramping up hospital operations includes several concomitant perspectives. First, the hospital would like to return to business as usual. The novel ICUs must be converted back to acute care wards, ORs, PACUs, and the like, thus reverse-engineering the physical alterations that were performed to create the novel ICUs. Second, from the perspective of critical care, while the overall number of hospital and ICU COVID-19 cases have decreased, the ICU census may remain well above normal due to ongoing COVID-19 admissions as well as COVID-19 patients with persistent respiratory failure who remain on mechanical ventilators. Unfortunately, these patients may not follow a typical course for long-term ventilation and their care may require significant space, resources, and staff. The ICU team may be challenged as it determines how to manage two competing priorities: maintaining care for the remaining acutely and chronically ill patients with COVID-19 versus the loss of space and reallocated staff due to the resurgence of usual hospital operations. ICU staff stress will also be increased because the resurgence of hospital operations will add electively or emergently admitted patients to the ICU census. This scenario may compound and perhaps highlight the staffing divide between those who do and those who do not care for COVID-19-infected patients. This too creates a staffing challenge that must be addressed fairly.

ICU organizations should coordinate with hospital and departmental administrators, as well as clinical leadership, to devise a transition plan that helps the hospital resume usual patient care and revenue generation but also maintains care of critically ill patients with and without COVID-19. Further complicating these interconversions, at least in New York state, is the recognition that the governor’s office is requesting plans for hospital responses to a COVID-19 resurgence in the fall of 2020. Thus, New York State hospitals may not fully deconstruct pop-up ICUs as they await a possible fall resurgence.

Moving Forward
At the level of the ICUs and pop-up ICUs, as the current crisis diminishes there is an opportunity to perform technical upgrades that would better prepare care spaces to again care for patients from a distance in the event of a COVID-19 resurgence. Some of the accommodations that enabled care to be located outside the patient room can be made durable. Examples include installing power outlets and conduits to eliminate extension cords and IV extension tubing running on floors and under doors. Rooms that did not have windows or webcams can undergo improvements at a less frenetic pace. Such modifications may aid planning and renaming conventions should they be pressed into service as novel critical care spaces.

Eventually this pandemic will ebb, and it is vital that we learn from our shared experiences to plan how to successfully meet the next pandemic or similar challenge. To prepare for that day, hospitals should preserve (with written, photographic, and video documentation) what they have done during this pandemic to cope with all its aspects. Hospitals should be prepared to redeploy lessons learned in establishing novel ICU spaces and staffing and care plans within their
facilities to meet patient care needs that may once again outstrip available ICU space. Enhanced local stores of PPE, therapeutic agents, and even ventilators may form the basis on which future preparedness is built at the local level. Finally, intensivists and other critical care professionals should communicate with their peers to learn about innovations that may be applicable to them the next time such a pandemic occurs. Innovations that enable and advance managing patient care at a distance may be highly prized in support of HCW safety.
References


https://www.epa.gov/newsreleases/epa-releases-list-disinfectants-use-against-covid-19


Additional Resources

Expanding ICU Capacity


Guidelines for Management of Patients With COVID-19


Mechanical Ventilation Strategies


Contributing Medical Centers
We acknowledge the following contributors from 16 U.S. medical centers.

1. Adventist Healthcare Fort Washington Medical Center, Fort Washington, Maryland. Milad L. Pooran, MD.

2. Einstein Medical Center, Philadelphia, Pennsylvania. Mark J. Kaplan, MD, FACS.

3. Emory University Hospital, Atlanta, Georgia. Toni Ash, RN; Star Claytor, RN; Karl Egsieker, BS, BSN, RN; Ivey Feldman, RN; Rose Gourdikian, RN; Karen Nelms, RN; Kendra Slaton, RN; Randy Walker, RN.

4. Holy Name Medical Center, Teaneck, New Jersey. Adam D. Jarrett, MD, MS, FACHE, Selwyn Levine, MD, FCCP; Steven L. Mosser.

5. Hospital of the University of Pennsylvania and the Veterans Administration Medical Center of the University of Pennsylvania, Philadelphia, Pennsylvania. Lewis J. Kaplan, MD, FACS, FCCP, FCCM.

6. Massachusetts General Hospital, Boston Massachusetts. Carolyn J. La Vita, MHA, RRT.

7. Memorial Sloan Kettering Cancer Center, New York, New York. Christine Ammirati, PA-C; Lindsay Boyce, MLIS; Stephanie Chu, MPA, BSN, RN, CCRN-K, NE-BC, BCCCP; Ashely Jackson, MS; John Letson; Mitulkumar Patel, PharmD, BCCCP; Monique James, MD, Sarah Rebal, MS, RN, ACNP-BC; Jared Snavely, PharmD, BCPS; Frederic G. Stell, MBA; Anita Wang, PharmD, BCPS; Elaine Yam, PharmD.

8. Montefiore Medical Center, Bronx, New York. Michelle Ng Gong, MD, MS.

9. Mount Sinai Medical Center, New York, New York. John M. Oropello, MD, FCCM, FCCP.

10. Newton-Wellesley Hospital, Newton, Massachusetts. Kevin M. Buckley, RRT.

11. New York-Presbyterian Hospital, New York, New York. Tricia Brentjens, MD; David H. Chung, MD; Amy L. Dzierba, PharmD, BCCCP, FCCM.

12. Orange Regional Medical Center, Middletown, New York. Rhonda D’Agostino, MSN, ACNP-BC, FCCP, FCCM.

13. Tampa General Hospital, Tampa, Florida. Beatrice Adams, PharmD, BCPS, BCCCP; Kevin Ferguson, PharmD, BCPS, BCCCP; Maresa Glass, PharmD, BCCCP, FCCM.


15. University of Cincinnati, Cincinnati, Ohio. Richard Branson, MSc, RRT, FAARC, FCCM.

16. University of Nebraska Medical Center, Omaha, Nebraska. Breanna Hetland, PhD, RN, CCRN-K.