

Service Line Care Delivery Model for COVID-19 Patient-Centric Care

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In late December 2019, reports surfaced describing a new virus, SARS-CoV-2, that is responsible for COVID-19.¹ Because of the contagiousness and potential lethal course of this disease in some individuals, the World Health Organization declared the SARS-CoV-2 outbreak a pandemic on March 11, 2020.^{1,2}

As a result of this fast-spreading disease, hospitals around the world had to quickly develop strategies to treat patients with symptomatic COVID-19 while developing appropriate methods for protecting health care and frontline workers. Confounding these actions was a relative lack of knowledge about COVID-19 and its treatment, supply shortages of essential personal protection equipment (PPE), and a lack of tests to identify infected patients.³⁻⁹ Here, we describe how a large, multihospital health system that serves a diverse population transformed into an integrated and unified system through implementation of systemwide service lines to overcome these obstacles and provide seamless care for all patients with COVID-19.

The Inova Health System (IHS) is a not-for-profit network of 5 major hospitals (1927 licensed beds), primary and specialty care practices, emergency and urgent care centers, outpatient services, and destination institutes. In 2019, Inova and its 18,000 employees provided more than 2.7 million encounters of care to Northern Virginia communities through medical and surgical routine and quaternary services, a level 1 trauma center, emergency departments (EDs), and ambulatory healthplexes. Just prior to the COVID-19 pandemic, in January 2020, Inova changed its care model to deliver care using an approach with 11 systemwide service lines as a means to align care among all the hospitals. Among these, the Inova Medicine service line was created, which included hospitalists, critical care providers, ED providers, and providers from subspecialties such as infectious disease and pulmonary medicine groups, who were given the primary responsibility for delivering inpatient care for patients hospitalized with COVID-19.^{10,11}

Getting Ready for the Virus

We paid close attention to reports from both Italy and New York City,^{12,13} areas considered the epicenters of the COVID-19 virus in

ABSTRACT

OBJECTIVES: The COVID-19 pandemic has caused hospitals around the world to quickly develop not only strategies to treat patients but also methods to protect health care and frontline workers.

STUDY DESIGN: Descriptive study.

METHODS: We outlined the steps and processes that we took to respond to the challenges presented by the COVID-19 pandemic while continuing to provide our routine acute care services to our community.

RESULTS: These steps and processes included establishing teams focused on maintaining an adequate supply of personal protection equipment, cross-training staff, developing disaster-based triage for the emergency department, creating quality improvement teams geared toward updating care based on the most current literature, developing COVID-19–based units, creating COVID-19–specific teams of providers, maximizing use of our electronic health record system to allocate beds, and providing adequate practitioner coverage by creating a computer-based dashboard that indicated the need for health care practitioners. These processes led to seamless and integrated care for all patients with COVID-19 across our health system and resulted in a reduction in mortality from a high of 20% during the first peak (March and April 2020) to 6% during the plateau period (June–October 2020) to 12% during the second peak (November and December 2020).

CONCLUSIONS: The detailed processes put in place will help hospital systems meet the continuing challenges not only of COVID-19 but also beyond COVID-19 when other unique public health crises may present themselves.

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Europe and the United States, describing how the virus was overwhelming their respective health care systems. Our health system subsequently took precautionary and preparatory steps in March 2020 to be ready when the virus became prevalent in our communities and service areas. The first preparatory step to deal with the pandemic was the formation of the Inova COVID-19 Coordination Center (IC3), whose purpose was to coordinate all operational and clinical activities in the system and to align activities with those related to the regional, statewide, and federal efforts.

As a part of these efforts, teams were created to deliver specific infrastructure for the pandemic (described in detail later).

The second step was to predict the pandemic's developing impact on our system. To accomplish this, we used 3 forecasting models to provide real-time guidance: the COVID-19 Hospital Impact Model for Epidemics (also known as CHIME), the Qventus model, and the University of Washington's Institute for Health Metrics and Evaluation model.¹⁴⁻¹⁶ Although the models varied considerably in their projections, the Qventus model provided us with the most accurate forecasts of the clinical needs for our system.

Capacity surge force. To address the worst-case scenarios that were initially forecasted by these models, we assembled a surge force team, which rapidly collected information from all sites of care to include our 5 hospitals to fully understand their capacity and their status so that they would be matched with the best qualified surge force providers available (described below). We used our electronic health record (EHR) system (Epic) to create dashboards that tracked patients, inpatient unit capacity, intensive care unit (ICU) capacity, staff, and mechanical ventilator status (**eAppendix Figure 1** [eAppendix available at ajmc.com]). The dashboard was updated daily and used to determine the operating status of each hospital and to allocate specific and sometimes scarce resources where needed.

At the same time, we created a COVID-19 surge provider database of more than 750 providers, compiling all the local inpatient and outpatient physicians and advanced practice providers who volunteered to help when needed. Collection of key characteristics of each provider into our database was automated via a web link and then each provider was graded based on an inpatient skill set. Creation of this database was a challenge because of the diversity of our medical staff, which included employed providers as well as providers from private practices for each of our hospitals. Given the diversity of medical staff processes for each hospital and the provider entry points, a fast-track systemwide process was established to allow rapid credentialing, contracting, and EHR training for all nonemployee providers who volunteered to become active at one of the hospitals or sites of care (**Figure 1**). Once the database was functional, hospitals could request providers with specific qualifications. Requests for extra providers were reviewed on a daily basis and providers were

TAKEAWAY POINTS

- ▶ COVID-19 has brought significant challenges to the traditional model of delivering efficient and effective care.
- ▶ Given the unrelenting waves of this pandemic, we provide steps outlining how community hospitals can build sustainable care delivery models that can flex up and flex down as care demands now and for future public health crises.
- ▶ The processes we put in place allowed us to care for more than 8000 hospitalized patients with COVID-19 from March 2020 to March 2021.
- ▶ Our quality improvement and team-based approach helped to drive our COVID-19–related mortality rate down from a peak of 20% in March 2020 to 12% during the peak of the second wave (November–December 2020).

assigned to different sites of care based on 5 surge-level criteria to appropriately allocate providers, personnel, and equipment.

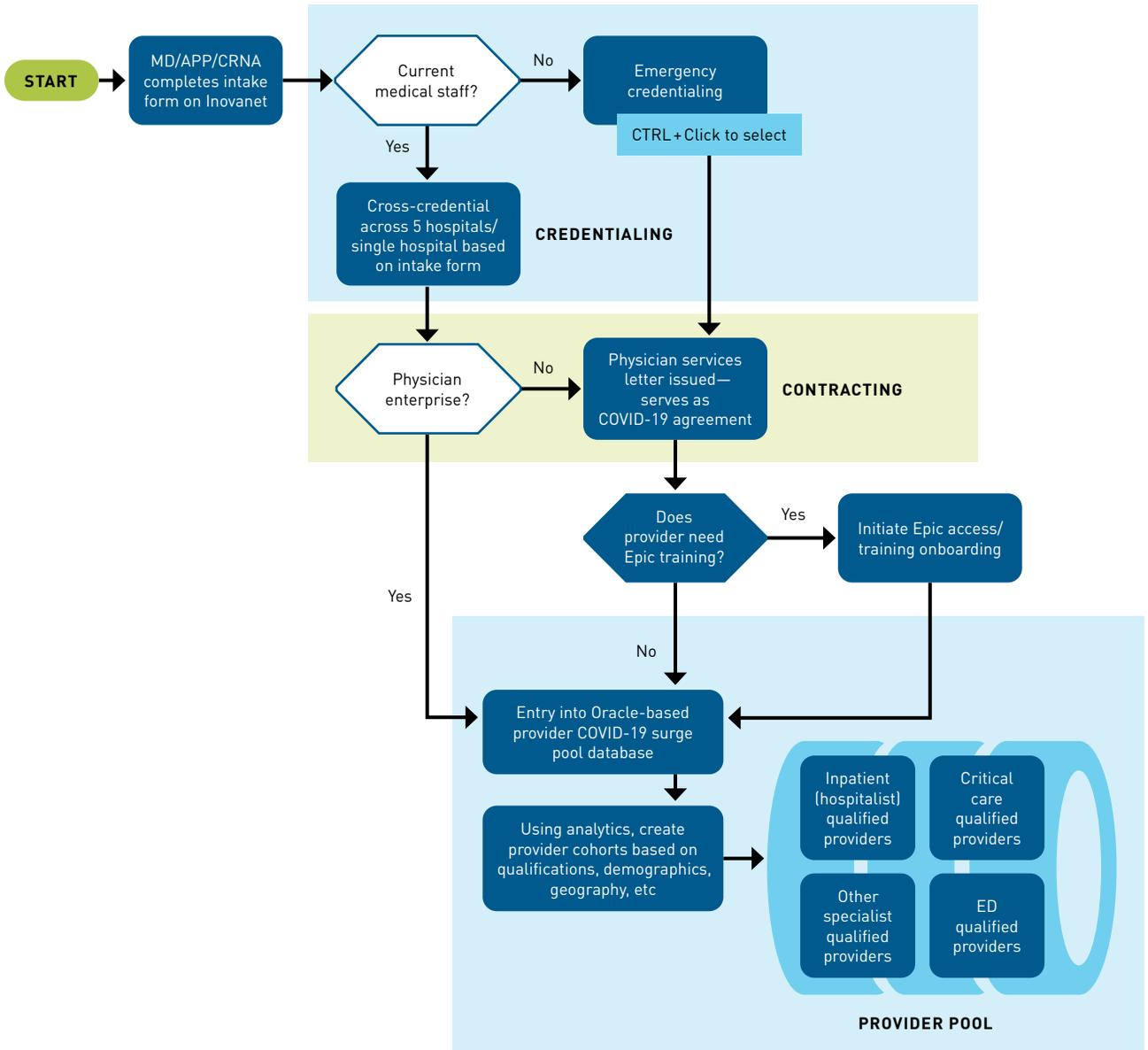
Nurse staffing and competency. Before the appearance of COVID-19 in our region, the nursing leadership team had developed a resource management center (RMC) to track all nurses and their credentials in the system. The purpose of the RMC was to move nurses into the units with the greatest need in a timely manner. The database contained information on nurses' current and past areas of experience, as well as years of nursing experience. Using this information, nurses could then be assigned to different tiers of skill level, which allowed for easy identification of those who could quickly move into complex environments, such as the ICUs. The RMC also provided education to update skills or to provide new COVID-19–related skills. Each unit developed a scope of work and expectations for nurses assigned from the RMC. In addition, the team model of nursing was instituted to facilitate and maximize the skills/knowledge of each team member, which included new nurses as well as physical therapy, occupational therapy, and technical staff.

Simultaneously, other action items initiated by RMC included working with the onsite childcare center to accommodate staff's childcare needs; deploying qualified personnel (such as behavioral health specialists and chaplains) to help with the stress and the grief of caring for these challenging and often isolated patients; working with the PPE committee to protect staff; and working with the information technology (IT) department to develop methods to monitor continuous pulse oximetry readings on iPads, which assisted the nurses in maintaining awareness of patients' oxygenation status. Additionally, emergency time off related to COVID-19 was instituted for all staff.

Facility capacity and flow team. After assessing the system's capacity, our IC3 converted all critical care and intermediate care beds at our 5 hospitals to negative-pressure rooms, reducing the risk of exposure for our providers in advance of the first surge. In this context, the number of our staff infected with COVID-19 was 2.1%, of which only 31% (0.65% rate) could be traced back to an exposure in the health care setting.

The surge team also organized the planning to increase the critical care and acute care bed capacity by 200%. The surge team purchased

FIGURE 1. Inova Health System's Expedited Medical Staffing Process



APP, advanced practice provider; CRNA, certified registered nurse anesthetist; ED, emergency department.

substantial supplies and capital equipment such as continuous renal replacement therapy (CRRT) and ventilators to ensure that all health care providers could provide the highest level of care to our patients. Last, the surge team also worked with our electronic ICU (eICU) team to not only provide virtual critical care services for some of our units but also create a transfer center that could move patients among different hospitals and sites of care, based on acuity levels at each hospital, in a seamless and safe manner (see later section on eICU).

Formation of Multidisciplinary COVID-19 Units

In the early phase of COVID-19, the Inova Medicine service line created the multidisciplinary early recognition and intervention team (MERIT) (Figure 2). This team was developed in response to the influx of patients with COVID-19 who quickly decompensated due to rapidly progressive hypoxemia. Collaboration among hospitalists, nurses, respiratory therapists, and subspecialty groups (critical care/pulmonology and infectious disease) produced a standardized internal approach to calculate the patients' risk of

rapid decompensation while allowing for maximum patient safety and ensuring appropriate allocation of hospital resources.

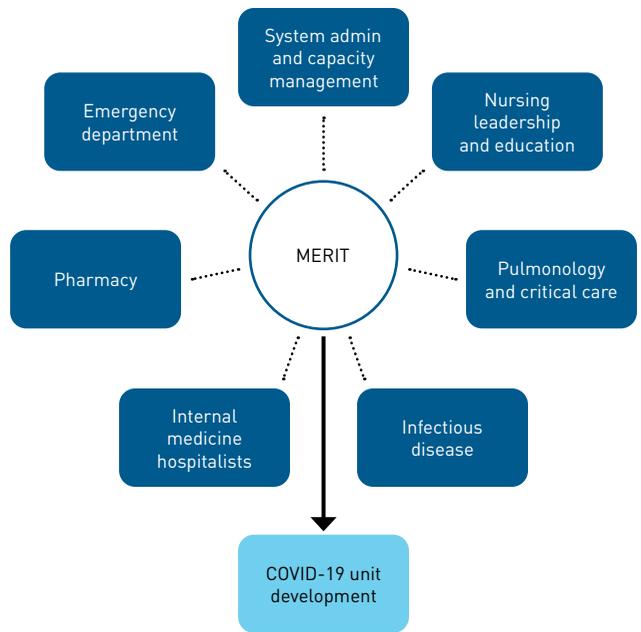
As MERIT evolved from individual and small group discussions into a large working group, the need for designated units to cohort COVID-19 patients was quickly realized. As such, MERIT was able to address this need by creating 2 standardized COVID-19 units: the standard unit and the augmented unit (a COVID-19 step-down unit with defined admission criteria). Both of these floor units were scalable and defined, in part, by the maximum level of oxygen therapy available. A modified operating (such as a project-specific leadership structure and adjusted staff ratios) and clinical structure was also created, driven by the needs of the floor units.

An outcome of the clinical structure was the establishment of the case review team as a secondary rounding entity. The case review team consisted of a hospitalist and a charge nurse who worked together with a floor pulmonologist assigned to a COVID-19 unit. The case review team rounded 3 times daily, with the primary goals of early identification of patients with COVID-19 who were at risk for deterioration, including rapidly progressive hypoxemia (or otherwise severe COVID-19 illness as defined by internal criteria), and application of a standardized treatment approach to mitigate the need for an ICU transfer and/or mechanical ventilation (Figure 3). Nursing staff and medical hospitalists had positive responses to the case review teams' approach, which helped to reinforce their common mission and share the emotional burden of caring for the severely ill and dying patients. The approach was also effective in identifying deficiencies in supplies and skills. Specialized COVID-19 units with experienced and new staff were also developed as a result of the MERIT assessment of needs to meet the rapid evolution of the COVID-19 crisis (Figure 4).

Critical care infrastructure. Rapid decompensation as a result of COVID-19 can lead to intubation, mechanical ventilation, and the need for intensive critical care.¹⁷⁻²¹ To develop a coordinated systemwide effort, the Inova Medicine service line assembled a critical care strike force to provide emergent care and coordinate all critical care activities throughout the system. In addition, the critical care medical coordinators developed their own surge staffing plan that incorporated the calculation of the number of specialists needed to cover each shift and meeting daily to discuss each unit's needs. Also, to better manage the particular needs of the different ICUs, the coordinators developed a management system in which the surgical department oversaw the surgical ICUs to include the cardiovascular and neurosurgical ICUs, the pulmonary department oversaw the medical ICUs, and the department of medicine oversaw the COVID-19 units and the high-acuity COVID-19 units. We also utilized our eICU to provide resources and tele-ICU care to any of the hospitals that had reached capacity.

Each hospital was assigned a physician liaison who communicated with the critical care team and hospital administration on a daily basis to address patient management. Mortality and morbidity review sessions discussed variations in and adjustments to practice, based on literature reviews performed by the critical care team.

FIGURE 2. MERIT Structure and Formation



MERIT, multidisciplinary early recognition and intervention team.

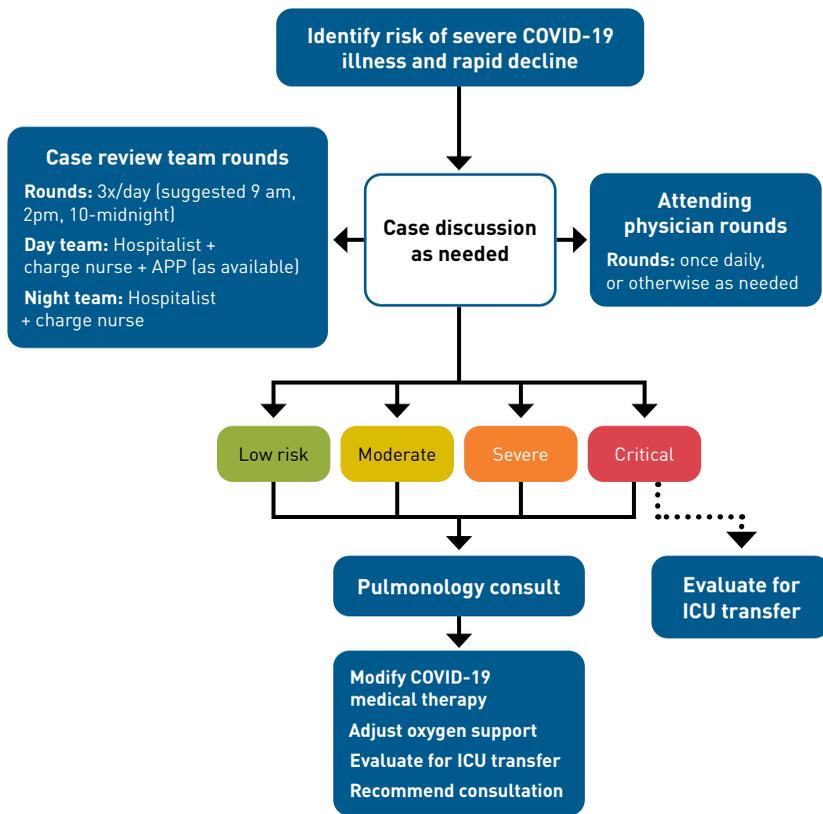
Intensive care specialists also worked closely with hospitalists to develop a COVID-19 pathway that kept patients on medical floors with tight oversight and monitoring parameters. These specialists oversaw the creation of additional negative pressure rooms, transformed intermediate medical care units into critical care units, and enhanced care delivery models by increasing the presence of hospitalists, pulmonologists, and respiratory therapists. These measures allowed more patients to be managed on the medical floors rather than in the critical care units.

eICU Critical Care Team (virtual care and telemedicine)

The use of telemedicine was enhanced to deal with the challenges of COVID-19, including the reduction of staff exposure to COVID-19 and preserving PPE. As such, the teams responsible for Epic, MyChart, IT, security, continuous improvement, quality, clinical engineering, and marketing came together to devise new processes. In this context, the telemedicine team increased the number of iPads on telecarts so that every bed with a COVID-19 patient had an individual iPad. In addition, VidyoConnect, a Health Insurance Portability and Accountability Act-compliant end-to-end video solution that combines secure transmission of videoconferencing sessions,²² was available on each iPad, reducing the number of times a staff member needed to enter a patient's room.

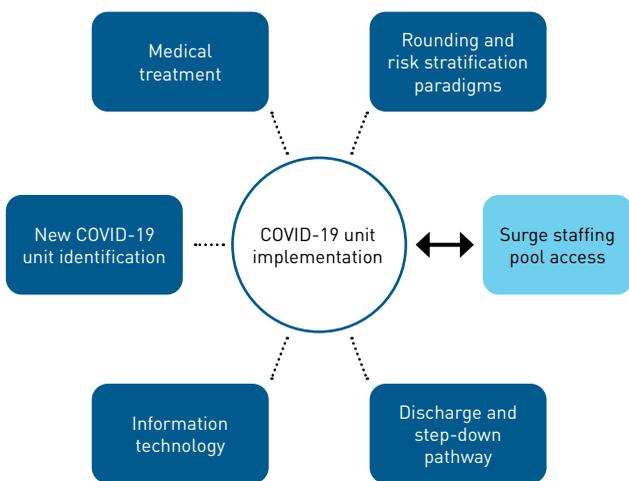
The amount of centralized monitoring equipment on the units was also increased, which allowed the expansion of eICU telemonitoring to augment staffing in areas facing a surge of patients with COVID-19. As a result of its enhanced monitoring

FIGURE 3. COVID-19 Rounding Paradigm



APP, advanced practice provider; ICU, intensive care unit.

FIGURE 4. COVID-19 Unit Implementation



capabilities, the eICU also became the transfer and bed management center, as well as the centralized review area for the remote oxygen saturation monitoring system using Masimo Signal Extraction Technology, or SET.²³ These expansions not only increased the capabilities of the eICU, allowing the delivery of care to our patients with COVID-19 in an efficient and seamless manner, but also assisted in reducing staff exposure and the potential for COVID-19 infections while preserving PPE.

Efforts in emergency medicine units. The ED is the point of entry into the health care system for most patients with COVID-19.²⁴⁻²⁶ Therefore, Inova Medicine's EDs incorporated a real-time early warning system, the National Emergency Department Overcrowding Scale (NEDOCS), into the Epic dashboard to avoid overcrowding and to make sure that if or when additional staffing resources were needed, they would be provided in a timely fashion.²⁷ The NEDOCS is based on the variables of total patients in the ED, total ED beds, number of admissions, total hospital beds, number of ventilated patients in the ED, longest boarding time for admitted patients, and longest wait in the waiting room. **Figure 5** demonstrates the NEDOCS surge levels. The ED also added in buffers such as telemedicine.

Additionally, the ED developed its own interactive system that was based on projected patient volume and acuity, allowing frontline administrators to calculate the number of workforce hours needed to safely staff the ED. These tools (NEDOCS and the Inova ED Resource Model) were made available to all of Inova's main and freestanding EDs (12 sites). Staffing for the indicated needs came from the surge plan and involved not only a pool of board-certified emergency physicians who were emergency cross-credentialed among all EDs but also a multispecialty physician surge pool.

Extracorporeal membrane oxygenation. COVID-19 can result in profound respiratory failure, which prevents a patient's response to maximal medical therapy.^{19-21,28,29} Extracorporeal membrane oxygenation (ECMO) is given to patients with severe respiratory failure.²⁹ In our system, venovenous ECMO was used as a rescue therapy for patients with a ratio of arterial oxygen partial pressure to fractional inspired oxygen below 100 despite lung protective ventilation, prone positioning, and neuromuscular blockade. In addition, ECMO was provided to patients with COVID-19 whose inadequate ventilation resulted in a severe respiratory acidosis that compromised perfusion. Patients within the system were screened daily through the use of eICU to ensure early recognition and rapid transition of care. Following discussion with a multidisciplinary team,

patients were transferred to the ICU to undergo bedside cannulation under transesophageal echocardiographic guidance.

Following cannulation, patients underwent continued prone positioning if they did not show improvement. Most patients also received high-flow CRRT, under an investigational protocol, to attenuate the cytokine storm during the initial 24 to 72 hours. Anticoagulation was maintained with bivalirudin unless contraindicated. Early mobilization was facilitated by use of a specialty bed (Kreg Medical Inc). Patients who did not make a rapid recovery (after 1 week) and were unable to be weaned from sedation because of agitation underwent evaluation for percutaneous tracheostomy. Following recovery of lung function, patients underwent bedside decannulation. Intravenous anticoagulation was continued for an additional 48 to 72 hours, and patients were transitioned to an oral anticoagulant upon discharge. Follow-up after ECMO was provided at an outpatient clinic and with hematology.

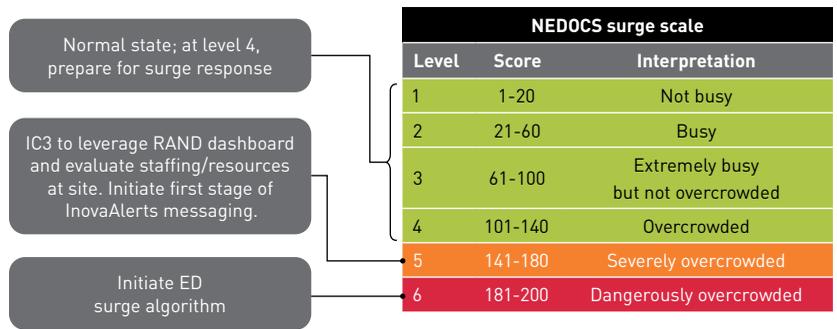
Testing and Infectious Disease Support

Testing for SARS-CoV-2 has been and continues to be a challenge.^{30,31} At the beginning of the COVID-19 pandemic, a limited number of polymerase chain reaction (PCR) tests were available, and they had turnaround times of many days. The long processing time hindered patient care—especially for determining when patients in isolation could be removed from isolation and when patients could be safely discharged to their homes. Early in our experience, a systemwide infectious disease team started working in close association with the laboratory staff of the pathology department to streamline testing and decrease the turnaround time for results. In addition, our system gained access to point-of-care tests and the ability to read more test results in house, both of which have decreased our turnaround time.

We also expanded our internal capacity by utilizing our research laboratories; by acquiring new systems for PCR tests; and by outsourcing some testing to our reference laboratory, in addition to continuing in-house testing. The infectious disease and laboratory teams also created an algorithm to assist health care workers in their decision-making for providing care to patients with suspected COVID-19 (eAppendix Figure 2). Plus, in addition to testing policies and procedures, our systemwide infectious disease team was actively engaged with the PPE committee and in discussions of isolation procedures and medical treatments for COVID-19.

Geriatric and palliative care. Given COVID-19's high morbidity and mortality in older adults, the Inova Medicine service line actively engaged its Division of Geriatric and Palliative Care team members from the beginning of the pandemic, who then provided planning assistance to the entire health system.³²⁻³⁴ The geriatric service provided a trained staff member on each shift to assist hospitalists

FIGURE 5. National Emergency Department Overcrowding Scale



ED, emergency department; IC3, Inova COVID-19 Coordination Center; NEDOCS, National Emergency Department Overcrowding Scale.

in managing this population and joined with the palliative care service to help manage patient symptoms, facilitate discussions of the goals of care, and assist with end-of-life care. The geriatric and palliative care teams also developed a symptom management and supportive care order set to aid hospitalists in management of patients who had a high symptom burden but were not at the end of their life.

Staff support and protection. Procurement of PPE is a constant challenge for every health system in the United States. Our approach was multidisciplinary and involved creation of subcommittees to ensure that appropriate resources were deployed to the care providers, and a task force met twice weekly to stay on top of the demands for PPE. The task force's members included representatives from the supply chain department, the infection prevention department, the Central Management Office, and the quality control department; colleagues from the legal, physician, and nursing groups; and allied health system employees.

Given the enormous task of providing guidance for PPE usage while also trying to ensure an adequate long-term supply, 3 subcommittees were created that also met twice weekly. The appropriate use subcommittee provided oversight and guidance for general PPE usage. The subspecialty PPE subcommittee addressed PPE needs in procedural areas and for those groups at high risk for exposure to COVID-19 (eg, the ED, interventional radiology, the cardiac catheterization laboratory).

The last subcommittee was the creative solutions team. This team was focused on ensuring a lasting supply of PPE; it addressed reprocessing of N95 masks through technologies such as exposure to ultraviolet light and hydrogen peroxide, creation and deployment of reusable gowns, and mask fitting based on qualitative methods to avoid the destruction of the masks. These subcommittees reported to the main task force where final discussions and recommendations would be made based on the current supply and the need to keep our providers safe. The recommendations would be forwarded to

the executive leadership at the system level and communicated out to all staff members daily.

Patient Discharge Processes

Given the unpredictable course of COVID-19, planning patient discharge was a complicated process. The MERIT, along with the social work and case management departments, set plans for discharge. Patients in ICUs are first transferred to specialty step-down units. Once patients are stable, they are assessed again, and the appropriate place for discharge is selected. Given the different criteria for admission to a chosen place of discharge, except for home, a patient's length of stay could be extended for a number of days. However, as more testing equipment, with faster turnaround times and better prepared staff, has become more common, lengths of stay are decreasing.

IHS also created a multidisciplinary team to address post-intensive care syndrome and created an education program for hospital and transitional care providers to encourage referrals for the COVID-19 post-intensive care syndrome population and their caregivers. We expect that our discharge process will continue to develop as we learn more about the long-term outcomes of COVID-19. Finally, as a part of our "one system" approach, we quickly transformed one of our decommissioned labor and delivery units into a skilled nursing facility for patients who were declined acceptance back to their prior long-term facilities.

Investigational and Compassionate Use Medications

Given the lack of established drug treatment for COVID-19, a number of medications have been given to patients.^{35,36} Although some of these regimens were given for compassionate use, treatment algorithms have been continuously evaluated for evidence updates. Treatments considered included remdesivir, corticosteroids, convalescent plasma, and hydroxychloroquine.

Putting It All Together: Impact on Outcomes

To date, IHS has provided this integrated care to more than 8000 patients hospitalized with COVID-19 with an overall death rate of less than 10% across the entire time span of the pandemic. However, most notably, over the course of the pandemic, the mortality was reduced from a peak of 20% in March and April 2020 to 6% during the plateau period (June–October 2020) to 12% during the second peak (November–December 2020). We also reduced our intubation rate from 46% in March 2020 to 7.5% by June 2020, which remained stable during the second peak. The length of stay was also reduced from 10.49 days during the first peak to 8.02 days during the second pandemic peak. These actions also allowed for minimal diversion of resources needed for the provision of care for non-COVID-19 patients. In addition, over time, recognizing the extreme demands placed on all caregivers, the hospital system created wellness programs and provided emergency time off and other initiatives to overcome provider exhaustion. As a result of these actions, we were able to restart elective surgeries in June

2020 in a safe, efficient manner. We were also able to adopt other medical advances: One was a stand-up outpatient monoclonal antibody infusion center for patients with mild COVID-19 in a day hospital model of care, and another was one of the most efficient mass vaccination sites in the region, which has been used as example of an innovative care delivery model.³⁷⁻⁴⁴ Finally, we have developed a protocol and infrastructure to collect data and provide care for COVID-19 long-haulers' disease (also known as long COVID or postacute sequelae of SARS-CoV-2 infection). In fact, according to recent estimates, up to 30% of people who have been infected with COVID-19, including those with mild disease, can experience long-term problems. This issue is so compelling that the National Institutes of Health has launched a 4-year, \$1.15-billion study called Long COVID to learn about this distressing public health issue.⁴⁵ We believe that the group of patients who develop post-COVID-19 chronic sequelae could pose a substantial burden to health systems that will require better understanding and management.

It is important to note that despite the COVID-19 challenges, during the past year our main hospital campus became a Magnet-designated hospital and achieved Stroke Center of Excellence status. Both of these achievements recognized the extraordinary care provided during this difficult period of time. However, it must also be acknowledged that despite these success stories, our changes in the processes of care were not without challenges. It is plausible that our intense focus on COVID-19 diverted focus from other important areas of our patient care mission. For example, we had to place on hold the development of our service lines established to deliver comprehensive care around clinical care pathways. Despite our efforts to provide support to our providers and staff, more could have potentially been done to reduce the psychological, physical, and emotional burden of dealing with this pandemic in such an intense manner.

Regardless of these potential limitations, our innovative and efficient approach to rapidly develop an integrated, collaborative, and patient-centric model of care provided our patients, we believe, with optimal care. In addition, our new service line-based models of care delivery are now well positioned to deal with any future major challenge and to provide seamless care delivery to all our current patients. On the other hand, it is difficult to compare our processes and outcomes with those of other hospitals, which may have faced different challenges and responded to them in a variety of ways.³ As more details emerge from other hospitals' responses to COVID-19, we may be in a better position to compare and contrast different approaches implemented by different health systems and hospitals. ■

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eAppendix Figure 1. Inova Health System Dashboard Used to Identify Staffing and Beds

Adult Hospitalist Provider Staffing

Facility
All

Date
May 5, 2020



v5.1 Andrej Kolacevski

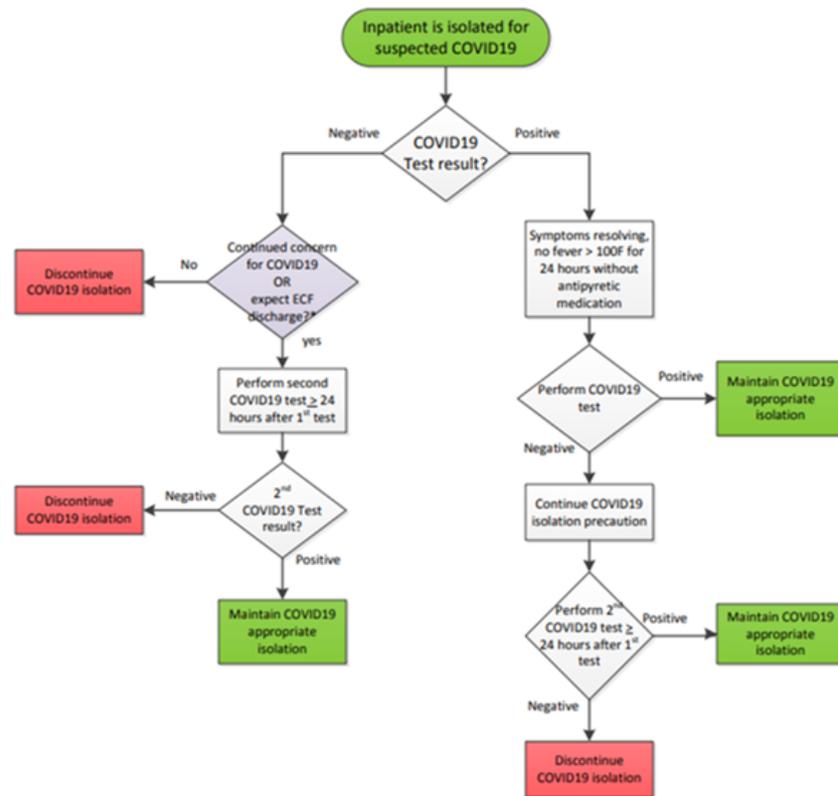


Realtime Capacity/Negative Pressure Room Available on the Epic Inova Capacity Management Dashboard

Moonlighter Usage	Moonlighter Available	Residual APP Staffing Status	Rem. Worker Availability	Quarantined Providers
Low	High	Low	High	0
High	Low	Low	Medium	0
Low	Low	Medium	Low	0
Low	Low	Low	Low	0
Low	Low	Low	Low	0

Adult Hospitalist Data Updated 5/5/2020

eAppendix Figure 2. Infection Control Algorithm



Discontinuation of COVID19 Isolation for Inpatients with Confirmed/Suspected COVID19 April 24, 2020

*ID doctor can be consulted if unsure, on call ID Doctor in the COVID Coordination Center can be contacted 8am-8pm (571)472-0321 (if ID not already involved or unsure who to call)
ECF=extended care facility (SNF, ALF, Rehab)

Providers should discharge patients when patients are stable for discharge. Discontinuation of isolation and decision to discharge from hospital are independent decisions