Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Disaster has been defined in numerous terms. But in essence, disaster is a disruption of function that causes the ability of the affected community to overcome using its resources.\(^1\) Pandemics are considered progressive occurrences with one causal organism, but various reasons for expanding from local infectious outbreak to a global pandemic. Unlike natural disasters, which most often have definitive onset and known number of immediately affected populations, epidemics most often begin sporadically and increase based on the route of transmission, infectivity, and mitigation efforts. This variability can complicate all stages of the disaster cycle (Fig. 1).

All disaster preparedness begins with basic concepts. Chance of the hazard or event happening to an area and the vulnerability of that community in the event of that event. This is termed the hazard vulnerability analysis (HVA). Novel infectious outbreaks such as coronavirus disease 2019 (COVID-19) are difficult because transmission, at-risk population, natural history, and effective public health policies are unclear early in the course. This leads to short or even nonexistent time to do an HVA. Before COVID-19, the 2019 U.S. National Health Security Preparedness Index, which assesses the ability to provide health care during large-scale public health threats, reported a significant gap in the U.S. health-care system to maintain quality health care during and after such an event.\(^2\) This chapter gives the authors’ perspective of how our systems approach disaster planning to the COVID-19 pandemic. Both health systems have multiple hospitals that overlap in Pennsylvania, which experienced a surge of COVID-19 patients early in the United States. The University of Pittsburgh Medical Center (UPMC) is urban based, while Geisinger Medical Center is rural based. Both systems’ hospitals and their communities are historically interconnected.

Proper preparation, resource allocation, and education contribute to variability and disaster response. Several studies from natural disasters show that resiliency and collaboration can support recovery efforts for communities. Some communities face unique challenges such as rural locations with geographic variability, funding,
coordination, and cooperation among local networks. The capacity and capability of a community and health system to respond to emergencies determine preparedness. Capacity is defined as having enough personnel and supplies, while capability has the correct resources. Appropriate and timely resource allocation and mobilization are essential steps to ensure preparedness. Unlike natural disasters, epidemics can be prolonged and put extreme pressure on the health systems making mitigation or “flattening the curve” paramount to maintaining capacity and capability.

From prior disaster research and recent COVID-19 experience, several themes emerge. There is extensive variability across the national, local, and organizational levels in addressing preparedness policies. Despite this variability, there is a clear need for essential aspects of preparedness, including assessing resources (stuff/space), training for providers (staff), and increased communication/collaboration across networks/programs. The inadequate response, failure to triage, and lapses in communication are common systemic barriers to significant incidents.3

The initial assessment must also include the identification of all stakeholders. The stakeholders include the community, the health-care system, and the local/state/national networks. Each stakeholder group has systemic and organizational structures established to aid in disaster response. In the community, this includes federal, state, and local governments and the community residents.

Community
The community requires information and education about their role in preparation and response. Public health networks and the existing health-care system strive to work in concert to orchestrate disaster response. The success of a coordinated
response and action plan is dependent on the strength and stability of the existing networks. Information and education are essential for the community to participate in their protection. Infection control and public health initiatives need to be accurate and timely communicated. Dissemination of precise information must include national and local health-care efforts to support public health. Additional measures by local government and primary care providers can help the community.

Geisinger has a robust connection with the community, given the population that it serves. Through social media and other public forums, Geisinger engages the community. Their participation through public health initiatives, such as universal mitigation strategies, and following local visiting policies are essential to combat surge. Geisinger leadership held community town halls throughout the pandemic to engage the public. Additional challenges to community preparedness are the dissemination of accurate and timely information. During an election year, the political climate can affect the tenor and quality of information that reaches the community. Public health initiatives should strike a neutral tone and be rooted in evidence and science. In the end, the public depends on its health-care system and the institution’s preparations.

Health care

Stuff

Health-care preparedness is the analysis and preparation of what is required and anticipated opportunities to plan. Disaster planning includes mobilization of necessary resources. The effective systemic response must have a coordinated and collaborative model to expect future surge. The importance of recognizing the current state versus the predicted future state is essential. Pandemic preparation at our institutions was a multipronged approach. The capability of our existing network to flex and respond requires the understanding of the supply chain and the available resources.

Resources and the delivery of care to patients demand accuracy. Supplies such as equipment, oxygen, and medications must be available as an alternative solution. The disruption of the supply chain during a disaster period also needs to be anticipated. Each department assessed current supplies and leadership focused on policies and procedures to implement throughout the network. For example, our existing triage policy was reviewed and updated by a multidisciplinary team of critical care leadership, physicians, and medical ethicists. Past analysis of disaster preparedness helps inform and prioritize activities that maximize a hospital’s capability to respond.4

Health-care delivery and estimates for surge capacity are required. Models exist to assist officials both nationally and locally for surge planning tools (PACER). Strategies to improve capacity such as (1) opening unlicensed beds, (2) canceling elective admissions, and (3) implementing reverse triage were all used simultaneously in preparation for the pandemic surge.5 At the network level, daily communication and collaboration supported our response to meet current needs for intensive care unit (ICU) level of care.
In the Society of Critical Care Medicine’s ICU Readiness Report to evaluate the state of ICU preparedness during the height of the COVID-19 pandemic in March 2020, 82% of respondents reported ICU shortages and bed capacity and 58% reported issues with adequate ICU staffing. Proactive planning for ICU staffing augmentation is paramount to the successful response to a local surge in ICU and critical care patient volumes. Each hospital system must design a system which caters to their personnel needs in terms of physicians, advanced practice providers (APPs), and nursing staff, among others. There will be an array of capabilities based on preexisting personnel, but plans should incorporate contingency plans to add additional personnel who are either present in the hospital working in different roles or with the use of outside personnel via ICU telemedicine. Institutions must have a framework to plan for increased capacity with the proportional expansion of staff and stuff. A framework was recently published, suggesting a tiered/graded system provides adequate staffing structure to respond. The local surge planning involves unit closures and redeployment of employees.

UPMC is a 40-hospital system ranging from rural to tertiary/quaternary academic centers in Pennsylvania, New York, and Western Maryland. They designed and rolled out a system-level ICU pandemic surge staffing algorithmic plan for implementation when “normal” ICU resources were exhausted and the potential for 100%–200% surge increase in patient volume occurs (reference). The plan was developed to ensure that local needs were balanced with system resource supply. A tiered-provider strategy was used by the hospitals to allow for adequate ICU and critical care coverage by physicians and nurses who had some experience in managing acutely ill patients. The first step in designing any staffing plan is to ascertain what were the existing staffing and then determine how this could be augmented with additional providers including tele-ICU medicine capabilities. UPMC used a tiered staffing algorithm designating “Tier 1” providers as critical care providers including telemedicine critical care providers. “Tier 2” providers were identified as those physicians with prior/remote critical care training, experience and skills, other airway capable providers (e.g., certified registered nurse anesthetists), and those who were non-airway providers but were ICU-capable providers (e.g., APPs). A “flex” tier, if available, could be a separate procedure team specifically for intubations, bronchoscopies, central and arterial lines, prone positioning, etc. This flex team could free up procedural time for those critical providers in the ICU and on the ward to focus on clinical management. In Fig. 2, the tiered staffing strategy shows how critical care including mechanical ventilator management be administered to four groups of 24 patients with a team managed by a critical care-trained physician. In Fig. 3, a more detailed outline is presented for the progression from Tier 1 to Tier 3 providers with the possible additional of tele-ICU support as well as the additional of a potential procedural team.

Based on the literature and experience, it was estimated that a Tier 1 provider on-site or as a tele-ICU provider could provide oversight care for 7–12 acutely/critically ill patients alone or possibly with the additional of a dedicated procedure team. Once this initial threshold is reached, Tier 2 providers will need to be added (each Tier 2 provider manages eight patients). With the addition of two Tier 2 providers, a Tier 1
Tiered Staffing Strategy for Pandemic
Requiring Significant Mechanical Ventilation

FIG. 2
A tiered staffing model demonstrating how a small group of critical care experts working in concert with non-critical care providers can provide critical care to an expanded number of patients during a crisis. APP = advanced practice provider, CAA = certified anesthesiology assistant, CRNA = certified registered nurse anesthetist, DO = doctor of osteopathic medicine, MD = medical doctor, RT = respiratory therapist.

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FIG. 3
A more detailed example of a tiered model for the expansion of critical care. Utilization of dedicated procedural teams for airway, central access, and proning is shown, allowing Tier 1 providers to be telemedicine and not on site. Tier 1 provider = critical care experts including telemedicine critical care; Tier 2 provider = providers with prior critical care training, experience, and skills (i.e., APP); Tier 3 = providers without previous critical care experience or skills. A separate classification as a “flex” tier would be those who might comprise a procedure team: providers with skill sets in intubation, bronchoscopy, central line insertion, arterial line insertion, prone positioning, but without bedside critical care expertise.

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provider could manage up to 16 patients. Once a threshold of 16 patients has been reached, an additional eight-patient team may need to be added to reach the highest threshold to manage 24 patients by a Tier 1 provider. Once the care of 16 patients is reached by the Tier 1 and 2 providers, it is recommended, if available, to add tele-ICU capabilities in addition to Tier 3 providers, who have no ICU experience, but can manage four patients each under the direction of the Tier 1 provider. This algorithm does not include resident or fellow trainees since there are many hospitals that do not have residents as part of their workforce. However, if trainees are available, they can be used as potential Tier 2 and 3 providers. Although this framework was originally developed by UPMC in response to the COVID-19 pandemic, this ICU provider staffing model can be applied for any response to increased ICU staffing demands for any disaster or mass critical care scenario.

At Geisinger, the critical care department and the biocontainment unit (BU) provided system expertise in the form of “site managers.” The site managers taught just in time hands-on personal protective equipment (PPE) simulation for COVID-19 and educated redeployed employees to act as donning and doffing buddies in emergency departments and COVID units. As members of the BU, the site managers were also well trained in infection control and were deployed to hospitals, clinics, and nursing homes to help with infection control education. They also established and managed the workflow process for dedicated COVID units. Anesthesiologists, hospitalists, and surgeons were updated on the management of non-COVID critically ill patients in compacted classes based on commercially available professional societies courses. The eICU platform assists our hardest-hit hospitals (Fig. 4).

**FIG. 4**
Use of source experts to scale-up capability.
Space
At the system level, action plans should address the increased need for surge patient care area. Preparation and procedures should outline plans to increase capacity in current and surge states. The variability and dynamic nature of a disaster highlight the need for flexibility and fluidity in the organization. In real-time, patients must be managed and directed to the appropriate level of care. This coordinated effort must be collaborative and actively monitored.

In the pandemic’s initial stages, COVID patients went to separate ICU and medical/surgical units. The conversion of existing ICU and med/surgical units into negative pressure rooms. The hospital’s preparation supports the required capacity. As the rate of infections and hospital admission decreased, our leaders made conscious decisions to maintain all COVID patients in one unit. Our current structure cohorts all COVID patients (ICU vs non-ICU) for the hospital. That existing space is evaluated by leadership daily. Employees receive daily emails that graph current trends and patient volume. This indicator may be an early warning system for climbing infections and the potential need for increased capacity.

Once patients are out of the acute phase of illness, they transition to post-acute care. The patient’s level of recovery determines appropriate placement. It can include skilled nursing facilities or home health. An adjunctive and flexible program at our institution is Geisinger at home. This program monitors patients at home with nursing visits and close follow-up during the post-acute care period. In the future, strengthening this outpatient network and mode of health-care delivery may reduce the need for hospital admission. The ability to offload intensive and resource-demanding care to the outpatient arena provides flexibility. In another way, innovation may transform future delivery of care.

How

a. Established “quality care” and evidence-based protocols are necessary to ensure basic practice standards. Multidisciplinary workgroups were assigned to tackle specific health-care areas and follow up-to-date evidence and emerging literature. Revisiting and revising past policies is essential to remain current and prepared for disaster. For instance, systemwide COVID-19 patient care guidelines were created by a multidisciplinary committee and updated weekly.

b. Innovation improves health-care delivery and resource utilization. During the pandemic, telehealth has received a significant boost in support. Our existing eICU platform provided support to our critical care colleagues at the most impacted locations. Additional telemedicine support in the outpatient setting allowed primary care providers to deliver preventative care. The innovation continues throughout the pandemic with alternative solutions to common problems.
Provider and family

The total impact of the virus is unknown, and health-care workers are not immune. Internal resilience often balances everyday stressors. However, the accumulation of additional burdens can disrupt the internal demand/resource paradigm. Without self-awareness, the transition from one level of functioning to another may progress to the point of dysfunction. Stress responses, such as increased irritability (flight), anxiety (flight), and stuck (freeze), should be recognized as warning signs. Often mental health is overlooked in times of disaster.

At Geisinger, we have a dedicated ICU psychologist who works as part of the care team, conducting evaluations, brief intervention, and assistance with managing psychological distress in patients and families. During the COVID pandemic, this psychologist continues to provide care, addressing delirium, acute anxiety, distress, and traumatic stress symptoms in hospitalized COVID-positive patients. She also provides an emotional support to patients’ families via telephone, when distressed family members are identified by ICU staff.

It has been observed that COVID patients with higher severity of illness, often requiring higher levels of sedation, tend to experience increased delirium, agitation, delusional memories, and hallucinations during ICU stay. Furthermore, calls to distressed family members have been disproportionately made to families of younger, more severely ill patients, and those with more prolonged ICU stay.

In addition to patients and families, the ICU psychologist also regularly offers support to staff and frontline members of the care team. During the pandemic, this support has occurred both informally and formally. Informally, her presence in the COVID unit working among staff and inquiring about the well-being of care providers generally helps to increase the morale of unit staff. Formally, at the beginning of the pandemic, the psychologist assisted in facilitating the inception of a program designed to “care for the caregiver” or provide peer-to-peer support to hospital workers and staff, the Resilience in Stressful Events (RISE) program. This program, designed at Johns Hopkins, is a confidential peer support initiative intended to provide in person brief psychological first aid and support to health-care personnel who have experienced stressful or distressing clinical events. RISE aims to decrease rates of burnout and second victim syndrome in health-care providers. This program is now used in more than 30 hospitals nationwide. At Geisinger, RISE, though initially planned to be implemented at the end of 2020 or early 2021, was expedited at the request of the critical care department to meet the rising stress of the COVID pandemic.

The continuum of COVID patient and family care does not end with hospital discharge. At Geisinger, many of these patients, based on the severity of illness, are offered participation in the post-ICU survivor clinic. Patients seen in the post-ICU clinic are regularly among the sickest patients treated in the ICU. During the initial clinic visit, patients, typically accompanied by a caregiver, are evaluated by the ICU psychologist, a critical care physician, and, for those with a history of documented delirium in the ICU, a neuropsychologist as well. At present, we have begun to see
discharged COVID-positive patients and family members in the clinic. These patients appear to have some increase in post-ICU syndrome (PICS)—new or worsening impairment in physical, psychological, or cognitive health and functioning that occurs following critical illness and persists beyond discharge from the hospital.\footnote{9} We have observed our patients experiencing challenges with adjustment to ongoing respiratory and physical limitations (e.g., decreased lung capacity, shortness of breath, limited mobility, generalized weakness), anxiety and concern for future deterioration in health or reinfection with COVID, symptoms of posttraumatic stress disorder related to delusional memories associated with heavy sedation use (e.g., reexperiencing delusional memories in the form of flashbacks and nightmares), symptoms of depression, survivor guilt, anger, and, in one patient, ongoing inattention and visual hallucinations despite otherwise normal recovery. We have referred some of these patients for ongoing treatment with psychologists or further evaluation with neuropsychology, along with follow-up care for physical concerns. Caregivers of COVID-19 patients have also reported psychological distress associated with isolation during the hospital stay, perception of the slow recovery of loved ones, and anxiety associated with the health concerns.

Patients with COVID-19 are at increased risk of delirium due to multiple proposed mechanisms and pathways associated with this virus.\footnote{10} Higher rates of delirium during ICU admission increases the likelihood that COVID patients will have ongoing needs, including PICS following hospital discharge. Also, isolation associated with restrictions in visitation policies and hospitals and post-acute care settings, and higher rates of illness severity and complication, increase the risk that family members and caregivers of COVID patients will experience long-standing psychological distress (i.e., PICS-families [PICS-F]). Thus a post-ICU clinic, like ours at Geisinger, is a vital part of assessing and addressing the ongoing needs of COVID-positive patients and families following hospital discharge.

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**Other disaster care during COVID-19—Experiences from the front line**

Other disasters, both natural and human made, will occur during a global pandemic—additional states of disaster stress a tenuous health-care delivery system. Disasters, in conjunction with COVID, will present unique and unprecedented challenges. Health-care institutions should review their emergency operations plan to incorporate COVID mitigation strategies that apply during events that cause an influx of patients. Recent examples include Hurricane Laura and the West Coast wildfires. A state of emergency and disaster, if appropriately prepared, can be managed successfully.

1. **Natural disasters**

   Natural disasters such as hurricanes, floods, earthquakes, wildfires, tornadoes, tsunamis, volcanic eruptions, etc. continue to occur globally. Given modern
advances, some of these events now have an advanced warning from minutes to
days in advance. The large-scale geographical impact of events can displace a
large number of people. Displaced people will need shelter; some people will
have complex medical needs or comorbidities. Shelter layout requires planning
and needs evaluation in the era of COVID.

Forcing social distancing can be accomplished by limiting and distancing the
number of cots placed in a shelter. Utilizing additional areas for the housing of
displaced persons, like hotels, would be preferred as it is more accessible to
cohort those screening positive for COVID exposure and symptoms. Cohorts of
families in shelters also assist in social distancing among other occupants. The
health-care system may assist with daily patient screening in shelters
(temperature screening and COVID symptom questions). Health-care staff may
also be displaced and could require housing assistance. At our institution, call
rooms and off-campus housing were open to any staff who required isolation or
quarantine. If able, health-care facilities should ascertain where all patients are
presenting from and where they are lodging.

Contact tracing and early mitigation are essential for COVID-positive
patients. Natural disasters can cause an initial influx of patients from injuries due
to the event. If the infrastructure is damaged, patients can overwhelm functioning
hospitals or clinics by presenting with minor illnesses or injuries; in the recovery
phase, patients may seek medication refills and treatment for cellulitis, insect
bites, sprains/strains, laceration repairs, etc.

2. Human-made disasters

Human-made disasters such as active killer events, events involving
chemicals, explosions, transportation accidents, acts of terrorism, etc. continue to
present systemic challenges. These events are usually chaotic, unpredictable, and
can result in many patients presenting to hospitals to seek treatment. A majority
of patients may self-present to a hospital for treatment; emergency medical
services agencies, especially in rural settings, may be overtaxed by the volume of
patients at the scene.

Due to the acuity and volume of patients presenting to a hospital during the
initial phase of the disaster, it may be impossible to screen all patients for COVID
signs and symptoms. Emergent and aerosolizing procedures may be required for
multiple patients. In most instances, patients with chemical exposure will need
decontamination before entering the hospital. Attempts to distance and to apply
universal masking to patients in decontamination lines may not be feasible. Wet
decontamination is accomplished with copious amounts of water and soap. The
goal is to decontaminate as many patients in a short period effectively and limits
sanitizing in between patients.

3. Mitigation strategies

In the event of a disaster, these mitigation strategies may assist in curbing and
containing the spread of COVID. Depending upon the situation, some of these
strategies are relatively easier to implement and may already be in place before a
disaster occurs. It is imperative that even in a disaster, we do not forget the
basics—handwashing, cleaning equipment/surfaces, and proper donning/doffing
of PPE; staff safety will always take precedence. Including COVID mitigation strategies in disaster planning and preparedness is essential. Testing these strategies before an actual disaster will assist in finding deficiencies that can be improved upon and will make staff more comfortable and familiar with the disaster plan.

- Universal source control should be implemented by masking all individuals presenting to a hospital or shelter. Hospitals would need to ensure that an adequate supply of masks are available for distribution as there will be an increase in demand.
- If possible, all individuals should undergo screening before entry into the hospital. Screening would consist of temperature checks, questions to identify COVID symptoms, and questions to identify potential exposure to COVID or those with COVID symptoms. Patients requiring lifesaving interventions, higher acuity patients, and those who are not capable of adequately answering questions may not be screened. If space allows, cohort patients with positive COVID signs/symptoms into a separate isolation area and positive COVID exposure into a separate quarantine area.
- Consider having all staff providing direct patient care wear an N95 mask with eye protection (or powered air-purifying respirators, if available, for those who failed fit testing) for all patient encounters.
- COVID testing is already challenging, and availability/laboratory capacity is stretched further during a disaster.
- Increasing the opportunity to perform hygiene is paramount. Adding or increasing the quantity of alcohol-based hand rub in patient care areas and areas where people may be gathering can increase compliance with sanitizing hands. If water supply has been compromised, the addition of portable handwashing stations would be highly beneficial.
- The frequency of sanitizing patient care areas, high-touch surfaces, communal bathroom/shower areas, and sleeping areas should be increased.
- Displaced hospital staff may need lodging in the event their homes were damaged or destroyed. Locating lodging space for displaced staff on the hospital campus is beneficial. Keeping the same staff from different shifts assigned to the same individual sleeping area would reduce the number of people exposed if a staff member becomes positive; having a sign-in log would help track staff in an exposure. Cleaning of the lodging area should be performed between shifts.

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