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.

chapter 28

Surge Capacity

Julie Ann P. Casani and Albert J. Romanosky

The events of 2001 are often cited as being pivotal for a new definition of preparedness. In actuality, there were multiple factors forcing the healthcare industry to look at surge capacity before the 2001 terrorist attacks on the United States. Beginning more than two decades earlier, crises in emergency department overcrowding provided insight into the necessity for flexing the number of hospital beds, providing rapid discharge of inpatients, delaying scheduled surgeries, diverting ambulances based on triage criteria, and altering practice paradigms to allow "auxiliary" nursing staff to provide necessary emergency care. Since 2001, events such as severe acute respiratory syndrome (SARS) and smallpox preparedness have illustrated the need for surge capacity and the ability of facilities not only to flex upward the number of beds but also to supply specialized or specified treatment (e.g., high-level respiratory isolation). The majority of surge planning has focused on trauma care for victims of multicasualty incidents; terrorist and industrial chemical incidents; and public health emergencies, such as bioterrorism and natural epidemics. There are discrete differences in the type of capacity needed for each type of incident, but there are overarching principles that can benefit surge capacity planning for all-hazards disaster planning.

One of the great challenges has been funding for surge capacity. Health economics in the United States, in an attempt to limit escalating healthcare costs, has resulted in the overall reduction of acute care inpatient beds and has eventually led to a vastly expanded network of industry related to home care and intermediate care facilities. In most acute care hospitals, making the "bottom line" is a challenge in itself, let alone providing services and capacity for an event that may never happen, developing resources that are costly with limited or no pre-event funding, and planning for expenditure of resources that may not be reimbursed. The end result is opposing forces and policies in which preparedness efforts are attempting to increase surge capacity while cost containment measures are shifting care away from acute care centers (ACCs).

Surge capacity has been defined as encompassing "potential patient beds; available space in which patients may be triaged, managed, vaccinated, decontaminated, or simply located; available personnel of all types; necessary medications, supplies and equipment; and even the legal capacity to deliver health care under situations which exceed authorized capacity."[1] Integral to this definition are the multiple elements, not solely facilities or beds. Hick and colleagues[2] go on to define surge capability as the "ability of the health care system to mange patients who require specialized evaluation or interventions." This distinction is important because it focuses on the more specialized resources and nonfixed bed capabilities. Historical events and theoretical models provide estimates of the number of acutely ill people requiring care after disasters. However, the definition of an "acutely ill or injured" patient is case-dependent and does not reflect the *level of care* the victim may require. Trauma-related projections range from 100 to 300 patients/1 million population after mass casualty incidents (MCIs) to 300 to 600 patients/1 million population, according to the National Disaster Medical System (NDMS) plans. There are limited projections for bioterrorism or large-scale communicable disease models. These include the NBC-CREST (Department of Defense) model estimates of 500 patients/1 million population and pandemic influenza planning estimates of 15% to 35% of the population. The pandemic influenza model assumes a gross attack rate of 30% and would result in five times as many influenza-related hospitalizations and deaths as in a regular influenza epidemic with the current levels of vaccination in the population, mostly in persons ages 65 and older.[3] Based on data from the influenza pandemic of 1918 to 1920, projections were made with respect to the current population of Germany (approximately 82 million). An estimated 20 million to 25 million cases of influenza will occur, with 200,000 admissions to hospitals, resulting in a total of 1.6 million days of hospitalization, 120,000 deaths from influenza, and an annual excess mortality of 175,000. This is a ratio of 2500 hospital patients/1 million population. Approximately 1.2 million cases of pneumonia as a secondary infection also should be expected.[4]

Because of the wide spread of estimations, which are dependent on the causative agent, for planning purposes, many use 500 adult and pediatric victims/1 million population above the daily capacity to calculate surge capacity. A regional capacity requirement example is found in Table 28-1; Region A is an intrastate region in which City A is located.[5]

TABLE 28-1 REGIONAL CAPACITY REQUIREMENT

	POPULATION	SURGE (BEDS/ PATIENTS)	CURRENT DAILY CAPACITY	INCREASE
State A	5,595,211	2798	10,006 (48 facilities)	28%
Region A	2,571,695	1286	6129 (22 facilities)	21%
City A	628,670	314	3827 (12 facilities)	8%

Most projection prototypes assume the current healthcare delivery model, which may or may not be attainable or sustainable at high levels of patient load. Regardless of cause, to approach projected levels of surge demands, multidisciplinary, multientity, regional, collaborative planning must be undertaken because no single component can provide all of the necessary resources. The authors of the Agency for Healthcare Research and Quality document, *Regionalization of Bioterrorism Preparedness and Response,*[6] conclude that "regionalization is likely to benefit elements of a bioterrorism response including the provision of surge capacity in essential response services such as triage, the provision of medical care, distribution and dispensing of prophylactic therapies, outbreak investigation, security management, and emergency management.... Coordination of these organizations may benefit from implementation of information management strategies and pre-event agreements that specify response roles, remuneration, and chain of command."

Overall coordination of planning and response is critical for implementation. The introduction of new modalities and paradigms presents a challenge to responders and the public who will instinctively react as they have in the past. If new programs and responses are expected to be implemented, then adequate communication, education, and exercises will reinforce this implementation. Incident management systems and Incident Command Systems must be integrated along with communications systems and protocols.

Multiple models have been postulated for the systematic, graded response necessary to provide a capacity to care for an overwhelming influx of patients.[7,8] These models provide tool kits for evaluating the utilization of current resources and defining supplementary resources to provide the necessary location, staff, and supplies for response. Additionally, the type of incident may require a shift in necessary assets and availability of these assets. For example, the immediate response required in a catastrophic explosion will require a different strategy than the sustained nature of a wide-scale communicable disease event. Few of these models allow for healthcare staff to be among the ill or injured. In the Toronto SARS experience, the incident rates among nurses who worked in emergency departments, intensive care units, and coronary care units ranged from 10.3% to 60.0%.[9] In addition, non-ill providers who fail to report for duty may further affect response. The potential unreliability of the assessment of available resources may be especially troublesome if the healthcare workforce is particularly vulnerable physically or psychologically, as in the SARS outbreaks of 2003 and the early outbreaks of Ebola hemorrhagic fever. Likewise, few of these models anticipate the loss or compromise of a healthcare facility or access to it if it is located in close proximity to the event.

There are a number of dynamics that must be considered to prepare overall for a surge of acutely ill or injured patients. On a daily basis, the healthcare system attempts to provide the necessary triage, treatment, and health maintenance at a level that is determined as "normal operations." A tentative balance of supply and demand is struck, based on dynamic shifts within a health system that is typically already at capacity. The actions implemented are variably applied and do not address the root causes behind the immediate crisis of overload: the critical nursing shortage, health insurance inequities, national malpractice concerns, and health economic trends. In many cases, the immediate demand is met and the system returns to an ever-increasing new normal of stress.

During the day, week, month, or season, if a peak in the number of patients is observed, then local, facility-specific provisions adapt to this increased demand by implementing "emergency operations." This may result in longer office hours, emergency department diversion, longer wait time for ambulances, early discharge protocols, etc. A 2001 American Hospital Association survey showed that 60% of all and 80% of urban hospitals described their emergency departments as "at" or "near" capacity, as did 90% of all Level 1 trauma centers with more than 300 beds.[10] One in eight hospitals reported emergency department diversion 20% or more of the time. About 20% of the hospitals' capacity can be freed up by discharging existing patients, canceling elective surgery, and calling in off-duty staff. This response is usually (1) area limited, (2) time limited, (3) difficult but manageable, and, (4) occasionally "routine." Repeated or prolonged stress at this level results in either a short-term (weeks) decay or, optimally, long-term solutions, such as increased staff, re-engineered space, etc. Close examination of these solutions provides important insight into potential solutions to a larger-scale, longer-term surge capacity situation. The incremental costs of re-engineering space to provide flexible utilization is much more cost-effective and allowable under most regulatory systems than is a fixed building or permanent assignment of space. The process involved in changing operations, such as surgery scheduling and staff shift flexibility, provides insight into the impact of long-term disaster services. For example, Rambam Medical Center in Haifa, Israel, can increase the number of burn victims it can handle from 15 to 136 by altering staff allocations and re-engineering space.[11]

Larger-scale events, longer-term events, or those requiring specified care will place unique demands on a system, regardless of emergency operations preparedness. It should not be assumed that 100 times as many patients require 100 times the amount of response. At some point, which will vary depending on resources, community, and type of event, a critical threshold will be met in which "emergency operations" no longer suf-

fice. At this point, "disaster operations" are implemented. Efforts such as (1) "aggressive diversion" of patients to triage and decontamination facilities, (2) implementation of treat and release/refer protocols, (3) transfer of nonacute admissions to long-term care facilities, and (4) institution of widespread home care plans may be put into operation (Fig. 28-1). "Aggressive diversion" of patients refers to the direction or redirection of ambulances and patients away from acute care facilities to locations that provide triage, decontamination, and/or treatment. This may be done by transportation away from facilities, public information campaigns instructing people *not* to go to hospitals but rather to seek care at off-site centers, etc. Treat and release protocols and referral protocols may be implemented to allow for expedient care and throughput in alternative facilities or by physician and nurse extenders. Each of these programs requires extensive planning, policy and statutory research, and public dialogue in preparation for implementation.

CURRENT PRACTICE

A matrix of planning capacities is offered (Table 28-2). It is recognized that this is only one approach to maneuvering through the very difficult process of assigning resources and anticipating needs. This matrix is prepopulated and is provided as a starting point for planners. It is fully expected that communities may add or delete components that reflect available resources and cultural acceptance of their uses. A discussion of the components follows.

Arenas of care have been delineated with the assumption that there will be a continuum of care and that patients may not attend every arena. The "prehospital" arena is care delivered between the scene of the incident and definitive care. The care may be provided by traditional first responder entities (law enforcement, fire/rescue/emergency medical services [EMS], etc.) or via portable emergency triage and decontamination centers for large-scale events. This arena may also include any ad hoc informal community first aid centers. Integration of these may be a challenge, especially in light of limited communications and information systems. However, general public community education and preparation may eliminate a portion of the system's surge demands. It may be assumed that not every person needs to be treated in a formal medical care unit. It may also be assumed that not every patient will be cared for in a prehospital arena and may self-refer directly to "traditional facilities." In fact, the overwhelming majority of ambulatory patients are likely to self-refer to the nearest known traditional facility (hospital) in an acute disaster, such as natural disasters, explosions, etc. In some public health emergencies that develop and progress more slowly, this may or may not be the case. Education efforts and consistent, clear information programs and policies could affect this behavior.

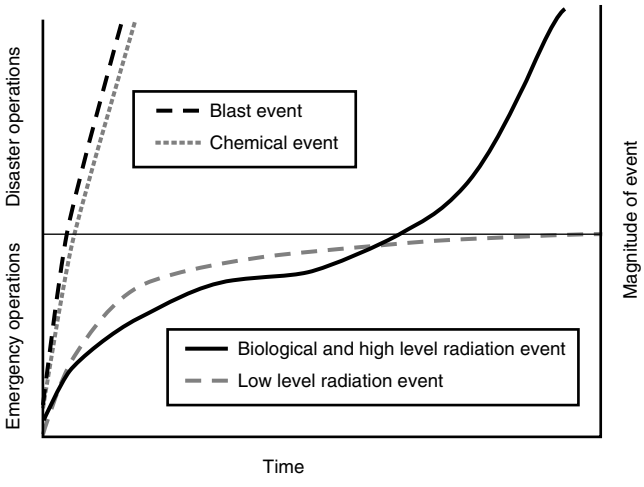

FIGURE 28–1. Response and magnitude of event plotted against time. Depending on the nature of the event, the healthcare system will attempt to respond to the increased demands. As demand for services increases, "normal operations" will be replaced by "emergency operations." As the system is again stressed, the response shifts to "disaster operations."

"Traditional facilities" refers to locations where acute and general care is routinely delivered. These include emergency facilities, hospital- and nonhospital-based; private healthcare provider offices; small and large group practices; and community health centers, both private and those operated by public health entities.

During a health emergency, care may be shifted away from traditional facilities, either through naturally occurring forces or through policy and procedure implementation. It is commonly assumed that an expanded capacity within traditional facilities will provide the answer to surge demands. It is postulated here that if that were the case, then surge capacity would not be an issue at all other than building and supplying more traditional facilities. As elaborated earlier, this is antithetical to current market and overall health policy forces and is the very reason surge capacity becomes problematic. Therefore, to supply services during the increased stress of a health emergency, the system will need to look to "nontraditional facilities" in addition to the traditional facilities for resources. For a biological event or communicable disease public health emergency, this may include establishing treatment and triage centers not in hospitals but in other locations, such as long-term care facilities, hotels, and schools, perhaps using the Soldier Biological and Chemical Command (SBCCOM) Modular Emergency Medical System model.[12,13] For a chemical event, this may be establishing locations for decontamination, triage, and treatment away from emergency departments, for example, in an off-site triage, treatment and transportation center (OST^3C)[14] if such a center can be established quickly and in close proximity to the event so that it is visible and accessible.

Finally, there can be many patients who are either not treated in an acute care facility of any kind but are referred home and are treated and/or followed-up at home or at a later time as referrals. This "nonfacility" domiciliary environment should not imply noncare. Instead this may require quite complex care and complex case management and will engage the medical and nonmedical communities and family resources.

TABLE 28-2 SURGE PLANNING MATRIX*

COMPONENT	PREHOSPITAL ARENA	TRADITIONAL FACILITIES ARENA	NONTRADITIONAL FACILITIES ARENA	DOMICILIARY CARE ARENA
Facilities	Triage facilities Decontamination facilities Private offices, community health centers, large group practices Transport vehicles (emergency medical service [EMS], private carriers, transportation sector resources)	Emergency departments, urgent care centers Hospitals Public health centers	Off-site treatment centers (acute care facilities) Long-term care facilities (off-site triage, treatment, and transportation center [OST^{5}C])	Homes Dormitories Hotels
Personnel	EMS providers (ALS/BLS) Public health and hospital workers Volunteers Disaster medical assistance teams (DMATs), U.S. Public Health Service (USPHS) Metropolitan Medical Response System (MMRS)	Healthcare providers Volunteers	Healthcare providers Public health Volunteers DMATs, USPHS Nongovernment organizations Medical professions students Strategic National Stockpile	Public health: epidemiological investigation and tracking Home healthcare agencies Community and faith-based groups Nongovernment organizations
Medication and supplies	MMRS DMATs Planned caches Vendors	Strategic National Stockpile Planned caches Vendors	Strategic National Stockpile Planned caches	Strategic National Stockpile Vendors Planned caches
Policy (including legal and statutory issues)	Triage protocols Mutual aid agreements Credentialing of volunteers	Specialty hospital designation Triage protocols Discharge planning Transfer protocols Credentialing of volunteers	DMATs Vendors Transfer protocols Credentialing of volunteers	Coordination

*This matrix is prepopulated with elements to begin planning efforts for surge capacity. Please refer to the chapter text for descriptions and discussion of the elements listed.

Facilities

Prehospital Arena

In areas where private-sector ambulances are not typically used for emergency transport, prior memoranda of understanding (MOUs) may be necessary to ensure availability, credentialing of personnel, emergency reimbursement, dispatch protocols, medical direction, etc. Additional resources from the transportation sector may be engaged, optimally with prior planning. Buses, taxis, and vans, both public and private service, can be used to transport large numbers of patients. Public-sector transportation vehicles are typically rapidly and easily accessible to government authorities. Many government authorities contract with private conveyance systems for more routine transportation needs. There may be opportunity to expand those contractual services to include emergency availability for transport not only of patients but, potentially, personnel. Finally, use of mass transportation vehicles may offer shelter for victims during the initial phases of a disaster.

Traditional Facilities Arena

Much has been done in the United States to prevent damage to critical structures from natural hazards such as earthquakes and floods. Seismic design provides stability of hospitals and allows for maintenance of care in high-risk areas.

Traditional facilities typically provide surge capacity for beds by reallocating designated beds to the event. For example, postanesthesia areas that have cardiac monitoring capabilities may be turned into intensive care units. Hospital-based same-day surgical suites may be used in the treatment of acute injuries because they also house minor surgical supplies. Rooms with additional oxygen outlets that are used on a daily basis as a single-bed room can be used to cohort contagious patients.

As demand increases, patients requiring isolation who are dispersed throughout the hospital can be gathered into specialized multiroom units. Specialized needs for high-level respiratory and isolation units may be "created" by relatively low-cost engineering with the installation of ventilation deflectors that allow for negative air flow to those rooms individually or to a unit. In an incident, air flow and air exchanges can be adapted to provide flexible utilization of nonspecialty bed capacity. The authors of *Regionalization of Bioterrorism Preparedness and Response*,[6] through retrospective analysis, determined that "pre-event hospital designation contributes to lower costs and improved patient outcomes. The evidence from trauma care regionalization suggests that a key component of high-quality, cost-effective care is limiting high-cost specialty care to specifically designated hospitals

with increased experience in treating severely injured patients. A bioterrorism response system may benefit from the pre-event designation of hospitals." However, in the SARS events in Toronto, it was found that the transfer of patients to designated facilities may have contributed to further spread of the disease, especially early in the outbreak when control measures were still being clarified and made universal.[15,16] Well documented in the literature and further described by Einav and colleagues[17] in a study of terrorist-related MCI blast incidents, the most urgent and nonurgent victims are taken to the nearest hospital, even if it is not a designated trauma center. The authors suggest a paradigm shift in trauma care in which all hospitals should have some minimal level of capability for trauma care. In fact, the most recent model in Israel designates the nearest hospital as the evacuation hospital to which all trauma victims are taken. Only the most seriously wounded get surgical intervention while other less critical victims are sent to surrounding facilities after stabilization of life-threatening injuries, thereby making the facility serve as a triage center. In a mass-casualty event, referral and transfer to tertiary care facilities for advanced specialty care may be necessary and desired; however, in the disaster operation phase, these specialized services may no longer be available, either because the services have been diverted to general care or the specialty services are overwhelmed. Additionally, until or even after aggressive diversion of patients to triage centers is well established, patients may still self-refer to the hospital of their choosing for a number of reasons, including proximity, insurance coverage, and personal preference. It may be unpredictable as to which facilities will become a focus for care and likely that many, if not all, hospitals will become primary institutions. For this reason, *every* facility must be prepared to care for patients.

In addition to hospitals, other traditional facilities will be used through self-referral or through a planned, graded diversion triage plan. Patients with minor illness and injuries can be triaged to urgent care centers, public health centers, and community health centers. The results of a pre-event inventory of laboratory and radiologic capabilities will determine optimal triage protocols.

In disasters in which access to critical routine healthcare is disrupted, such as for patients undergoing hemodialysis and those with a chronic fragile health status, diversion to traditional facilities may place a surge capacity need in a different manner. Traditional facilities will need to be capable of maintaining critical services while also contributing to the community's surge capacity.

Nontraditional Facilities Arena

The OST^{3}C model uses a rapidly deployable center that would accept patients, either self-referred or transported by ambulance from an explosion or chemical event. It has been suggested that early deployment of local medical centers can alleviate the burden placed on local hospitals.[18] Decontamination facilities may need to be established rapidly to prevent further contamination of the center. Patient care flow in the center directs patients first to a triage process and then to either a transportation section for transfer to a hospital or to a treatment area for definitive care. The duration of care is anticipated to be relatively brief (24 hours or shorter) and may consist simply of observation for further symptoms. Because most casualties in an acute, rapid-onset event (explosion, structure collapse, or chemical release) will be rapidly transported, the most significant weakness of the OST^{3}C model is the need for rapid deployment and implementation. Therefore, the OST^{3}C facility must be well planned, well integrated, and well rehearsed. This frequently limits its utilization; however, two additional potential roles for such a facility include short-term (12- to 24-hour) observation units and predeployment for large-scale events, such as mass gatherings. Physical requirements include access to controlled vehicular traffic for ambulance use, male and female lockers and shower facilities or an external water supply for outside decontamination, heating and air conditioning, electricity with generator back-up, etc. Potential buildings to be used for an OST^{3}C are gymnasiums, fitness centers, hotels conference centers, and any other building with large space capacity.

The acute care center (ACC) component of the Modular Emergency Medical System (MEMS) provides a care center approach. As described in *Modular Emergency Medical System: Concept of Operations for the Acute Care Center,*[19] the ACC is designed as an organized, equipped, and staffed facility specifically to provide services to those affected by a biological or communicable disease event. It is designed to treat patients who require acute care but not mechanical ventilation for a duration of days to weeks. Patients who require intensive life supportive care would be admitted to a traditional hospital. The ACC would be near a traditional hospital but transparent to the public who should self-refer or be referred to the center's emergency department for initial evaluation and subsequent triage.[19] However, the ACC also could be integrated into diversion protocols to alleviate emergency departments from this triage function and optimize the ACC's utility. The ACC module is a 250-bed pod system (5 × 50-bed nursing units) that is expandable to a maximum of 1000 patients and requires 40,000 to 48,000 square feet. Ideal buildings include armories, schools, hotel conference rooms, and community centers. These buildings offer adaptable space, heating and air conditioning, kitchen facilities, adequate plumbing facilities, and power and water supply. They also may supply necessary Internet access.[19]

Long-term care facilities (nursing homes, assisted living facilities, and rehabilitation centers) may be available either for acute care patients or for patients who were discharged early from traditional acute care facilities to make beds available for disaster victims.

Special medical needs shelters that focus on attending to people requiring specialized services may allow the healthcare community not only to provide acute services to this population but may also allow for continuing care and domiciliary care for subacute and longer terms of treatment. The need for this type of shelter and the specific resources necessary must be planned for after an assessment of the community, optimally before an event.

Domiciliary Care Arena

Patients who are discharged from a hospital, treated and released home from triage centers, or those being observed at home for symptoms will require specific facility resources. Adequate home care accessories (e.g., wheelchairs, crutches, bandages) may need to be made available. Patients being monitored by public health authorities either for epidemiological information or symptoms will require adequate access to telephone monitoring or access to providers visiting at the home. As required, the homes must be able to provide heat or air conditioning, power, water, a food supply, and the basic needs. If homes are not available, alternative domiciliary care can be provided at locations such as hotels and college dormitories.

There are additional considerations for all of the previously cited facilities. Care should be taken not to identify facilities assumed by other response agencies (e.g., American Red Cross, National Guard Armories). In addition, portable structures, either hard shell or tent type, can be used and provide cost-effective, nonconstruction solutions. The length of use may be affected by the choice of shell, weather elements, and actual use. MOUs with facilities, especially if not publicly held, should be instituted to allow for availability and postevent reimbursement and recovery. Alternatively, adequate legal authority of local or state officials to commandeer facilities must be established and used.

Personnel

During the evolution of the event through to disaster operations, the roles of personnel may change and practice paradigms may shift. Table 28-3 illustrates this shift in roles.

Prehospital Arena

For formal incident scene triage, treatment, and transport, traditional fire/rescue/EMS and other first responder agencies will provide the necessary care. Informal triage and transportation will also be performed by bystanders and the casualties themselves. The formal resources can be supplemented with community teams, such as the Community Emergency Response Teams (CERTs). The CERT program is an all-risk, all-hazards training in which citizens may initially take actions on their own, and these actions can make a difference. The CERT program was developed by the Los Angeles Fire Department (LAFD) to engage citizen volunteer efforts to augment the response capacity before and during the department's response. In 1993, the Federal Emergency Management Agency (FEMA) made the concept and program available to communities nationwide. The Emergency Management Institute (EMI), in cooperation with the LAFD, expanded the CERT materials to make them applicable to all hazards. In January 2002, CERT became part of the Citizen Corps, a unifying structure to link a variety of related volunteer activities to expand a community's resources for crime prevention and emergency response. As of December 2004, 50 states, three territories, and six foreign countries were using the CERT training for a total of 1900 CERT teams.[20]

Because of the magnitude of a catastrophic event, such as an explosion, adaptations will be made as MCI operations are instituted. Triage will be abbreviated with use of systems such as the Sacco Triage Method or START (Simple Triage and Rapid Treatment Plan) method, which were both developed for use by rescuers with basic first aid skills to triage patients in 30 to 40 seconds or less. The Sacco Triage Method attempts not only to assign a level of acuity to a patient but also allows available resources to be assigned to the patient. Optimally, treatment will be limited and patients will be transported per MCI protocols.

Central collection points, such as portable triage shelters or the OST^{3}C, can be staffed with personnel other than traditional first responders. Care at these intermediary centers is not expected to be a substitute for that provided in a traditional emergency department; staff should be able to provide, at a minimum, basic life support functions. Individual jurisdictions may decide to staff these centers with personnel who can provide a higher level of care if, for example,

TABLE 28-3 HEALTHCARE PROVIDER ROLES*

PROVIDER	DAILY ROLE	ROLE DURING SURGE
Public health: State and local	Mental health, epidemiological investigations, disease monitoring, alerting, healthcare regulation and oversight, expertise resource, laboratory analysis	*Crisis and resource management and coordination, regulatory relief Neighborhood Emergency Help Centers (NEHCs), ACCs, OST^{3}C*
Hospitals	Diagnosis and treatment of all patients	Diagnosis and treatment of *critically* ill patients
Community health providers: Private practitioners, large group practices, community health centers, surgicenters	Care and treatment of noncritically ill patients (general medical and mental healthcare)	Care and treatment of *less critically* ill patients (minor trauma and surgical patients)
Fire/Rescue/EMS: Public and private	Scene Incident Command System and control Triage, treatment, and transport	Triage, treatment, and transport; *greater role in crisis and resource management and coordination*

*The roles of providers may shift as the event unfolds and evolves. This table reflects (in italics) new or differences in roles that may be required of providers.

screening and dispensing of prophylactic antibiotics or vaccinations are to occur. Several models are offered for establishing a triage and dispensing site, optimizing personnel resources, and projecting the number of persons to be vaccinated or dispensed medicines.[21,22] The Bioterrorism and Epidemic Outbreak Response Model (BERM)[23] provides a computer model for determining the number and types of personnel necessary for such a clinic site and can be used for planners to provide adequate resources. Most dispensing site plans are based on the medical model and, therefore, provide for some degree of triage for ill patients. It is anticipated that these providers will be public health and community volunteers because hospital employees will be occupied in their respective facilities.

Additional resources available for "prehospital" arena care include those involved with volunteer corps, disaster medical assistance teams (DMATs), and the Metropolitan Medical Response System (MMRS). These resources allow for reliance on personnel responding directly to the emergency rather than staff required to report for duty at traditional facilities.

A federal DMAT, which is part of the National Disaster Medical System (NDMS), is a group of medical and support personnel designed to provide emergency medical care during a disaster or other unusual event at a location usually remote from the origin of the team. DMATs deploy to disaster sites with adequate supplies and equipment to support themselves for 72 hours and provide medical care at a fixed or temporary medical site. They may provide primary healthcare and/or augment overloaded local healthcare staff. DMATs are designed to be a response element to supplement local medical care until other federal or contract resources can be mobilized or the situation has resolved. Each DMAT deployable unit consists of approximately 35 individuals; however, teams may consist of more than three times this number to provide some redundancy for each job role. This ensures that an adequate number of personnel are available at the time of deployment. A team is composed of medical professionals and support staff who are organized, trained, and prepared to activate as a unit. Some states and regions are developing intrastate DMATs or Medical Reserve Corps. In a large-scale disaster, a DMAT's ability to provide local personnel surge capacity may be limited because these teams frequently draw on the same pool of professionals already expected to respond during the disaster.

The MMRS, directed by U.S. Department of Homeland Security and FEMA, directly supports enhancement of existing local first responder, medical, public health, and emergency management by increasing systematic, integrated capabilities to manage a weapons of mass destruction MCI until significant external resources arrive and are operational (typically 48 to 72 hours). The program provides training, supplies, medical caches, and coordination within a metropolitan jurisdiction. It does not supply additional personnel but provides an organizational structure and resources for response in a region. There are 125 MMRS operations in the United States.

Traditional Facilities Arena

Care of patients at traditional facilities may require additional resources, the reapportioning of staff to different staffing patterns, etc. Relative to the amount of surge capacity within the hospital, planners could calculate the number of necessary additional staff as follows:

168 hours per week ÷ 40 hours per week workload
= 4.2 full-time equivalents (FTEs)

Each staff position requires 4.2 FTEs for 24-hour operations, 7 days a week.

If a 1:4 staff-to-patient ratio is maintained, then:

(No. of surge beds ÷ 4) = No. of staff positions

(No. of staff positions) × (4.2 FTEs) = No. of additional healthcare providers necessary per week

If a 1:6 staff-to-patient ratio is maintained, then:

(No. of surge beds ÷ 6) = No. of positions

(No. of staff positions) × (4.2 FTEs) = No. of additional healthcare providers necessary per week

If a 1:10 staff-to-patient ratio is maintained, then:

(No. of surge beds ÷ 10) = No. of staff positions

(No. of staff positions) × (4.2 FTEs)
= No. of additional healthcare providers necessary per week

Table 28-4 presents the calculated staffing needs for the various staffing ratios calculated for the regional surge beds presented in Table 28-1.

An additional staff resource to hospitals is a preestablished system of volunteers. Healthcare provider volunteers who are not full-time employees, who are retired, or who are no longer in clinical practice but maintain a license may be available for emergency staffing. Volunteer management programs must provide for the recruitment, confirmation of credentials, emergency notification/ deployment, and training/orientation of these valuable individuals. Individual healthcare entities

TABLE 28-4 ADDITIONAL STAFF REQUIRED FOR SURGE

	POPULATION	SURGE (BEDS/ PATIENTS)	HEALTHCARE PERSONNEL (1:4)	HEALTHCARE PERSONNEL (1:6)	HEALTHCARE PERSONNEL (1:10)
State A	5,595,211	2798	2938	1958	1175
Region A	2,571,695	1286	1350	900	540
City A	628,670	314	329	220	131

must decide whether to accord any particular healthcare worker emergency privileges to practice in facilities for which it has responsibility. Approaches include accepting the credentials maintained by other accredited healthcare facilities during an emergency into facility emergency preparation plans, relying on government programs that develop volunteer medical corps, and/or establishing mutual aid agreements. The Emergency Systems for Advance Registration of Volunteer Health Care Personnel (ESAR-VHP) is an additional step to provide for coordinated emergency increases in staffing of physicians, nurses, pharmacists, behavioral health professionals, emergency medical technicians, and other appropriate healthcare professionals. The ESAR-VHP system, still in development, would establish a regionally accepted, standardized advanced registration system for healthcare professionals through collaboration of hospitals, licensing boards, professional organizations, etc.

Managing the number of spontaneous volunteers by providing rapid credential verification and logistic requirements increases organizational burdens. Providing adequate coordinated efforts for volunteers and integrating these well-intentioned and needed individuals would yield positive results for all parties.

Nontraditional Facilities Arena

Once the provision of care is shifted or augmented to a nontraditional facility, the targeted reserves of healthcare providers likewise shifts away from those in traditional hospitals. Out-of-hospital primary providers, public health providers, volunteer corps, DMATs, and other federal assets will be relied on to deliver care in these locations. In addition, nongovernment agencies, such as the American Red Cross Disaster Relief Services and Salvation Army, may deliver care. A pre-event inventory of agencies, type of care provided, and number and identity of providers must be conducted to provide a responsible plan without "double counting" assets. For example, the use of National Guard medical personnel may be a pivotal piece of a community's plan. However, many of these personnel are also providers at local hospitals or may become an essential federal asset and may not be accessible for local response.

It is recommended in the ACC model to have the following minimal staffing per 12-hour shift for a 50-bed nursing subunit:

- Physician (1)
- Physician's assistant (PA) or nurse practitioner (NP) (physician extenders) (1)
- Registered nurses (RNs) or a mix of RNs and licensed practical nurses (LPNs) (6)
- Nursing assistants/nursing support technicians (4)
- Medical clerks (unit secretaries) (2)
- Respiratory therapist (RT) (1)
- Case manager (1)
- Social worker (1)
- Housekeeper (1)
- Patient transporter (1)

The minimal number of staff providing direct patient care on the 50-bed nursing subunit per 12-hour shift is 12, which includes the physician, physician extenders, nurses, and nursing assistants.

While the absolute number of providers necessary changes as the event progresses from "emergency operations" to "disaster operations" so, too, do the roles change. As illustrated in Table 28-3, as "disaster operations" and aggressive diversion are implemented, community providers may be tasked with providing care to the less critically ill and injured patients, whereas the hospital providers will be responsible for the more critically ill and injured patients.

Domiciliary Care Arena

Domiciliary care will, of necessity, require case management. This case management may be provided by several resources at various stages of the event and the patient's course. If the patient is hospitalized, the case management through hospitalization and through to discharge may be assumed by the facility. However, if the person is never hospitalized or is discharged from a facility, public health, community practitioners, etc., may be responsible for assuming this role. A pre-event inventory of resources for domiciliary care will reveal what currently exists in a community, what the needs may be, and any gaps that will occur during a disaster, which may be addressed through preparedness activities.

Public health authorities will be engaged in the epidemiological investigation, including case investigation and case contact. They are also likely to be responsible for the monitoring of symptoms and the initiation and maintenance of quarantine in communicable disease outbreaks. In addition, public health agencies typically provide telephone hot lines with information for providers and the general public. In Toronto, 225 residents met the case definition of SARS. Toronto Public Health investigated 2132 potential cases of SARS, identified 23,103 contacts of SARS patients as requiring quarantine, and logged 316,615 calls on its SARS hot line.[24] Temporary suspension of nonessential services may result in additional public health personnel; however, a long-term event will require regular re-evaluation of the need to reinitiate these services.

Providers of domiciliary care may come from professional and nonprofessional resources. Home health agencies and nongovernment agencies, such as the American Red Cross, may be available and have capacities to provide professional level services. Basic services, such as oral hydration, dressing care, and activities of daily living, may be provided by community-based formal and informal networks. Families, churches, and community organizations can be engaged to deliver such services and may be willing to do so, provided they are given the resources, minimal-but-meaningful education, and appropriate protection to do so. Pre-event outreach can organize these groups and allow for adequate support.

Medications and Supplies

Medications and supplies are commonly regarded as a short-term need and vulnerability. In fact, in a long-term event, such as a communicable disease event, supply shortages may become an increasing and broader issue. A disas-

ter may quickly exhaust available supplies, including medications, or may prevent the further replenishment of supplies from outside of the affected area. It is important to conduct a needs assessment and have an ongoing materials management process to assess current and anticipated needs and acquisition and appropriation of supplies on hand. In many U.S. disasters, supply shortages have not occurred, but rather, excessive donations have created a different challenge (see Chapter 35). Unfortunately, the preevent purchase and stockpile of equipment can be costly and difficult to justify in the current economic environment and as healthcare facilities continue to shift to "just in time" inventories. Graded increases in par levels of supplies, regionally leveraged purchases, and rotation into stock can ease the financial burden of preparedness. Federal response systems anticipate this need and purchase, and strategic forward deployment has been under way at that level. However, depending on the nature of the incident, it is prudent to assume that facilities and agencies should plan on being self-sufficient for the first 48 to 72 hours after an event. This places an additional burden on planning for an event, such as an explosion or chemical event, which will require adequate resources within the first hours or sooner. In this case, outside resources should be used to provide subsequent care and to restock used supplies.

If additional supplies are warehoused at central locations, numerous factors will need to be taken into consideration, including apportionment decisions, speed and mechanism of delivery, and access to delivery location. Limited material supplies may not meet demands, and an apportionment policy should be decided on before an event to allow for dialogue, education, and evidence-based decisions by officials. The speed and mechanism of delivery may vary, depending on the incident. Natural disasters may impede surface transportation of surge supplies. During the Sept. 11, 2001, attack on the Pentagon, emergency response vehicles, police closing of roads, and the ordered evacuation of federal facilities created a transportation gridlock, limiting the delivery of anticipated supplies to some hospitals in the District of Columbia (MedStar Health System, personal communication, January 2004).

Adequate personal protective equipment (PPE) for the anticipated surge capacity staff will be necessary to maintain a healthy staff. Depending on the nature of the event, the type of PPE used will likely be the most protective until the causative agent is defined. Standards for such PPE are well defined by the Occupational Safety and Health Administration. In disasters with noncontaminated physical hazards, such as an earthquake with building collapse, PPE should consist of protection for the extremity, head, ears, and eyes. In the prehospital arena, for suspected chemical, contaminated explosive, or unknown contamination scenes, personnel functioning within a "hot zone" are likely to be in Level A protection. Level A PPE offers the highest level of protection. It encompasses positive pressure breathing apparatus, SCBA, with a fully encapsulating chemical suit. After the removal of victims and subsequent decontamination, graded "step-down" in protection can be made until a level appropriate for definitive protection is attained. For example, initial evaluation of patients with an unknown communicable disease may first be approached with the provider in full high-efficiency particulate air (HEPA) respiratory and splash precautions. Once the infectious agent is identified and other potential preventative steps are taken (e.g., vaccination), PPE can be shifted to the appropriate mask and Universal Precautions. Amounts of PPE required to sustain a response is dependent on the durability and lifespan of the equipment (single-use versus multi-use), inter-user transfer of equipment (sharing), and the anticipated number of changes per provider. Durable hazardous materials gear may have longevity of several days into an event, may be able to pass from one worker to another, and is not necessarily disposable after each use. N95 respirators used for smallpox respiratory protection may be usable by a single user over a 12-hour shift but would *not* be shared and would be disposed of after the shift. Estimation of PPE requirements can be made by the following formula:

No. of personnel per day × No. of exchanges per day per person = No. of anticipated PPE sets per day

Medical supplies such as antibiotics, chemical antidotes, bandages, and splints can be maintained at traditional facilities and/or cached at central locations. Anticipating the number of needed supplies will depend on the anticipated surge needs and will likely be proportionate to those needs. Adjustments will need to be made with materials managers' assistance to accommodate differences in durable and nondurable goods. Additional resources include prepositioned caches in traditional first responder agencies (police, fire/rescue/EMS) and in agencies such as emergency management agencies and public health agencies. Deployable assets such as the Strategic National Stockpile, the CHEMPAK program, DMATs, and MMRS, have caches of medical materials not only to sustain the function of the teams but for treatment of casualties and patients. There are numerous community resources that should be inventoried and may be available for use. Pharmaceutical vendors, veterinary pharmacies and practices, dentists and dental supply warehouses, etc., may have supplies that are usable and available. Planning for use should include emergency procurement plans, apportionment policies, and MOUs with these entities to expedite postevent recovery.

Delivery of essential supplies such as power, food, and water must be considered for those people who, because of their injuries or illnesses, cannot access these services on their own. Traditional formal disaster relief services, such as the American Red Cross and Salvation Army, and nonformal services, such as community and faith-based groups, should be integrated so that patients in domiciliary care are identified to them and the organizations are part of an individual's case management plan.

Legal and Policy Issues

Policy development and decisions, to the extent possible, are best made or planned for in the pre-event stages when level heads prevail; there is the ability to adequately review current literature and science; and dialogue, debate, and education can be accomplished.

Triage, treatment, and transfer protocols; mutual aid agreements; and credentialing programs will require the input and review by legal counsel. Additional statutory

and regulatory changes may need to be sought to provide the bases for emergency powers of officials, medicolegal protection as practice paradigms shift, and compensation and liability for surge personnel.

Aggressive diversion of patients described earlier raises several critical legal concerns and questions. Issues related to malpractice liability, state regulations, and the Federal Emergency Medical Transfer and Labor Act (EMTALA) must be well researched and addressed.

EMTALA provides for, among other items, adequate screening before patient transfer, maintenance of level of care during transfer, and an accepting physician at the receiving facility. Triage away from a facility without well-established protocols that have been reviewed and approved by legal authorities will result in unwelcome anxiety and noncompliance by healthcare providers. During *nationally* declared disasters, EMATLA regulations may be suspended by authorities, but during *local* or *state* disasters, they will be in force.[25]

Even with effective planning and use of resources, an overwhelming event may outstrip resources and result in the re-evaluation and acceptance of a degradation of the standards of care. Serious discussions of this potential must be conducted before an event, not only with policy makers and legal experts but also with the general public.

CONCLUSION

Overall, the goal of surge capacity planning is to provide a series of prepositioned processes to ensure the delivery of appropriate care with appropriate resources in a graded, phased response. A potentially overwhelming response can be planned and provided for with adequate assessment of the population's needs and community resources and the development of plans for matching these needs with resources, augmenting as necessary. Planning may not necessarily include large capital expenditures but will provide stimulus for creative collaborative processes. The integration of disciplines and practices is essential because no single healthcare component can shoulder this alone. Integration of the general public through to multiple government agencies in response to a disaster will ultimately provide for an overall surge capacity.

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