

# AUGMENTING CRITICAL CARE CAPACITY DURING A DISASTER

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## Objectives

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- Identify the 4 components of surge capacity.
- Explain how surge capacity relates to intensive care unit (ICU) readiness for a mass casualty incident.
- Discuss the challenges inherent in maintaining high surge capacity in the ICU.
- Explain how ICU surge capacity fits within the larger framework of disaster medical response.



## Case Study

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A train has derailed in a residential neighborhood of a major city, and a tank car carrying chlorine gas is leaking. Emergency medical services have received several reports of residents near the accident site who are experiencing wheezing, shortness of breath, and ocular irritation. A nearby elementary school is getting ready to send children home for the day. Your hospital is placed on alert to receive victims of the chemical release.

- What would the on-call intensivist want to know about the hospital's readiness to deal with patients in acute ventilatory failure?
- What plan could the charge nurse for the receiving ICU rely on to ensure adequate nursing coverage?
- Does the respiratory care provider in the ICU have adequate equipment to meet the needs of new patients who require mechanical ventilation?

# I. INTRODUCTION

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In a medical context, the term *surge capacity* refers to a healthcare delivery system's ability to rapidly accommodate an increased demand for services under extenuating circumstances. The 3 most commonly identified components of surge capacity are staff, stuff (equipment, supplies, and pharmaceuticals), and space (room to accommodate patients, providers, and equipment) (1). A fourth, usually problematic, component is structure (delineation of management infrastructure). How a modern intensive care unit might respond to a major catastrophic event is informed by how it deals with everyday stressors.

In a 2007 survey of hospital leaders, the American Hospital Association found that 30% of hospitals cited a lack of staffed critical care beds as the key reason for ambulance diversions (2). With ICU occupancy rates holding stable at 65% and the number of acute care hospitals providing critical care medicine declining by 13.7% between 1985 and 2000 (3), surge capacity planning is paramount. This is not a US issue alone. In 2006 Ontario, Canada, reported 1,057 of 1,789 critical care beds could accommodate patients requiring mechanical ventilation, with occupancy rates approaching 90% (4). The surge capacity of a given intensive care unit is likely to incorporate external resources as a crisis evolves because the increased demand is quantitative, temporal, and clinical based upon the nature of the catastrophe. Under these circumstances, operational efficiency derives from collective resource management. A circumspect conceptualization of surge capacity therefore places the intensive care unit, as defined by the 4 "s" components cited earlier, within a broader context of disaster response (government agencies, service organizations, etc).

# II. COMPONENTS OF SURGE CAPACITY IN THE ICU

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## A. Critical Care Staffing

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Ideally, when disaster strikes, the right people with the right skills will be available and empowered to respond to their highest potential. Projected trends in critical care workforce capacity, however, suggest that attaining such a goal may be difficult. The demand for critical care by an aging US population alone will outpace available physician specialist hours by 22% in 2020 and by 35% in 2030 (5). Similar shortfalls (a 29% deficit by 2020) are forecasted for critical care nurses (6). In addition to staff shortages, critical care systems will assuredly face logistical challenges related to clinician utilization. Vacations may need to be postponed, complex shift rotations may have to be implemented, and mechanisms for contacting out-of-hospital staff might have to be engaged. Cross-privileging of providers, so-called disaster privileges, among otherwise unaffiliated institutions may save valuable time. Tiered systems affecting a range of healthcare providers may have to be implemented. In a tiered system, staff trained in critical care would collaborate with other staff on care teams designed to streamline the flow of care delivery. Staff would be assigned duties commensurate with their training but might also be asked to perform other necessary tasks (documentation, patient transport, etc). Guidelines from the

Working Group on Emergency Mass Critical Care recommend that when the number of critical care nurses is insufficient, other nurses should work with them in a ratio no greater than 3 noncritical care nurses to 1 specialized nurse (7). The group proposes other ratios for physicians, pharmacists, and respiratory therapists.

**!**  
*Creative approaches to staffing can ameliorate personnel shortage.*  
**!**

Provider-to-patient ratios would also change depending on the scope of the catastrophe. In a protracted disaster, staffing ratios may be affected by the immediate and long-term psychological stress placed on provider teams. For example, depression and insomnia were remarkably more prevalent among Taiwanese nurses working in severe acute respiratory syndrome (SARS) units during the acute phase of the 2003 outbreak than among colleagues working in other units (depression, 38.5% vs 3.1%; insomnia, 37% vs 9.7%) (8). Debriefing and counseling to help lessen caregiver stress has reportedly been helpful in a series of catastrophes (9), and plans for bringing resources to bear should inform surge capacity. Indeed, caregivers' distance from their own institution and familiar support systems is a significant stressor. Moreover, working in a disaster zone away from home adds to the psychological stress borne by healthcare teams, as occurred when members of the Israeli Defense Forces Medical Corps were called to the disaster zone after the Turkish city of Adapazari was devastated by an earthquake in August 1999 (10).

## B. Critical Care Staff

When faced with a disaster, an intensive care unit must have an adequate breadth and supply of life support resources available at a moment's notice. The ICU should have a plan to rapidly parse its equipment inventory, identify any deficiencies, and acquire needed items through multiple channels, including vendors, other nearby institutions, and government agencies. Radio-frequency identification technology may have a key role to play in this regard, given its documented efficacy in locating misplaced equipment and tracking pharmaceutical dispensation (11). A recent review of managing mass casualty respiratory failure identifies the safety, adequacy, and technical caveats involved with the use of positive pressure ventilation equipment ranging from bag-valve manual ventilators to anesthesia machines. It also highlights fundamental aspects of oxygen storage and delivery, use of heat and moisture exchangers, and operation of the Impact Univent Eagle 754 and Puritan-Bennett LP-10 ventilators maintained in the US Strategic National Stockpile (SNS) (12). Because critical care providers may be deployed to hospitals in other states when mass casualty incidents occur, they should be familiar with the operation of these emergency ventilators and others purchased by state governments or eventually substituted or added to the SNS.

**!**  
*Having inadequate resources in inventory may be just as frustrating as an absolute lack of resources.*  
**!**

Critical care providers at the epicenter of a surge may find their resources quickly exhausted due to just-in-time purchasing arrangements. A group-purchasing organization recently surveyed its member hospitals to assess their ability to cope with pandemic-related demands on their supply chains and found several notable resource limitations, even in personal protective equipment (13).

At the local level, stockpiling is not a cost-effective means of managing potential scarcity. Estimates reveal that the pharmaceuticals, ventilators, and catheters needed to treat 100 moderate- to high-acuity disaster victims (equivalent to a fire in a densely populated structure) for just 3 days could cost \$1.1 million (14). Some of the cost and immediate demand may be offset by government intervention, such as deployment of 12-hour push packages from the SNS (15). Nonetheless, local institutions may still expect to ration certain infrastructural elements. The notion of rationing supplies in the context of a mass casualty incident is likely to generate ethical concerns among clinicians, though guidelines for the allocation of mechanical ventilation have been advanced (16).

The nature of the catastrophe itself may affect demand for certain equipment. This is evidenced by the 1999 Marmara earthquake in Turkey: scores of victims required hemodialysis due to crush injury and rhabdomyolysis, and excess mortality was associated with shorter treatment duration (17).

### C. Critical Care Space

Adequate workspace in the ICU has always been a problem. A recent 15-year review of the use of critical care beds in the US demonstrated that although the total number of hospital beds decreased over that time period, the number of critical care beds actually increased by 26.2% (18). Despite the availability of more beds, the occupancy rate remained relatively constant at approximately 65%. (This is somewhat less than the 84% occupancy rate published in 1993 [19], in part because the length of stay for critical care patients increased by almost one third during the study period.)

When the demand for ICU care suddenly swells due to a disaster, possible space-saving strategies include discharging stable patients to home or to low-acuity care facilities in the community; expediting transfer of any noncritically ill patients to general wards; boarding patients in hospital areas where close monitoring can be ensured, such as postanesthesia care units and emergency departments; and canceling elective surgeries that would require postoperative care in the ICU. Triaging patients to appropriate wards or temporary facilities other than the ICU is important because models suggest that up to 90% of healthcare demand following a sudden-impact, high-trauma disaster derives from conditions treatable in an ambulatory setting (20). Effective triage will free inpatient facilities to focus on the care of critically ill victims.

The ICU staff should be prepared to perform relatively standard procedures under ergonomically suboptimal conditions. One study identified the minimum space required to safely complete 3 frequent, high-risk tasks: washing and lifting a patient from a bed to a wheelchair using a mechanical lift, transferring a patient between 2 beds, and resuscitating a patient (21). In a disaster setting providers may be forced to perform these duties in cramped quarters. Alternatively, more space can be generated rather quickly with advance planning. As evidence of the efficacy of such planning, Hick et al cite the Inova Health System (Fairfax, VA), which responded to the 2001 Pentagon terrorist attack by making 343 additional beds and 43 operating rooms available within 3 hours of the event (22). These authors also contend that 20% of a hospital's bed capacity can

! *Appropriate triage of stabilized patients to step-down wards can reduce bed scarcity.* !

be mobilized within hours using a strategy of expediting discharges, converting single rooms to double occupancy, and using “flat-space” like that found in waiting rooms and lobbies.

A disaster might destroy a hospital, in whole or in part, inflicting hardship on patients and providers alike. Such a situation was poignantly described by a neurosurgeon working at Charity Hospital in New Orleans, Louisiana, during the 2005 Hurricane Katrina disaster (23). Reports about the Hurricane Katrina experience also show a crucial benefit of alternative site use. Because 10,367 urgent care visits by displaced victims were handled at the Convention Center in Dallas, Texas, utilization rates at local trauma centers and emergency departments remained stable (24). The implication for mass casualty critical care is clear: alternative site usage for less acute problems could free up needed space.

The response to Hurricane Katrina was further supplemented by the deployment of a mobile field hospital with critical care functionality (25). This proved to be a promising means of augmenting space in a catastrophe, though most deployable field hospitals are not normally staffed or equipped to provide mass critical care. Several military organizations maintain aeromedical evacuation and treatment units (26) and floating hospitals (27), which could also expand the reach of critical care operations. Unfortunately, US Department of Defense aeromedical evacuation and transport capability—short-distance, rotary-wing and longer-distance, fixed-wing aircraft with supporting crews and equipment—may not be available for domestic use due to ongoing international obligations. Therefore, relieving ICU census may not be feasible, and facilities may be forced to shelter in place for awhile.

## D. Critical Care Structure

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When disaster strikes, a medical institution necessarily becomes the nexus of both healthcare and administrative endeavors. The ICU finds itself strategically placed within a larger framework of pre-hospital caregivers, service organizations, and government agencies. Persons who might have specific management roles in the ICU under normal conditions may not be available when an emergency response plan is activated. Health coalitions have devised incident command systems for multiple hospitals that do not require the presence of specific individuals for successful implementation (28). Disaster response plans commonly involve rapid assembly of multi-disciplinary teams whose members are assigned specific duties, an approach that underscores the necessity of effective communication. Following the 2003 SARS outbreak in Toronto, Canada, a group of intensive care providers outlined a crisis response team schema to avoid future problems with team structure and function (29). There may be some advantage to applying principles of crew resource management to such groups.

Since 1994, the US Air Force has maintained Critical Care Aeromedical Transport (CCAT) teams, each consisting of an intensivist, a critical care nurse, and a respiratory therapist, who can use portable ultrasound, mechanical ventilator, and point-of-care laboratory equipment to provide focused critical care services for up to 3 patients (30). This type of highly mobile, sophisticated care team may be incorporated into civilian hospital response when demand exceeds resources or space. Such teams may also be included in plans to transfer stabilized patients to step-down care venues.

The threat of hierarchical breakdown is always present during the initiation of a disaster plan, but incorporating some flexibility into the plan allows unanticipated issues to be addressed on the fly. Leaders of the incident command system at a large Taiwanese hospital during the 2003 SARS outbreak who were interviewed after the event reported the creation of several new positions within their response structure that permitted rectification of unforeseen developments (31). Like the previous examples, this demonstrates that being prepared for the next time hinges on the reflection of a dedicated group of individuals and, often, institutional acceptance of their ideas.

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*Some flexibility in the incident response hierarchy may allow for creative resource utilization.*

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### III. ADAPTING TO DEMANDS OF A SURGE

The 4 “s” components of staff, stuff, space, and structure govern of surge capacity in the ICU. Each entails unique challenges informed by stressors placed on the ICU not only when disaster strikes but also during routine operations. The lack of a cohesive approach to managing the elements of surge capacity can be detrimental precisely when tolerance for error is at its lowest.

During a disaster, in addition to doing more with less, critical care providers may well need to alter their usual care mindset. Rather than optimizing the treatment of a small group of patients, caregivers may be expected to perform a limited set of key interventions (eg, invasive monitoring, vasopressor administration, mechanical ventilation) for as many patients as possible.

Surge capacity protocols must be established and rehearsed to avoid potential dissonance between practitioners’ ethical convictions and the needs of the disaster situation. In its assessment of the impact of rationing ICU beds on care delivery and patient outcomes, the Values, Ethics, and Rationing in Critical Care Task Force concluded that patients who were refused ICU admission by a triage officer largely due to their perceived minimum potential to benefit from intensive care services had a 3-fold higher risk of hospital mortality than patients who were admitted to the ICU (32). This testifies to the gravity of daily decision making by ICU professionals and foreshadows how frustrating decision making might be when demand exceeds capacity.

## AUGMENTING CRITICAL CARE CAPACITY DURING A DISASTER

- Surge capacity refers to the ability of an ICU to rapidly and comprehensively expand the scope of its services during extenuating circumstances.
- The key elements of surge capacity are staff, stuff, space, and structure.
- Staff must be appropriately trained to operate safely in a mass critical care setting and be prepared to function outside their normal job duties.
- Crucial equipment must be identified and procurement mechanisms must be put in place prior to a mass casualty incident.
- Planning for a surge requires the identification of additional appropriate space in which to manage large numbers of critically ill patients.
- During a surge, the usual approaches to managing patients may need to be altered. (For example, high-risk but stable postoperative patients may need to be transferred to general wards unless they require specific critical care interventions.)
- A regional plan to distribute patients among a variety of hospitals and trauma centers should be developed before a disaster occurs.
- Critical care staff may expect to deal with ethical concerns if local and regional assets are overwhelmed.
- Triggers signaling a need to change the usual approaches to critical care should be determined prior to a mass casualty incident.



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## Suggested Readings

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