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Equipment, Supplies, and Pharmaceuticals: How Much Might It Cost to Achieve Basic Surge Capacity?

Dan Hanfling, MD

Abstract

The ability to deliver optimal medical care in the setting of a disaster event, regardless of its cause, will in large part be contingent on an immediately available supply of key medical equipment, supplies, and pharmaceuticals. Although the Department of Health and Human Services Strategic National Stockpile program makes these available through its 12-hour "push packs" and vendor-managed inventory, every local community should be funded to create a local cache for these items. This report explores the funding requirements for this suggested approach. Furthermore, the response to a surge in demand for care will be contingent on keeping available staff close to the hospitals for a sustained period. A proposal for accomplishing this, with associated costs, is discussed as well.

ACADEMIC EMERGENCY MEDICINE 2006; 13:1232–1237 © 2006 by the Society for Academic Emergency Medicine

Keywords: surge capacity, disaster medicine, pandemic influenza, critical care

Local preparedness efforts for mass casualty management, whether terrorist induced, otherwise man-made, or secondary to a natural phenomenon, have focused on the use of hospitals or health care facilities for the placement of the great majority of patients generated by such events. Traditional disaster planning has largely concentrated on "fixed occurrence" events, such as those created by transportation accidents, in which there are a finite number of victims requiring hospitalization. The "mass assassination" terrorist attacks of 2001, the threat from emerging infectious diseases, or the proclivity of terrorists to threaten large populations with unconventional weapons, including the use of bioterrorist agents, all create the urgent need for communities to improve on current capabilities. Communities must create solutions that effectively extend the ability to deliver uninterrupted medical care in the face of an extended, longer-term event. A recent example of this was the crisis faced by hospitals in the cities

of Hong Kong and Toronto as they struggled with their management of severe acute respiratory syndrome and the effect this transmissible emerging infectious disease had on the health care delivery systems of these cities.

Comprehensive preparedness must include the ability to provide for "surge capacity," the common parlance used to describe the need for creating and staffing additional beds used for patient evaluation, diagnosis, monitoring, and treatment. "Surge" can be defined as the ability to rapidly meet increased demand for medical care. "Capacity" refers to a measure of the ability to absorb the increase in number of patients. This definition does not necessarily imply the presence of "demand over time." It also does not specifically imply "capability," which suggests the availability of specialty medical care delivery, such as burn, trauma, pediatric, or intensive care, for example. The extent of available medical capability in a disaster environment will necessarily need to be decided ahead of time by the community planners responsible for the provision of health and medical services.

From Emergency Management and Disaster Medicine, Inova Health System, Falls Church, VA; Emergency Medicine, George Washington University, Washington, DC; and George Mason University, School of Public Policy, Fairfax, VA.

Received February 24, 2006; revision received March 27, 2006; accepted March 27, 2006.

Address for correspondence and reprints: Dan Hanfling, MD, Department of Emergency Medicine, Inova Fairfax Hospital, 3300 Gallows Road, Falls Church, VA 22042. Fax: 703-776-2893; e-mail: dan.hanfling@inova.com.

DEFINITIONS OF SURGE CAPACITY

Because disasters can be divided into two broad categories (fixed vs. extended events), so too must surge capacity be provided for each of these two distinct types of events. "Health care facility surge capacity" is the term that should be applied to the ability of each and every hospital to discharge existing patients to make those hospital beds available for incoming disaster event patients. In addition, this term should be applied to

the creative use of available space by a health care facility for the initial management of disaster victims. Examples of the creation of internal surge capacity abound from the experiences of health care systems most closely affected by the attacks in New York City and northern Virginia in September 2001. Inova Health System (Falls Church, VA) hospitals, for example, implemented their facility disaster plans, which included the expedited discharge of patients already designated to go home sometime that day or those deemed stable enough for continued management of their medical conditions at home. These plans also involved the cancellation of elective surgeries and the completion of all ongoing surgical cases. Thus, a surge capacity of 343 hospital beds (out of approximately 1,500 beds across this health system) and 43 operating rooms was made available within three hours of the attack on the Pentagon.¹ Many hospitals, in addition to creating such inpatient availability, also have plans to extend emergency department capability, such as by using lobby and waiting room areas and other patient care areas typically reserved for specialty patients undergoing gastroenterology, pulmonary, and cardiac procedures.

"Community surge capacity," or the development of "alternate medical facilities," can be used when health care facility surge capacity is maximized and is much more complicated and difficult to achieve. Planning for this contingency should be based on the pre-event designation of identified facilities that can be used to accommodate patients, albeit under circumstances in which the delivery of medical care may be limited or compromised. Because these are not health care facilities, many limitations exist in their overall ability to support the medical mission of continued health care delivery. However, pre-established logistical support, protocol development, and specific mission goals can be harnessed to create additional capacity for patients in the case of a large-scale disaster event that overwhelms existing health and medical resources.¹⁻⁴

EVIDENCE OF SURGE IN PAST EVENTS

A number of events occurring over the past decade have demonstrated the certainty with which a surge in demand for care following disaster events will occur. While the most recent events along the Gulf Coast of the United States demonstrated that catastrophic disruption of health care services can occur from natural disasters,⁵ a number of landmark terrorist attacks have also demonstrated a similar strain on health care resources, albeit of a much more limited nature.

The recognition of surge capacity as an issue requiring attention was probably first highlighted in the aftermath of the Aum Shinrikyo sarin gas attacks in the Tokyo subway system in March 1995. As a result of that attack, 984 patients required hospitalization, while 4,023 patients were evaluated in Tokyo hospital emergency departments and released.⁶ This equated to a surge in demand for care of approximately five patients seeking treatment for every one patient that was hospitalized (1:5 ratio).

As a result of the World Trade Center collapse in New York City in 2001, the five emergency departments in lower Manhattan closest to Ground Zero also noted a surge in patient care in the immediate aftermath of the

event. A total of 139 patients required hospitalization, although 790 patients presented for evaluation in the first 48 hours following the collapse.⁷ This equated to a surge in demand for care of approximately ten patients seeking care for every one patient that was hospitalized (1:10 ratio).

Barely two months later in that same year, the experience of one health care institution with the successful diagnosis, treatment, and management of inhalational anthrax in the Washington, DC, metropolitan area, where a number of congressional staffers and U.S. Postal Service employees were exposed to the deadly spores, suggests that in the case of bioterror attack, and possibly in the setting of a novel emerging infectious disease, many more people may present for evaluation and diagnosis. The emergency department of Inova Fairfax Hospital, for example, diagnosed two confirmed inhalational anthrax cases and screened more than 1,127 patients with influenza-like symptoms or concerns of anthrax exposure over a two-week period beginning with the delivery of the anthrax spores to the Hart Senate Office Building.⁸ In this instance, the ratio of infected patients as compared with potential exposures was 1:500, a marked shift in the amount of surge demand that is generated in response to a disaster event.

Four discrete events, one each caused by biological, chemical, and large-scale conventional terror attacks, and a natural disaster, each support the need to establish an all-hazards approach to acute care surge capacity.

KEY PLANNING ASSUMPTIONS

Review of these recent disaster events that generated definable surges in demand for care also validates a number of important assumptions regarding the development of acute care surge capacity. First and foremost, the rate-limiting step in mounting any coordinated response to a surge in demand for care will likely be the sustained availability of staffing. Whether it is as a result of the use of weapons of mass exposure, including biological, chemical, or radiologic attacks; the result of a contagious, infectious disease; or a result of widespread disruption in civil services, it must be assumed that staffing will be a problem. With the use of weapons of mass exposure in particular, workforce attitudinal surveys suggest that one fourth to one third of the workforce may be deliberately absent for some period.^{9,10}

Another key issue to recognize is that surge demand for care occurs in the context of continued delivery of basic health care services. Hospital services will be required to maintain routine delivery of emergency care. In fact, some researchers have noted that certain conditions, particularly those related to cardiovascular events, may even increase in times of great stress related to disaster. However, the level of staffing needed to match this increase in demand for care is not likely to be achieved, particularly in the setting of catastrophic disaster or those events related to contagious infectious disease. Decisions will have to be made in the pre-event disaster planning phase as to the apportioning of staff to meet routine service delivery needs in addition to the management of disaster victims.

Finally, the flawed response to Hurricane Katrina emphasizes the key assumptions that the initial forward

movement of patients is not likely to occur and that federal resources are likely to be unavailable for up to three days following the onset of any disaster event. A surge in demand for care is going to have to be handled locally, with locally available resources.

DISCUSSION

Much work has gone into the development of health care facility surge capacity over the past two years, largely supported by Department of Health and Human Services (DHHS) Health Resources and Services Administration (HRSA) and Department of Homeland Security Urban Area Security Initiative (UASI) grant funding opportunities. These grants have helped to fund an initial purchase of basic medical supplies and equipment. However, these grants have not provided the amount of funding required to establish an all-hazards provision of acute care surge capacity. The benchmarks established for these grants have been crafted so as to permit a wide variety of solutions applied to the issue of developing surge capacity. As a result of the absence of specificity, and the relative paucity of funding, this approach has resulted in piecemeal solutions to the problem of developing surge capacity. The amount of available funding for supplies and equipment has not included any items of significant cost, such as ventilators, infusion pumps, or cardiac monitoring equipment, for example. It has also not addressed the rate-limiting step in any surge capacity planning, namely the ability to recruit, retain, and deploy staff to the bedside during any given crisis.

As a result, the ability to provide acute and extended health care delivery in the setting of a surge in demand for care remains significantly limited. Furthermore, the planning and funding for medical surge capacity, and surge capability, remain far behind the other elements of the nation's tactical response to creating a secure homeland. Investments are needed in developing increased capacity at the health care facility level, as well as at the community level, including the identification of sites suitable for use as surge (alternate care) facilities. Given the very real concerns regarding an impending influenza pandemic, communities must focus on priorities for building such capacity that goes beyond the purchasing of beds, a metric that is too simplistic, and of little use, in creating the sort of capacity that is truly needed.

This requires stockpiling of certain key pharmaceuticals, equipment, and supplies. It requires a concerted focus on developing adequate staffing plans. It suggests the need for consensus development and dissemination of altered standards of care¹¹ and treatment protocols,^{12,13} reflecting the delivery of health care under the constraints of very limited resources.

Funding Requirement Projections

To create local health care surge capacity, whether it be health care facility based or a combination of the expansion of health care facility and community solutions, there are certain items that will need to be in place to facilitate a cogent, reasonable response to the demand for acute care. The methodologies by which these funding requirements are established in this report are somewhat arbitrary. By use of the nominal group technique, an ex-

pert panel of physicians, nurses, and hospital administrators (two emergency physicians, one pediatric intensivist, one trauma surgeon, one pediatrician, one anesthesiologist, one infectious disease expert, one respiratory therapist, three nurses, one pharmacist, and three hospital administrators) was convened to derive a basic set of pharmaceuticals, supplies, and equipment that might be required for the immediate delivery of basic emergency interventions to victims of a disaster event. The discussions focused on targeting a set number of patients resulting from all possible types of events, with a particular focus placed on providing initial burn and trauma care, as well as antibiotics and supportive care for events related to infectious etiologies. Specific antidotes for the management of chemically contaminated casualties were not included because of the reliance on the Centers for Disease Control and Prevention-funded Chempack program, which provides for the "forward" deployment of nerve agent antidotes including atropine, pralidoxime chloride, and benzodiazepines in large quantities under the Food and Drug Administration Shelf Life Extension Program. The Strategic National Stockpile purchased 2,124 Chempack containers for distribution in the 50 states and assorted U.S. territories.¹⁴ The state of Virginia, for example, received a total of 48 Chempack containers.¹⁵ The expert panel also did not consider any of the pharmaceuticals suggested for possible use in the event of radiologic contamination, because most initial care is focused on the treatment and management of any associated wounds and soft tissue injuries. In the selection of antibiotic agents, the group considered a very limited range of choices, with those selected having both indications for known threats and the ability to provide broad-scale coverage in a variety of clinical settings. The expert panel also included the provision of the antiviral agent oseltamivir, given the current exhortations of the senior leadership of DHHS to plan for local responses to a possible avian influenza pandemic.

All of the data on costs included in this report represent estimated wholesale costs and are very preliminary figures based on rudimentary projections. The pricing for medical equipment and supplies is based on the experience of one suburban health care system in negotiating contracts as a member of a group purchasing organization. The two largest such organizations negotiate contracts for critical medical supplies and dominate the medical purchasing at two thirds of the country's acute care hospitals.¹⁶ These group purchasing organizations serve as buying consortiums designed to leverage the purchasing power of hospitals, which in turn permits them to qualify for discounts on medical supplies. The majority of items listed here are available at wholesale cost, with a few of the supplies having an additional distribution margin of a few percentage points factored into the stated costs. All of the pharmaceutical costs included in this report also represent wholesale costs.

In selecting a very basic cache of pharmaceuticals, supplies, and equipment that until now have largely been out of reach of most planners responsible for the development of health care facility and community surge capacity, these costs are intended to demonstrate that even modest purchases of a very limited array of basic items will be expensive.

By taking this approach, it is possible to establish a “ballpark” figure that could be used to estimate surge capacity funding needs by health care planners attempting to create an all-hazards approach to delivering acute medical care. This methodology is based on the assumption that patients will be divided among those who have high, moderate, and low acuity. Furthermore, it is assumed that only those patients of high or moderate acuity will be those who initially require medical resources. High-acuity patients would require intubation, ventilator management, or multiple medications, including the use of vasopressors and intravenous fluids. The moderate-acuity patients would require medications and intravenous fluids. Each of these two categories includes basic (although not necessarily inexpensive) supplies and material required for the management of 100 patients (Tables 1 and 2) that are arbitrarily divided between high-acuity patients and moderate-acuity patients, simply for the sake of providing an estimate of costs.

The development of this model does not incorporate the availability of medications that are an existing part of the hospital’s “just in time” rotating stock of available pharmaceuticals. The assumption that is made is that these medications will be required for existing patient care needs and that given the sudden spike in demand, it is this additional cache of resources that will be required. This model does not take into account issues related to central storage, maintenance, and cache rehabilitation, which would result in additional costs, not computed for this model.

The decision to focus on 100 patients is based on the realization that any community could realistically face the challenge of being called on to handle 100 acutely ill or injured patients at any given time. Moreover, this estimate allows for some basic forecasting of funding requirements that in turn could be applied to any given jurisdiction for use in its calculation of surge capacity funding needs based on the HRSA benchmark of managing 500 acutely ill or injured patients per one million population.

In the category of medical equipment, the major items listed are ventilators and single- and triple-channel intravenous pumps. Given the relative paucity of ventilators available through the DHHS Strategic National Stockpile program compared with the number of patients who might require their use, and given the immediacy with which patients requiring advanced airway support need to be placed on ventilators, the availability of ventilators

Table 2
Medical and Surgical Supplies for Moderate-acuity Patients

Single-channel intravenous pump (unit price \$3,000)	\$150,000
Medical gases (oxygen only)	Assume these are available
Portable bedside suction units	Assume these are available
Hospital beds	Assume these are available
Dressings; intravenous catheters/ solutions; endotracheal airways; Foley catheters; other supplies	\$25,000

should be considered a critical metric in the evaluation of surge capacity. In the Inova Health System, for example, there are more than 1,500 staffed beds but only 189 ventilators available in four hospitals. Their average rate of use at any given time is 78%. Some investigators have recommended that “hospitals in the same region collaboratively plan to develop and maintain a non-federal stockpile of ventilators that could be rapidly distributed to hospitals that need them in a crisis.”¹²

With regard to the selection of intravenous pumps, it is recognized that some may consider this a luxury in times of crisis. However, the simple fact is that most medications in hospitalized patients are delivered by this method, suggesting that not to have these units on hand might further compromise the delivery of emergency care during a disaster event. Given the importance of providing “intravenous fluids for resuscitation and vasopressors to large numbers of hemodynamically unstable victims...”¹² inclusion of these pumps seems reasonable.

In the pharmaceutical category (Table 3), the calculations for 100 patients are based on the assumption that they will have to be managed for three days, given the potential for delay in receiving resupply from the “push packs” of the Strategic National Stockpile. The selection of medications is not meant to be definitive or represent the criterion standard in therapeutic choices, but instead is intended to illustrate what a representative sample of urgently required medications might look like and what their effect on cost would be. In this regard, the list includes the antiviral medication oseltamivir, given the current focus on pandemic influenza planning. It also includes some antibiotic choices that have been proven successful in the management of one or more of the CDC Category A bioterrorism agents or are indicated for broad-spectrum antimicrobial coverage. There are also a number of medications that would be reasonably expected to be used for patients of moderate or high acuity who are receiving intensive-level care.¹²

Based on these very cursory estimates, and assuming that these equipment, supplies, and pharmaceuticals are intended to manage 100 patients, 50 of whom require intensive, high-acuity level care and 50 of whom require less intensive but still considerable moderate level of care, for three days only, a very conservative estimate of funding requirements for these basic items would be approximately \$1.1 million per 100 patients. Extrapolating this to match the HRSA benchmarks, any given community attempting to create surge capacity for the initial management of 500 patients per one million population will require in excess of \$5 million to fund the purchase

Table 1
Medical and Surgical Supplies for High-acuity Patients

Univent 700 series pressure control ventilators (unit price \$7,000)	\$350,000
Triple-channel intravenous pump (unit price \$9,000)	\$450,000
Medical gases (oxygen and vacuum suction)	Assume these are available
Hospital beds	Assume these are available
Dressings; intravenous catheters/ solutions; endotracheal airways; Foley catheters; other supplies	\$25,000

Table 3
Estimated Costs of Basic Pharmaceuticals

Antiviral medication requirements based on assumption that 100 patients will be infected, and one healthcare worker per infected patient may also be exposed:	
Oseltamivir 75 mg tablets, 10 tablets each @ \$59.45 x 200	\$11,890
Basic antibiotics for use in secondary bacterial infection, or as first-line treatment for certain CDC Category A agents, or as broad coverage for burn care or overwhelming sepsis:	
Cefazolin 1 gram vials, 1,200 @ \$31.53	\$1,514
Clindamycin 900 mg vials, 900 @ \$165.94	\$5,974
Gentamicin 80 mg vials, 600 @ \$14.51	\$8,706
Ertapenem 1 gram vials, 300 @ \$407.11	\$12,213
Levofloxacin 750 mg premixed IV, 300 @ \$413.92	\$15,729
Basic supportive medications for use in moribund, hospitalized patients (assumes half of these patients will require intensive care unit level care with intubation and blood pressure support):	
Etomidate 40 mg vials, 50 @ \$97.00/2	\$2,425
Famotidine 20 mg vials, 600 @ \$8.73/25	\$5,238
Enoxaparin 80 mg, 150 @ \$336/2	\$25,200
Dopamine 400 mg/250 mL premixed, 150 @ \$102.69/18	\$15,403
Vecuronium 10 mg/vial @ \$2.78	\$10,008
Promethazine 25 mg/1 mL ampule @ \$2.03	\$1,015
Midazolam 5 mg/mL, 200 @ \$67.90	\$13,580

of this modest list of basic equipment, supplies, and pharmaceuticals.

It is important to note that these costs do not take into account sustainment and ongoing cache management costs, including those associated with periodic resupply and storage. It is also recognized that many of the equipment costs represent fixed, one-time expenditures, whereas the pharmaceutical and supply costs represent ongoing costs. While these differences will be important in assessing the long-term costs to maintaining a regional approach to surge capacity funding, it is the immediate, short-term, upfront costs that are the express focus of this report.

Surge Capacity Staffing Plans

Any discussion on the procurement of these items to support surge capacity would be incomplete without addressing the issue of staffing, the single most important element in the development of a cogent strategy to create surge capacity. Although it is very difficult to know with certainty the absolute number of staff who will be available to provide patient care in an extended disaster event such as pandemic influenza, steps can be taken to reassure the health care workforce and provide incentives for them to report for work. Given the geographically transient nature of the health care workforce, with many staff living far outside the communities in which they work, a plan for sustained work shifts has to be developed and implemented.

One such plan entails the establishment of memoranda of agreement with the hospitality industry so that hotels and other similar establishments would retain large blocks of rooms to be used by the health care workforce reporting for duty at nearby health care facilities. The cost for these rooms, and other associated services including food, laundry services, and child or elder care, would be paid by the hospital at a guaranteed rate, established in the pre-event planning phase, but below market value. These arrangements would have to be secured in the pre-event planning phase, given the possibility of

prices being artificially elevated at times of community crisis.

An estimate of costs for a single 900-bed hospital, based on a full census of patients at the hospital, with full staffing patterns (based on allotted average full-time equivalent nursing and medical technician positions staffed) and the transition of health care staff to 12-hour shifts for 96 hours (four shifts, with four off-periods domiciled at a local hotel at \$100/day, and assuming two health care staff per hotel room) would be approximately \$80,000 for four days. Note, however, that these costs are deferred costs, not payable unless or until required due to circumstances requiring the invocation of those memoranda of agreement. The development of such arrangements, however, is essentially cost-free.

CONCLUSIONS

Although by no means a rigorous economic analysis of the costs of developing acute health care surge capacity, this report is intended to explore some of the potential costs in developing such capacity, particularly as they relate to the procurement of basic medical supplies, equipment, and pharmaceuticals. This approach is intended to highlight the significant costs for developing such capacity by establishing a definable unit cost per 100 patients. Although there are many limitations to such an approach, not to mention the recent initiation of discussion in the medical literature regarding the rationing of care in large-scale disaster events, any community could face the need to manage this number of patients at any time. How many would really be able to handle even a modest sudden increase in the number of patients requiring care? How much might it cost to be able to do so?

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