

# The Measurement of Daily Surge and Its Relevance to Disaster Preparedness

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## Abstract

This article reviews what is known about daily emergency department (ED) surge and ED surge capacity and illustrates its potential relevance during a catastrophic event. Daily ED surge is a sudden increase in the demand for ED services. There is no well-accepted, objective measure of daily ED surge. The authors propose that daily and catastrophic ED surge can be measured by the magnitude of the surge, as well as by the nature and severity of the illnesses and injuries that patients present with during the surge. The magnitude of an ED surge can be measured by the patient arrival rate per hour. The nature and severity of the surge can be measured by the type (e.g., trauma vs. infection vs. biohazard) and acuity (e.g., triage level) of the surge. Surge capacity is defined as the extent to which a system can respond to a rapid and sizeable increase in the demand for resources. ED surge capacity includes multiple dimensions, such as systems, space, staffing, and supplies. A multidimensional measure is needed that reflects both the core components and their relative contribution to ED surge capacity. Although many types of factors may influence ED surge capacity, relatively little formal research has been conducted in this area. A better understanding of daily ED surge capacity and influencing factors will improve our ability to simulate the potential impact that different types of catastrophic events may have on the surge capacity of hospital EDs nationwide.

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Disaster preparedness has never been more important to our country than during the past few years, as a result of experiences with 9/11 and Hurricanes Katrina and Rita. All sectors of the health care system are focused on improving our ability as a nation to respond to future catastrophic events. Although a disaster may involve many components of the health care system, this article focuses on the emergency department (ED) perspective. Hospital EDs play an important role in disaster preparedness because they are the link between

out-of-hospital and hospital resources. Many hospital EDs face significant surges in demand on a daily basis because of their commitment to providing unplanned, emergent, and nonemergent health care services to all patients who present. A natural question that arises is, how much of what we know about daily ED surge can we extrapolate to catastrophic surge and disaster preparedness? The purpose of this article is to review what is known about daily ED surge and to illustrate the importance of gaining a better understanding of the daily phenomenon, so that it can be used as a foundation to more accurately predict how well hospital EDs will respond to a catastrophic surge in the demand for their services.

Hospital EDs across the country have faced considerable challenges for more than two decades in dealing with daily surge.<sup>1-6</sup> Daily ED surge causes ED crowding in facilities that do not have adequate physical and personnel resources to meet periods of peak demand. ED crowding is the result of a mismatch between surge and surge capacity and signifies that daily ED surge capacity is compromised. It is important to identify and eliminate bottlenecks in daily operations so that EDs run as efficiently as possible given the resources they have. ED crowding illustrates system breakdown and the potential impact that insufficient surge capacity can have on the provision of timely, appropriate care.

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**SURGE**

It is important to distinguish between surge and surge capacity. ED surge is defined as a sudden increase in the demand for ED services. Surge itself has not been of much interest to ED researchers or physicians. However, ED crowding, the consequence of daily ED surge, has received considerable attention by emergency physicians, hospital administrators, policy makers, and the public. Researchers and administrators traditionally have used surrogate indicators to quantify ED crowding, such as ambulance diversion, left-without-being-seen rates, or the number of patients boarding in the ED.<sup>5</sup> These indicators, however, measure the consequences of crowding or insufficient capacity, rather than daily surge itself. More recently, several multidimensional measures of crowding have been developed, but they include elements of both surge and surge capacity.<sup>7-9</sup>

In terms of ED operations, we propose that daily and catastrophic surge be measured by a combination of the magnitude as well as the nature and severity of the surge. The magnitude of the surge can be measured by the rate of patient arrivals to the ED. The nature and severity of the surge can be characterized by type (i.e., infectious vs. trauma vs. biohazard vs. illness) and acuity of the illnesses and injuries with which patients present during the surge.

Figures 1 and 2 illustrate the magnitude of daily ED surge by showing the percentage of new patient arrivals by time of day and day of week using 1996, 2000, and 2004 data from the National Hospital Ambulatory Care Survey (NHAMCS), which is a representative sample of approximately 400 hospital EDs nationwide.<sup>10</sup> Figure 1 illustrates that there is some degree of predictability in daily ED surge. Before the surge, at 6:00 AM, there are only 1.5 patients arriving per hour on average. The daily surge initiates around 7:00 AM and peaks at 11:00 AM (5.8 patients per hour). It plateaus at 6:00 PM (6 patients per hour) and then begins to decrease rapidly. However, it does not reach presurge initiation levels until after midnight.

There also is a trend by day of week, with a higher proportion of ED visits on Saturday, Sunday, and Monday compared with on other days of the week (Figure 2). By using time-series modeling techniques, Tandberg and Qualls forecast daily patient arrival for a six-month

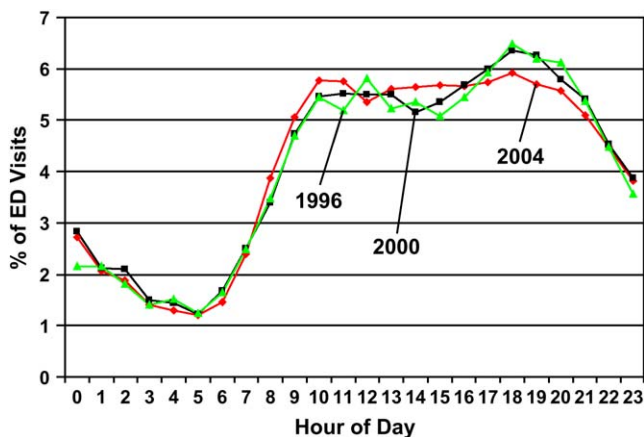


Figure 1. Percentage of ED visits by hour of day.

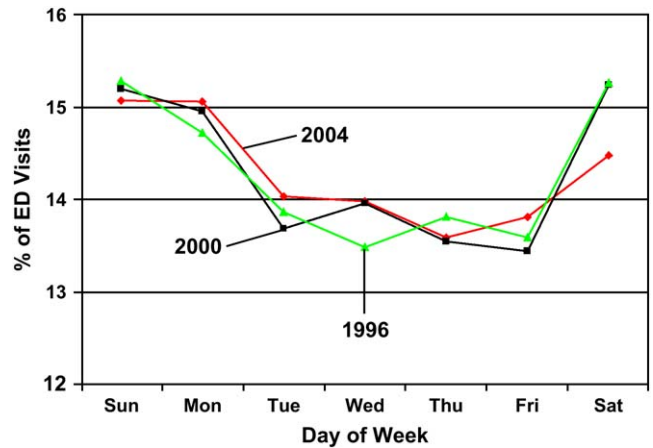


Figure 2. Percentage of ED visits by day of week.

period on the basis of historical data from the previous year and were able to account for 42% of the variance in daily ED arrivals.<sup>11</sup> All EDs across the country should be examining their patterns of arrival by hour of day and day of week and using this information to optimize ED surge capacity by matching staffing and resources according to the seasonal trends in demand.

Figure 3 displays the percentage of new arrivals who are emergent (i.e., who should be seen in less than 15 minutes) by hour of arrival by using 2004 and 2000 NHAMCS data (the triage scale was different in 1996). Further examination of these data suggests that patient acuity varies moderately by hour of day but not by day of week (data not shown). EDs commonly experience a daily surge as a result of multiple trauma patients being brought to their facility, as may occur after a multivehicle collision. Although the magnitude of this type of surge is not remarkable, the nature and severity of the injured patients can challenge ED capacity. A surge that involves patients with a life-threatening contagious disease is very different from a surge that involves the so-called worried well or involves patients of low acuity. Although present ED-triage scales may capture the nature and severity of daily ED surge, they may not be adequate for characterizing the nature and severity of catastrophic surge.

**Surge Capacity**

If we define daily and catastrophic ED surge in terms of the magnitude as well as the nature and severity of presenting illnesses and injuries, how do we define and

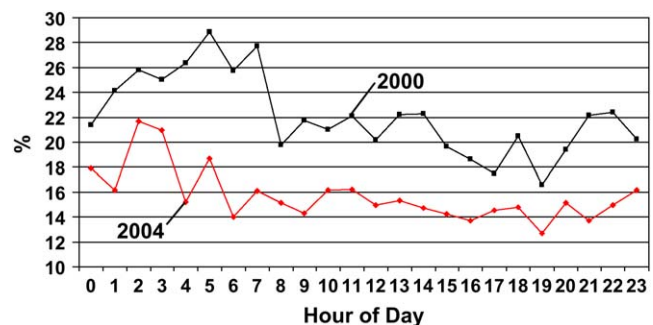


Figure 3. Percentage of emergent patients arriving by hour of day.

measure ED surge capacity? The American College of Emergency Physicians (ACEP) defines surge capacity in general as a “measurable representation of a health care system’s ability to manage a sudden or rapidly progressive influx of patients within the currently available resources at a given point in time.”<sup>12</sup> This definition is a good first step but it fails to enumerate the essential components of surge capacity. An important advancement to disaster preparedness will be the development of a conceptual model of ED surge capacity that defines its core components and identifies potential factors that may influence it. Although daily ED surge and catastrophic surge may affect components of ED surge capacity to a lesser or greater extent, we argue that the definition and model of ED surge capacity should be one and the same for both types of surge.

The core dimensions of ED surge capacity include space (number of beds, physical size of ED, etc.), staffing, systems (admitting process, clinical information systems, ancillary services, etc.), and supplies.<sup>13</sup> A multidimensional measure is needed that reflects both the core components and their relative contribution to ED surge capacity. Furthermore, ED surge capacity also must be conceptualized within the health care system as a whole because of the influence that other system components will have on it.

#### Factors That Influence ED Surge Capacity

What little we know about factors that may influence ED surge capacity comes mainly from the ED-crowding literature. The best example of this is a hospital resource, inpatient bed capacity. A number of studies have found that hospital occupancy lengthens ED length of stay and increases the time that an ED spends on ambulance diversion.<sup>14-17</sup> Forster and colleagues found that when hospital occupancy increased by 10%, the median ED length of stay for admitted patients increased by 18 minutes (95% CI = 11 to 24 minutes).<sup>15</sup> Likewise, McConnell et al. reported that the average ED length of stay for patients admitted to the intensive care unit (ICU) decreased by 25 minutes after the hospital increased the number of ICU beds from 47 to 67. The increased ICU bed capacity did not significantly decrease the ED length of stay for patients admitted to wards or discharged patients.<sup>14</sup> Schull et al. also found that the number of patients boarding in the ED, a surrogate measure of hospital occupancy, significantly influenced the time that the ED spent on ambulance diversion.<sup>16</sup> When evaluating the adequacy of ED surge capacity for a catastrophic event, it is clear from these data that we also will have to consider inpatient bed capacity.

In addition to hospital characteristics, patient, provider, and community factors may also impact ED surge capacity. ED surge capacity may be influenced by patient characteristics, such as age, the presence of comorbidities, insurance status, and personal resources (e.g., social support). Provider characteristics that may influence ED surge capacity include clinical experience and skills, pace and other individual practice variations, stamina, psyche, communication skills, and teamwork abilities. Studies that address the effects of ED surge on provider behavior and patient outcomes in the ED are needed.

Finally, community characteristics, such as the availability of primary-care services, skilled nursing facilities, and home health providers could influence ED surge capacity. During a catastrophic surge, the marked delineation between out-of-hospital and hospital services may blur as all components of the health care system rally to treat those in need of medical care. Thus far, the only study to examine the impact of community characteristics on ED crowding did not find an association. The number of inpatients awaiting placement in a chronic-care facility in the community did not significantly influence the amount of time that the ED spent on ambulance diversion.<sup>16</sup> However, this area warrants further investigation.

#### CONCLUSIONS

There is much to be learned about ED surge and about the factors that influence ED surge capacity. Clinical information systems are essential to understanding patient flow and to improving operational efficiency. To accurately measure daily ED surge and to identify potential bottlenecks before they cause significant delays in patient flow, hospital EDs require real-time, simultaneous measurement of many factors that can predict daily ED surge and surge capacity requirements. Very few institutions, if any today, have the information-technology infrastructure to accomplish this task. With the appropriate data, time-series modeling techniques can be used to examine the influence of different factors on ED surge capacity on a minute by minute basis. An individual hospital’s response to daily ED surge can be modeled, as well as multiple hospitals’ response, by aggregating data across hospitals. Data from multiple sites will strengthen our estimates and allow us to identify site-specific variations that influence ED surge capacity.

With a better understanding of daily ED surge capacity and the factors that influence it, the knowledge of catastrophic events and how to manage them can be combined with advanced simulation techniques to predict the potential impact that different types of catastrophic events would have on the surge capacity of hospital EDs. To do this, however, the following are needed: 1) a common metric for measuring daily ED surge, 2) a conceptual model of ED surge capacity, and 3) better clinical information systems with real-time data on all important aspects of ED operations and clinical care. The best way to prepare for a large-scale disaster is to be better informed and prepared for the mini-disasters that many of us experience daily in the ED.

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