
Metrics in the Science of Surge

Jonathan A. Handler, MD, Michael Gillam, MD, Thomas D. Kirsch, MD, MPH, Craig F. Feied, MD

Abstract

Metrics are the driver to positive change toward better patient care. However, the research into the metrics of the science of surge is incomplete, research funding is inadequate, and we lack a criterion standard metric for identifying and quantifying surge capacity. Therefore, a consensus working group was formed through a "viral invitation" process. With a combination of online discussion through a group e-mail list and in-person discussion at a breakout session of the *Academic Emergency Medicine* 2006 Consensus Conference, "The Science of Surge," seven consensus statements were generated. These statements emphasize the importance of funded research in the area of surge capacity metrics; the utility of an emergency medicine research registry; the need to make the data available to clinicians, administrators, public health officials, and internal and external systems; the importance of real-time data, data standards, and electronic transmission; seamless integration of data capture into the care process; the value of having data available from a single point of access through which data mining, forecasting, and modeling can be performed; and the basic necessity of a criterion standard metric for quantifying surge capacity. Further consensus work is needed to select a criterion standard metric for quantifying surge capacity. These consensus statements cover the future research needs, the infrastructure needs, and the data that are needed for a state-of-the-art approach to surge and surge capacity.

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The science of surge is critically dependent on metrics. Metrics provide the infrastructure that allows researchers to better understand surge and its

From Microsoft Health Informatics (JAH, MG, CFF), Redmond, WA; Georgetown University School of Medicine (CFF), Washington, DC; National Institute for Medical Informatics (JAH, MG, CFF), Washington, DC; Northwestern University School of Medicine (JAH, MG), Chicago, IL; Evanston-Northwestern Healthcare (MG), Evanston, IL; and Johns Hopkins University (TDK), Baltimore, MD.

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Address for correspondence: Jonathan A. Handler, MD. E-mail: jah505@northwestern.edu.

effects, allows administrators to better manage surge, and allows clinicians and public health entities to characterize surge and communicate that to the rest of the health care system. Metrics move the science of surge from the subjective and anecdotal to the objective and empirical. This movement to data provides the fuel that drives positive change toward better patient care.¹

The literature in the science of surge suffers from a lack of consistent definitions and their related metrics. In particular, there is no defined criterion standard metric that is consistently used across studies to determine when an emergency department (ED) is in a state of diminished or overwhelmed surge capacity.^{2,3} This makes comparisons of study results difficult, especially when study conclusions are not in harmony with one another. There is also no consistency on the data that should be collected by institutions for the purpose of surge and surge capacity research and management.⁴

This report aims to provide consensus statements regarding metrics related to the science of surge. These statements should help stakeholders understand the state of the art in surge, set the research agenda in this area, and provide the infrastructure needed for that agenda to succeed.

METHODS

To identify the current state of metrics in the science of surge, a breakout session at the *Academic Emergency*

Medicine 2006 Consensus Conference was convened. The consensus conference organizers chose a group leader for the topic of metrics. The group leader then sent out invitations to two large e-mail discussion groups in emergency medicine inviting participation in the working group. Participants in those discussion groups were asked to invite additional stakeholders, facilitating a “viral invitation” schema intended to garner the broadest and largest possible stakeholder participation. Announcements generated by the Society for Academic Emergency Medicine further served to alert the stakeholders and solicit their participation. A few weeks before the conference, an online discussion group was formed to begin generating and refining proposed consensus statements. On the day of the conference, members of the working group ratified several consensus statements and began discussion on others. Because of the short time allotted, the members of the working group requested continued online discussion after the conference. For several weeks after the meeting, statements were refined and then ratified when consensus was reached.

Under the ground rules set by and for this particular working group, statements were proposed and then modified until agreement was reached. Lack of comment was explicitly stated at the outset to be implied agreement. A single “nay” vote was considered to be lack of consensus. Once discussion had been completed for a topic (signaled by a call for a final vote and/or the absence of new commentary), the topic was closed. The final consensus statement was then considered ratified if there was a complete absence of “nay” votes and rejected if one or more “nay” votes were still outstanding.

CONSENSUS PROCESS RESULTS

Initially there was little disagreement among the members of the working group about the basic metric of “surge”; it is the rate of patient ingress per unit of time (such as new patients per hour). However, discussion of this metric rapidly led to controversy as the group considered the need to normalize this metric based on acuity, ED size, and ED staffing. Of far greater interest and contention was the discussion of “surge capacity” metrics. There was general agreement that surge capacity was the far more important concept, yet defining it with mathematical precision proved to be even more elusive. The relative complexity and importance of “surge capacity” over “surge” is reflected in the resulting consensus statements.

Seven consensus statements were ultimately ratified by the working group. These are presented and discussed in the following text.

Consensus Statement 1

Research and funding are needed to

- a. *develop and validate practical, high-value normalized metrics and tools that identify and characterize surge deficits and capacity and their effects on patients and the health care system as a whole.*
- b. *develop metrics that have the highest utility in guiding the management of surge.*

- c. *study the correlation between levels of daily and disaster surge and their effects on outcomes, measured by direct and indirect metrics of quality of care (such as actual errors and near misses).*

The funding and research applied to the metrics surrounding the science of surge are inadequate. Much of what is currently known about surge and surge capacity comes from anecdotes and expert opinion.^{4,5} These insights are important, but they lack the impact and utility of conclusions drawn from objective data.⁶ Some early research has provided some empirical evidence of the downstream effects of surge on a health care system,⁷⁻⁹ but much more is needed.^{5,6} Virtually all of the research has been in the realm of daily surge; very little objective data exist regarding the downstream effects of disaster surge. The metrics that have been studied have been rudimentary. They do not adequately identify the contributing factors of diminished surge capacity and do not assess the full spectrum of the effect of surge on the health care system or its impact on the quality of care.⁴

The working group agreed that no single metric would adequately paint a full picture of surge and its effects. Like “quality,” the “science of surge” is a complex concept that exists as part of a complex system. A full understanding of surge can only be achieved by piecing together many different metrics, each representing a different perspective and forming a cohesive picture only in the aggregate.⁴ Given the diversity of the underlying data that could be used to describe daily events, the number of metrics that could potentially be generated is huge. Yet, most health care systems can produce little or no real data regarding surge, and virtually no health care systems can produce such data in real time. Because the data that would drive these metrics can be difficult to obtain in some environments,¹ it is important to identify the metrics that have the highest practical value. Generating data will require many health care systems to invest in process modification and infrastructure upgrades. If that investment proves to have little practical utility, institutions could be discouraged from investing further in surge-related efforts.

Perhaps most importantly, metrics that demonstrate the correlation between surge and quality of care will be a driving force for change. Real change is unlikely without compelling data demonstrating the need to tackle this challenge to our health care system.

Consensus Statement 2

A national emergency medicine encounter registry should be created and funded for the purpose of collecting data from a representative national sample of emergency departments for research, including the identification of surge and surge capacity metrics and related outcomes.

Registries play an important role in research. They provide the infrastructure for large-scale, multi-institutional research efforts, offer a standardized data set, and facilitate continuous and ongoing research efforts.¹⁰ In the absence of a registry, each study requires a massive ad hoc effort to create and then destroy the infrastructure it requires for data collection.

A registry consumes significant resources, both at start-up and throughout its life. Therefore, a single-purpose registry (such as one dedicated solely to the science of surge) is less likely to garner the resources needed to succeed than a registry with broader objectives. A general purpose national emergency encounter registry would provide the infrastructure needed to answer many research questions, including those that relate to the science of surge.

Consensus Statement 3

Institutions should have one or more systems for tracking real-time resource availability and usage. Those systems should include data on both ED and hospital resources. These systems must be able to share that data electronically in real time with other systems, both inside an institution and across institutions, using a standard messaging specification.

Resource deficits are at the core of surge capacity and the problems caused by surge.^{11–14} Clinician time and attention, ED beds, inpatient beds, ventilators, medications, ancillary staff time, laboratory equipment, and radiology equipment are all examples of resources for which demand may outstrip supply during times of surge. Despite a relative paucity of research, there is subjective and objective evidence that these affect the quality and timeliness of patient care.^{5,7,9}

“Sunshining” these data, or making the data visible to those in a position to take action, is critical to successful process improvement. Queuing theory models, system dynamics modeling, and quality improvement initiatives (such as Continuous Quality Improvement, Total Quality Management, and Six Sigma) are extremely data intensive.^{15–17} Without real-time data, these and other approaches to the management of surge lack the key components necessary for success.

The working group emphasized the recognized fact that surge capacity deficit is not primarily an ED phenomenon. Capacity deficits arise through a complex set of interactions that involve an entire health care system.¹¹ That system includes the full diversity of a region’s health care system, including its hospitals, outpatient care providers, outpatient ancillary facilities, emergency medical services, and public health resources. Therefore, for efficient management of capacity, individual hospitals must be able to provide their own staff with data on available resources and also provide those data to the rest of the health care system. The working group was reluctant to mandate an electronic patient system for every ED, recognizing the need for flexibility in the actual implementation of resource tracking by institutions. However, for the sharing of data between systems and institutions, the working group agreed that standard messaging specifications using electronic data transfer systems are a critical component of success. This concept has prior consensus support.¹⁸

Consensus Statement 4

Hospital clinicians and administrators should have an electronic system that provides a single point of access to real-time hospital and ED surge capacity data. These data should reflect both true current capability and potential surge capacity (resources that are potentially free

but not immediately available, such as unstaffed beds). Methods should be provided to filter the data to show user-definable subsets, to make projections and short-term forecasts of resource availability based on real-time and historical data, and to simulate different resource management scenarios.

At times of high surge and exhausted surge capacity, clinicians and administrators have the least possible time available to gather information from a multitude of disparate sources to support their resource management decision-making needs. For this reason, it is critically important to have a shared organized view and a single point of access to all of these aggregated data. This concept has prior consensus support.¹⁹ Being able to search, filter, analyze, project, and forecast based on current and prior data provides the decision-making support that clinicians and administrators need to effectively manage both daily and disaster surge. The importance of data mining for ED management has prior consensus support.²⁰ The working group believed strongly that this single point of access should have sophisticated on-the-fly capability to search, to define cohorts and subsets, and to aggregate cases on any Boolean combination of criteria applied to any available data element. It should also have the ability to do forecasting, modeling, and scenario simulations (using queuing theory-based models, Bayesian networks, neural networks, fuzzy logic algorithms, and so on). Electronic systems supporting this level of functionality do exist,^{15,21} and flexibility of this order can only be achieved in an electronic system.

Implementing a real-time surge capacity reporting system in an ED that does not have an electronic patient tracking system may require manual updates of ED status summary information. That is an area of some concern for those in the working group, because during times of surge, nonclinical processes such as these may be abandoned in favor of more pressing clinical activities. While consensus was reached on the need for having surge capacity data electronically available at a single point of access, consensus could not be reached on the best process for meeting that need. Institutions are advised to consider a range of options for resource tracking and to choose the one that best fits into their environment, as long as they can also achieve the goal of making the data secondarily accessible in aggregated form from a single electronic source.

Consensus Statement 5

To the greatest extent possible, daily surge and surge capacity metric capture and information exchanges should be a natural by-product of the process of routine care, and disaster surge and surge capacity metric capture and information exchanges should be seamlessly integrated into the routine disaster response process.

The “doctrine of daily routine” applied to surge was perhaps best summarized by documents that have been produced by Federal Project ER-One: “Individuals function most effectively in stressful or unusual situations when the tasks they are called on to perform approximate their daily task routine. The capabilities designed into a facility should serve equally well, and, in fact, enhance day-to-day emergency department operations, as well as the extreme and complex patient loads that

arise from a mass casualty crisis.²² Others have noted the importance of this concept.²³ The working group believed that full integration of metric capture into the daily routine of care was critical to success in quantifying and managing surge and surge capacity. The notion that analytical and management information should be a by-product of ordinary operations, and that instant ubiquitous access to data is necessary for effective operations, has been supported by previous consensus statements.^{19,20}

Consensus Statement 6

At a minimum, the following metrics should be available from all hospitals in a digitally transmittable format that can be shared in real time or on demand with local, regional, and national entities:

- total number of empty and occupied licensed ED beds
- total number of occupied overflow ED beds
- total number of patients in the waiting room
- acuity level of triaged waiting room patients
- acuity level of ED patients
- total number of occupied and available intensive care unit beds
- total number of occupied and available non-intensive care unit beds
- number of ED nurses
- number of attending emergency physicians
- number of ED patients waiting for inpatient beds
- mean/median overall length of stay (for patients in licensed and overflow beds)
- mean/median waiting room times
- mean/median boarding times.

The working group wanted to give clear and concise guidance regarding a minimal initial data set for quantifying and managing surge and surge capacity, without putting undue pressure on institutions to provide exotic data of unproven value. Prior research on metrics of surge capacity has led to some formulae for measuring overcrowding (a concept related to that of daily surge).^{3,24,25} With many of the required elements of these formulae as a starting point, the working group added a few additional elements to form the list above, most or all of which have already been recommended by others.^{4,26,27}

The Centers for Disease Control and Prevention BioSense project already includes a number of these metrics in its “census” specification.²⁸ It is clear that these metrics (and probably many others) will be needed by local, regional, and national entities to support their efforts to study and manage both surge and surge capacity. Therefore, these data elements should be available in a digitally transmissible format to enable data sharing with these entities in order to support the health and welfare of the public.

Consensus Statement 7

A criterion standard metric for quantifying surge capacity and surge deficit is needed. This metric should, at least in part, be based on resource needs and availability.

Among all of the issues considered by the working group, the issue of a criterion standard surge capacity

metric was the most highly debated. In the existing literature on the metrics of surge capacity, the studies primarily use subjective clinician judgment as the criterion standard for validating proposed metrics.^{3,8,25} This is a manual process for which there may be wide variability between institutions.

The working group agreed that a criterion standard metric for quantifying surge capacity and identifying and quantifying states of overwhelmed capacity is needed to support research efforts. This metric does not need to be practical in everyday use but should address the needs of researchers and should serve as a criterion standard against which new and perhaps more practically applicable metrics can be validated. The optimal metric would be a definition-based one. If a definition of surge capacity can be created that is precisely defined and has a direct mathematical translation, then its mathematical translation would be a valid criterion standard metric “by definition.”

The American College of Emergency Physicians defines surge capacity 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.”¹² In 2006, a related American College of Emergency Physicians policy on ED crowding stated that, “Crowding occurs when the identified need for emergency services exceeds available resources for patient care in the emergency department (ED), hospital, or both.”¹³ A Centers for Disease Control and Prevention document on severe acute respiratory syndrome defines surge capacity as the “ability to obtain additional resources when needed during an emergency.”¹⁴ In each of these definitions, resource needs and availability are important components, and the working group agreed that a criterion standard metric should reflect this in some way.

Consensus could not be reached on a mathematically translatable definition of surge capacity upon which a criterion standard metric for identifying and quantifying states of surge capacity exhaustion would be based. Several of the committee members noted that surge capacity might be represented by a nonlinear function that does not readily translate to a simple linear equation.¹⁵ Many believed that this particular metric should include direct patient outcomes or otherwise consider the quality of care. Others noted that quality of care can be difficult to quantify, and outcomes are not known until long after the surge situation has long passed. Some in the working group believed that the definition and resulting mathematical translation should have direct references to, or draw more visibly from, concepts such as economic efficiency, queuing theory, and operations research and management engineering. Others believed that a purely resource-based mathematical definition might (at least in part) serve all of these functions: a resource-based definition based on inputs and outputs does not preclude a nonlinear relationship; the failure to provide needed resources in a timely fashion is one measure of the quality of care and a possible proxy for poor outcomes (assuming that the resources were truly needed by the patients for their health and welfare); the concepts of queuing theory, operations research, and economic efficiency would all utilize resource needs and resource

availability as inputs; and resource needs and availability are quantities that can theoretically be measured at the moment of surge.

Issues of metric normalization across the diversity of EDs, consideration of acuity, the need to consider the system as a whole, the possibility that we may modify the quality and outcomes we are willing to accept in times of crisis, and the time frame in which surge capacity is measured (e.g., is it the immediate surge capacity, or the capacity that will be available in four hours when a disaster plan has been fully activated, or the capacity that will be available in three days when a federal assistance response is fully mobilized?) further splintered the efforts of the consensus group to derive a mathematically translatable definition of surge capacity.

This is a difficult and complex issue, and the short time available to reach consensus may have made consensus agreement impossible. A longer consensus process devoted solely to this issue might lead to some resolution. Alternatively, a criterion standard surge capacity metric might be imposed by the force of will of a standards committee, governmental agency, or professional society. Finally, a de facto criterion standard surge capacity metric may emerge from whatever method is commonly chosen to validate surge capacity metrics in future studies. At this moment, the subjective opinion of emergency clinicians is the closest thing to an existing de facto criterion standard surge capacity metric.

CONCLUSIONS

The consensus process has generated seven statements that the working group hopes will guide clinicians, administrators, and researchers regarding the metrics of the science of surge. These statements cover the future research needs, the infrastructure needs, and the data that are needed for a state-of-the-art approach to surge and surge capacity.

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