A Novel Emergency Department Surge Protocol: Implementation of a Targeted Response Plan

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ABSTRACT

• **Objective:** Fluctuations in emergency department (ED) visits occur frequently, and traditional global measures of ED crowding do not allow for targeted responses to address root causes. We sought to develop, implement, and evaluate a novel ED surge protocol based on the input-throughput-output (ITO) model of ED flow.

• **Methods:** This initiative took place at a tertiary care academic teaching hospital. An inter-professional group developed and validated metrics for various levels of surge in relation to the ITO model, measured every 2 hours, which directly linked to specific actions targeting root causes within those components. Main outcome measure was defined as the frequency of sustained (≥ 6 hours) high surges, a marker of inability to respond effectively.

• **Results:** During the 6-month study period, average daily hospital occupancy levels rose above 100% (pre 99.5%, post 101.2%; \( P = 0.01 \)) and frequency of high surges in the output component increased (pre 7.7%, post 10.8%; \( P = 0.002 \)). Despite this, frequency of sustained high surges remained stable for input (pre 4.5%, post 0.0%; \( P = 0.13 \)) and throughput (pre 3.5%, post 2.7%; \( P = 0.54 \)), while improvement in output reached statistical significance (pre 7.7%, post 2.0%, \( P = 0.01 \)).

• **Conclusions:** The ED surge protocol led to effective containment of daily high surges despite significant increase in hospital occupancy levels. This is the first study to describe an ED surge plan capable of identifying within which ITO component surge is happening and linking actions to address specific causes. We believe this protocol can be adapted for any ED.

Emergency department (ED) crowding has been defined as “a situation where the demand for emergency services exceeds the ability to provide care in a reasonable amount of time” [1]. Crowding is an increasingly common occurrence in hospital-based EDs, and overcrowding of EDs has been shown to adversely affect the delivery of emergency care and results in increased patient morbidity and mortality [2,3]. Furthermore, the nature of medical emergencies dictates that rapid daily changes (or surges) in patient volume and acuity occur frequently and unpredictably, contributing to the difficulty of matching resources to demands. Accurate understanding and continuous measurement of where bottlenecks may be occurring within an ED are critical to an effective response to ED surges.

While it is now widely accepted that hospital inpatient overcapacity greatly contributes to crowding in the ED, there are many other factors related to overcrowding that are within the control of the ED. A conceptual model proposed by Asplin partitions ED crowding into 3 interdependent components: input, throughput, and output (Figure 1); this model has recently been accepted as the standard theoretical model for discussing patient flow through the ED by national professional groups such as the Canadian Association of Emergency Physicians [4,5]. Surges can arise from rapid demands in any of these areas, resulting in overall net ED crowding; however, depending on the model component affected, different approaches to solution design may be required. For example, a sudden massive influx of new patients arriving to an ED would cause a surge in the “input” aspect of the model, and response plans should address

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ED SURGE PROTOCOL

the issue with actions such as increasing triage capacity, or perhaps calling in additional physician resources in anticipation of looming “throughput” surge. Activating inpatient hospital responses may be premature and ineffective, wasting valuable resources that can be utilized elsewhere. In contrast, ED surges related to “output” factors may be best tackled with hospital-wide responses and resource reallocation.

Many of the widely used measurement tools for overcrowding produce one final overall net value on a one-dimensional scale, failing to capture the complexity of the root causes of surges. For example, the National ED Overcrowding Study (NEDOCS) scoring system, validated at various centers and widely used and studied [5–7] utilizes a number of institutional and situational variables to calculate a final NEDOCS score, which translates to “Not Busy,” “Busy,” “Overcrowded,” “Severely Overcrowded,” or “Dangerously Overcrowded” as a global state. Other published scoring systems such as the Emergency Department Work Index (EDWIN), while performing well in comparison to subjective impressions of physicians and nurses, also suffers from computation of a single final score, which makes it difficult to tie to specific actions or solutions [8]. Other surrogate markers quantifying ED crowding have also been used, such as left-without-being-seen rates, ambulance diversions, and total number of boarded patients in the ED; yet they too only measure consequences of crowding and provide little diagnostic information on when and where specific ED surges are actually happening throughout the day [9].

Responding to ED Surges
An effective surge plan should ensure the delivery of safe, effective care in response to various input/throughput/output surges in a coordinated and standardized manner. The ideal ED surge plan should include (1) a prospective continuous tool/method that accurately gauges the surge level (based on objective measures) in various components of the Input-Throughput-Output model of the department, (2) standardized targeted actions that are tied to specific triggers identified within that model to ensure effective solutions, and (3) built-in contingency plans for escalation in the face of sustained/worsening surges. Few studies have been published describing successful implementation of ED surge protocols, with the majority being linked to global ED crowding measures such as the NEDOCS score [10]. As a result, it is difficult to tease out the specific targeted actions that are most effective in dealing with the root causes of a surge.

Local Problem
Prior to the quality improvement initiative we describe below, the Ottawa Hospital ED had no formal process or method of measuring daily surges nor any standardized action plan to respond effectively to those surges. The state of “busy-ness” was often defined by gut feelings of frontline workers, which was quite variable depending on the individuals in charge of departmental patient flow. Often, actions to try and mitigate rising ED surges were triggered too late, resulting in consistent gridlock in the ED that lasted many hours. Several near-misses as well as actual critical incidences had occurred as a result of ineffective management of ED surges, and the authors of this initiative were tasked by senior hospital leadership with designing and implementing a novel solution.

Objectives
We describe our approach to the development, implementation, and evaluation of a novel ED surge protocol at a tertiary care academic hospital based on the principles cited above. Specifically, we sought to:

- define various levels of ED surge and to provide a common language for better communication between all stakeholders

Figure 1. The input-throughput-output conceptual model of ED flow. Adapted from reference 4.
incorporate the validated Input-Throughput-Output model of ED flow to provide a conceptual framework for measuring surges in real-time and developing targeted action plans

• standardize ED and organizational responses to various ED surges based on identified bottlenecks

• measure and evaluate the effectiveness of the ED surge plan implementation

• continuously modify and improve the ED surge protocol using quality improvement strategies

METHODS

Setting

The Ottawa Hospital is an academic tertiary care center with 3 campuses (Civic, General, and Riverside), with the ED providing coverage at 2 physical emergency rooms. The hospital is the regional trauma center as well as referral destination for many subspecialties such as cardiac, vascular and neurosurgical emergencies. This 1163-bed facility handles over 160,000 emergency visits a year, over 1 million ambulatory care visits a year, and roughly 35,000 surgical cases annually. The ED is staffed by 78 staff physicians, approximately 250 registered nurses (RNs), and ~50 emergency medicine residents/trainees.

The EDs are supported by a computerized tracking system that provides real-time metrics. This information is displayed by ED-specific geographical area on electronic whiteboards, which can be accessed on overhead monitors, desktop computers, and personal iPads. Information available to ED physicians and staff at any time includes individual-level data such as location, demographics, Canadian Triage Acuity Score (CTAS), and presenting complaint as well as departmental-level data such as patient volumes, wait times, length of stay (LOS), pending/completed diagnostics, consultation status and final dispositions.

According to the policy and standard operating procedures that govern research at the Ottawa Hospital Research Institute, this work met criteria for quality improvement activities exempt from ethics review.

Intervention

A working group comprising a project manager, ED physicians, managers, educators, care facilitators, and inpatient flow managers developed specific criteria defining various levels of surge for each component of the Input-Throughput-Output surge model (Figure 2). Since there is no universally accepted definition of surge published in the literature, the criteria were derived from consensus of local expert/leadership opinion as starting points for this project, and refined by polling frontline workers (care facilitators) on their perceptions of what constitute ED surges. The ED care facilitator’s position is held by approximately 10 senior nursing staff who are operational experts of ED flow and management, and has no specific bedside nursing duties assigned. Its main mandate is to manage overall flow of the department including but not exclusive to communication with inpatient units and local EMS dispatch, liaising with ED physicians to facilitate efficient use of limited monitored beds and other resources, and reassigning nursing resources around the department as needed.

Over a 4-day period care facilitators were polled on an hourly basis to determine what factors were important to the in determining how “busy” they perceived the ED to be. These factors included but were not limited to: total number of patients waiting to be seen; time to physician initial assessment; number of monitored beds available; and number of admitted patients boarded in the ED. Analysis was done to prospectively compare their perception of surge levels to the proposed Surge Plan metrics, and to ensure that the individual criteria for each level was practically meaningful and accurate.

Next, a set of standardized action and response plans were developed and agreed upon that tied specifically to a corresponding component of the different measured ED surge levels (these action plans are detailed in an online Appendix and are also available from the author). The fundamental guiding principles behind the development of each action item was that it should (1) target underlying causes - in a standardized way - specific to the relevant Input-Throughput-Output surge, (2) provide escalating level of effectiveness for each corresponding escalation in the surge level (eg, contacting a staff physician directly for a disposition decision for patients consulted in the ED, if the resident trainees have failed to do so in a timely manner), and (3) coordinate actions by various stakeholders in a planned and organized manner. Practically, the standardized targeted actions span across 5 different roles, which were explicitly listed on action sheets for care facilitators, clinical managers, patient flow managers, evening and night coordinators, and clinical directors.

Stakeholder Engagement

Our working group identified 9 internal ED stakeholder groups, 13 internal hospital-wide stakeholder groups, and 4 external stakeholder groups (Table 1). Prior to
implementation, multiple stakeholder meetings were held with all of the groups to determine the feasibility of the plan, validate the proposed metrics, and establish concrete actions to be taken by each stakeholder group in response to various surge levels. Examples of specific actions include shifting nursing resources between different areas of the ED, alerting inpatient services of ED surge levels, extra overtime staffing for hospital support staff, escalating discharges on the wards, consideration for ambulance diversion, and calling in extra ED physicians. Buy-in from different hospital stakeholders were further reinforced by senior leadership and management. Once the overall ED surge protocol was approved by relevant stakeholders and senior hospital management, individualized standard worksheets were developed (see Appendix) and training provided to relevant stakeholders.

### Implementation and Continuous Improvement

Given the complexity of the ED- and hospital-wide nature of the surge protocol, implementation was done over multiple phases and Plan-Do-Study-Act (PDSA) improvement cycles:

#### Phase I (Apr 2013 - Jun 2013)

The initial proposed ED surge level metrics were measured at a single ED campus. Care facilitators were
trained and asked to measure surge levels in the ED every 2 hours. This served as a testing period to gauge the sensitivity and reliability of our proposed surge level metrics, and no actual action items were triggered during this period. Stakeholder meetings were held to determine feasibility of the plan, validate the proposed metrics, and develop “standard work” action plans for each stakeholder group in response to the metrics. This first phase also allowed care facilitators to objectively reflect on ED surge patterns throughout the day, and provided everyone in the ED team a frequent global snapshot of how “busy” the department was at any time. Finally, surge level data during this phase confirmed previous suspicions that the Output component was the biggest driver behind overall ED surge level.

Throughout this phase, the ED clinical manager recorded all the usual actions taken in response to the different level of surges as felt appropriate by the individual care facilitator on duty. The variety of actions and types of escalations were collected and fed back to weekly workgroup meetings to help further refine crafting of standardized action plans for implementation of the surge protocol.

**Phase II (June - Aug 2013)**

An initial trial of a limited ED surge protocol was rolled out at both ED campuses, with actual action items being triggered in response to specific surge level metrics. The main focus of this PDSA cycle was to collect data on how the care facilitator groups at the 2 campuses utilized the surge protocol, as well as feedback on usability, barriers, and effectiveness. Regular audits were performed to ensure surge measurement and compliance rates. Educational sessions were provided regarding rationale and purpose of the plan so that all team members had a better understanding of ED surges. Frequent meetings with stakeholders to share updates continued throughout Phase II, allowing further engagement as well as fine-tuning of stakeholder action plans based on real-time experiences.

**Phase III (Aug 2013 - Dec 2013)**

The next phase of implementation expanded beyond the ED and included the hospital’s off-hours and off-service management group. This in effect was the official corporate roll-out of the ED surge protocol including full action plans for all stakeholders, including off-service clinical administrators, inpatient flow managers, and the director of emergency and critical care. Regular audits were performed to ensure compliance of measurement every 2 hours as well as performance of specified action items related to each surge level, with the actual surge level measurement completion rates of 98%.

**Data Collection and Analysis**

Over the study period April 2013 to December 2013 at the Civic campus and June 2013 to December 2013
at the General campus, ED surge levels were measured every 2 hours by the care facilitators and manually recorded in standardized ED surge protocol booklets. These were subsequently entered into Excel database for tracking and data analysis. Patient volumes and hospital occupancy levels were recorded daily. Perceptions of the primary users of the surge protocol (ie, care facilitators) were obtained via standardized interviews and polls. We present descriptive statistics and statistical process control (SPC) charts. Chi-squared test was performed for comparison of pre- and post-intervention frequencies of outcome measures.

Outcome Measures
The main outcome measure was the frequency of sustained (≥ 6 hours) high surges, a marker of inability to respond effectively. High surges were defined as Moderate and Major surges combined. Our expert group consensus was that combining the Moderate and Major surge categories to represent “high” surge was reasonable since they both require mobilizing resources on a hospital-wide level, and failure to improve despite 6 continuous hours of actively trying to address such high surges would lead to significantly higher risk for quality of care and patient safety issues.

Secondary outcomes include overall frequency of reaching high surge levels at various components of the Input-Throughput-Output ED flow model, hospital occupancy levels, and care facilitators’ perceptions on workload and overall effectiveness of the surge protocol.

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Pre-Intervention</th>
<th>Post-Intervention</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average # of daily ED visits</td>
<td>439.4</td>
<td>429.4</td>
<td>0.04</td>
</tr>
<tr>
<td>Daily hospital occupancy level</td>
<td>99.5%</td>
<td>101.2%</td>
<td>0.01</td>
</tr>
<tr>
<td>Percentage of time ED reached high surge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input</td>
<td>4.4%</td>
<td>2.7%</td>
<td>0.01</td>
</tr>
<tr>
<td>Throughput</td>
<td>20.5%</td>
<td>18.1%</td>
<td>0.08</td>
</tr>
<tr>
<td>Output</td>
<td>7.7%</td>
<td>10.8%</td>
<td>0.002</td>
</tr>
<tr>
<td>Percentage of time ED experienced SUSTAINED high surge above normal expected variation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input</td>
<td>4.5%</td>
<td>0.0%</td>
<td>0.13</td>
</tr>
<tr>
<td>Throughput</td>
<td>3.5%</td>
<td>2.7%</td>
<td>0.54</td>
</tr>
<tr>
<td>Output</td>
<td>7.7%</td>
<td>2.0%</td>
<td>0.01</td>
</tr>
</tbody>
</table>

RESULTS
ED Flow
Table 2 presents the summary statistics for both campuses comparing the pre- and post-implementation time periods. During the study period, the average number of daily ED visits decreased slightly by 10 patients per day (pre 439.4, post 429.4, P = 0.04), while the average daily hospital occupancy levels steadily rose above 100% (pre 99.5%, post 101.2%, P = 0.01). Despite rising hospital occupancy levels, the proportion of time the ED reached high surge levels decreased for Input (pre 4.4%, post 2.7%, P = 0.01) and Throughput (pre 20.5%, post 18.1%, P = 0.08) components of ED flow after implementation. The frequency of high surges in the Output component did significantly increase (pre 7.7%, post 10.8%, P = 0.002).

Statistical Process Control Charts
Figure 3 shows SPC charts for the different Input-Throughput-Output components of the 2 different ED campuses over the study period. Daily frequency of sustained high surges lasting 6 or more consecutive hours were plotted along with hospital occupancy levels. The number of times data points rose above the upper limit of the SPC chart (ie, above normal expected variation) pre- and post-intervention were used for statistical comparison. Overall for the 2 campuses combined, the frequency of sustained high surges above normal variation remained stable for Input and Throughput (pre 4.5%, post 0.0%, P = 0.13; pre 3.5%, post 2.7%, P = 0.54) components of the ED flow model, respectively. More importantly, the
frequency of sustained high surges in the Output component decreased, reaching statistical significance \([\text{pre}: 7.7\% \text{ vs post}: 2.0\%, \ P = 0.01]\), despite a rise in the total number of times the ED reached severe Output surges and overall hospital occupant levels.

**Survey of Care Facilitators**
The primary users and drivers of the surge protocol—the care facilitator group—felt strongly that the tool was easy to use and that it made a positive difference. 72% felt that the ED surge protocol has increased their workload but
92% felt that it was good for overall flow of the ED. Specific feedback included having a much more standardized language around communicating (and acting on) surges, and a better overall bird’s-eye view of the department.

**DISCUSSION**

Despite a call for urgent research on implementing solutions targeting daily ED surges (vs. global ED crowding) over a decade ago at the Academic Emergency Medicine 2006 Consensus Conference [12], little work has been published on distinguishing, measuring, and dealing with ED surges. McCarthy et al proposed the rate of patient arrivals to the ED by time of day as a rudimentary definition of surge, although they provided very little specific guidance on what to do with that information in the setting of responding to spikes in surges [13]. Asplin et al described a number of theoretical models to bridge ED census, daily surges, length of stay and quality of care, however they were never validated in real-life scenarios [14]. A systematic review published in 2009 summarizing articles that described theoretical and practical ED surge responses found a large heterogeneity of different proposed models with little standardization and multiple shortcomings [15].

To our knowledge, this study is the first to report on the actual development, implementation, and evaluation of a daily ED surge protocol that utilizes a widely accepted conceptual model of ED flow. Unlike single global measure of ED crowding, our protocol measures frequent surge levels for various Input-Throughput-Output components of the ED, which are tied directly to standardized specific actions to address underlying root causes. Despite continued rise in hospital occupant levels and budgetary restraints, we found a improvement in the number of times the ED actually hit severe surges with the exception of Output, which is expected since this component of the flow model is intimately tied to hospital occupant levels. When severe surges did happen, we were able to deal with them much more effectively and efficiently, resulting in an overall decrease in sustained surges in the ED including the Output component.

**Limitations**

Similar to other pragmatic quality improvement projects that rely on manual processes, it was difficult to ensure absolute compliance of surge level measurements throughout the study period. As a result, there were occasional missing surge level data at various times of different days. However, we believe these are relatively nonsignificant occurrences that balanced out over the pre- and post-implementation periods. In addition, we did not have the resources to robustly record and confirm completion of specific action items that were activated in response to various surge levels, although we did confirm verbally with frontline workers regularly that those actions were done. Future Plan-Do-Study-Act cycles will focus on explicit measurement of actual completed action items and further refinement of targeted responses to surge. Finally, while we were able to only collect and present data over a relatively short period of evaluation (and thus potentially susceptible to seasonal variations in ED flow), we believe that our data does support the surge protocol's effectiveness when compared to the robust trend of hospital occupant levels.

**Future Directions**

This ED surge protocol can be adapted and modified to fit any ED. The specific criteria defining Minor/Moderate/Major surges can be set up as ratios or percentages relative to total number of monitors, beds, etc., available. The principles of linking actions directly to specific triggers within each Input/Throughput/Output category could be translated to fit any-sized organization. Currently in progress is a longer evaluation period and based upon the results as well as individual feedback, necessary adjustments to our definitions, criteria and action items will be considered as part of ongoing quality improvement. The principles of our surge protocol are not limited to the ED, and we will explore its implementation in other hospital departments as well as methods to link them together in alignment with the hospital’s overall corporate strategy in tackling overcrowding.

**Conclusion**

In summary, implementation of this novel ED surge protocol led to a more effective response and management of high surges, despite significant increase in overall hospital occupancy rates and associated frequency of surges in the Output component of the ED flow model. Our surge measurement tool is capable of identifying within which area of the ED surges are occurring, and our ED surge protocol links specific actions to address those specific root causes. We believe this will lead not only to more accurate assessments of overall ED crowding but also to more timely and effective departmental and institutional responses.
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