BRIEF REPORT

Cancellation of Scheduled Procedures as a Mechanism to Generate Hospital Bed Surge Capacity—A Pilot Study

Olan A. Soremekun, MD, MBA; Richard D. Zane, MD; Andrew Walls; Matthew B. Allen; Kimberly J. Seefeld, MEd, MS; Daniel J. Pallin, MD, MPH

Department of Emergency Medicine, Brigham and Women's Hospital, Boston, Massachusetts USA

Correspondence:
Richard D. Zane, MD
Department of Emergency Medicine
Brigham and Women's Hospital
75 Francis Street
Boston, Massachusetts 02115 USA
E-mail: rzane@partners.org

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Abbreviations:
ICU = intensive care unit
MCI = mass-casualty incident

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Abstract

Background: The ability to generate hospital beds in response to a mass-casualty incident is an essential component of public health preparedness. Although many acute care hospitals' emergency response plans include some provision for delaying or canceling elective procedures in the event of an inpatient surge, no standardized method for implementing and quantifying the impact of this strategy exists in the literature. The aim of this study was to develop a methodology to prospectively emergency plan for implementing a strategy of delaying procedures and quantifying the potential impact of this strategy on creating hospital bed capacity.

Methods: This is a pilot study. A categorization methodology was devised and applied retrospectively to all scheduled procedures during four one-week periods chosen by convenience. The categorization scheme grouped procedures into four categories: (A) procedures with no impact on inpatient capacity; (B) procedures that could be delayed indefinitely; (C) procedures that could be delayed by one week; and (D) procedures that could not be delayed. The categorization scheme was applied by two research assistants and an emergency medicine resident. All three raters categorized the first 100 cases to allow for calculation of inter-rater reliability. *Maximal hospital bed capacity* was defined as the 95th percentile weekday occupancy, as this is more representative of functional bed capacity than is the number of licensed beds. The main outcome was the number of hospital beds that could be created by postponing procedures in categories B and C.

Results: Maximal hospital bed capacity was 816 beds. Mean occupancy during weekdays was 759 versus 694 on weekends. By postponing Group B and C procedures, a mean of 60 beds (51 general medical/surgical and nine intensive care unit (ICU)) could be created on weekdays, and four beds (three general medical/surgical and one ICU) on weekends. This represents 7.3% and 0.49% of maximal hospital bed capacity and ICU capacity, respectively. In the event that sustained surge is needed, delaying all category B and C procedures for one week would lead to the generation of 1,235 hospital-bed days. Inter-rater reliability was high (kappa = 0.74) indicating good agreement between all three raters.

Conclusions: For the institution studied, the strategy of delaying scheduled procedures could generate inpatient capacity with maximal impact during weekdays and little impact on weekends. Future research is needed to validate the categorization scheme and increase the ability to predict inpatient surge capacity across various hospital types and sizes.

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Introduction

Inpatient surge capacity, the ability to generate staffed and ready inpatient beds in the event of an unanticipated surge in demand for inpatient healthcare services due to events such as mass-casualty incidents (MCIs) or pandemics, is an essential component of public health preparedness.[1] Historically, these types of events are not rare. Recent examples include the 2003 Rhode Island nightclub fire, when there was a spike in demand for local inpatient burn, surgical, and intensive care unit (ICU) capacity to care for victims.[2] There also was a sustained demand of inpatient capacity related to the 2009–2010 H1N1 influenza pandemic.[3]

Groups	Definition	Examples
A	No impact on inpatient bed capacity; expected length of stay <1 day OR patient already an inpatient	Day surgeries Procedures on patients already admitted to hospital
B	Impact inpatient bed capacity; can be delayed indefinitely	Excision of non-infected or benign mass Joint replacement Cosmetic procedures
C	Impact inpatient bed capacity; can be delayed 7 days	Excision of oncologic mass Cardiac catherization for unstable angina Fixation of closed orthopedic injuries
D	Impact inpatient bed capacity; cannot be delayed AND cases on patients admitted via emergency department	Emergent trauma cases Actual or impending bowel necrosis/perforation Excision/Incision and Drainage of infected mass Infected joint wash out and reduction/fixation of open orthopedic injuries Cardiac catherization for acute myocardial infarction Unstable ectopic pregnancies Emergent cesarean section Ovarian torsion Operative intracranial hemorrhage Spinal cord decompression Transplants

Table 1—Study categorization of inpatient procedures

Over the last two decades, as a result of decreasing reimbursement and the drive for higher efficiency, hospitals increasingly rely on maintaining a high inpatient census to meet tighter budgets. In addition to increasing patient volumes and demand, this has eliminated excess inpatient capacity from the hospital system.[4,5] This has led to US hospitals operating at or near capacity, thus limiting their ability to respond to a large surge in demand due to a MCI or pandemic.[6]

Studies have specifically examined the ability to generate incremental inpatient capacity including reopening of shuttered hospitals,[7] conversion of non-clinical areas to clinical areas,[8] and early discharge of stable patients.[9] While all of these interventions can increase inpatient capacity, they require time to implement and mobilize specific resources.

While the emergency plans of many hospitals include plans for delaying or cancelling scheduled procedures to create surge capacity, the process by which this would be done typically is unstructured, and the potential inpatient capacity that might be generated is not quantified or predictable. A literature search of recent peer-reviewed literature found no published planning tools or descriptions of structured mechanisms by which procedures could be delayed or the potential impact of this strategy on inpatient surge capacities.

In this study, a system was developed by which scheduled procedures can be categorized by their potential impact on inpatient surge capacity if the procedures were to be cancelled or delayed. Then, the potential capacity was determined when the system was applied to the study hospital procedural schedule. For example, elderly patients scheduled for elective hip replacement routinely are hospitalized for an average of five days after the procedure.[10] Therefore, cancelling or delaying this procedure would allow the bed reserved for that patient to be available as surge capacity. An observational study in New York City after the 11 September 2001 attacks found that physicians employing a non-systematic modification of procedural schedules, admissions, and discharges to create surge capacity for the expected victims of the event resulted in a 9% reduction in occupancy by 12 September from the 10 September baseline.[11] Another observational study in Toronto during the severe acute respiratory syndrome (SARS) outbreak demonstrated a 12% decrease in admissions due to restrictions on non-urgent use of hospital services.[12]

Methods

This pilot study was designed to determine the potential impact of delaying or cancelling scheduled procedures on inpatient surge capacity. A methodology was devised by which scheduled procedures were categorized by their potential impact on inpatient capacity and applied to an existing operative schedule. A four-week sample of scheduled procedures at a single adult, tertiary care hospital was analyzed. One physician-in-training and two research assistants reviewed all of the medical charts of patients who had procedures during the four-week period and applied the categorization methodology.

The four one-week periods were chosen by convenience. Weeks that included government and major religious holidays were excluded. The four weeks studied were weeks beginning: 05 November 2007, 04 February 2008, 07 April 2008, and 04 August 2008.

Charts for all procedures in the four-week sample period were reviewed by research assistants, and the cases were categorized using the schema in Table 1. This schema facilitated categorization of procedures based on their impact on inpatient capacity and the safety of their delay. For cases in which categorization

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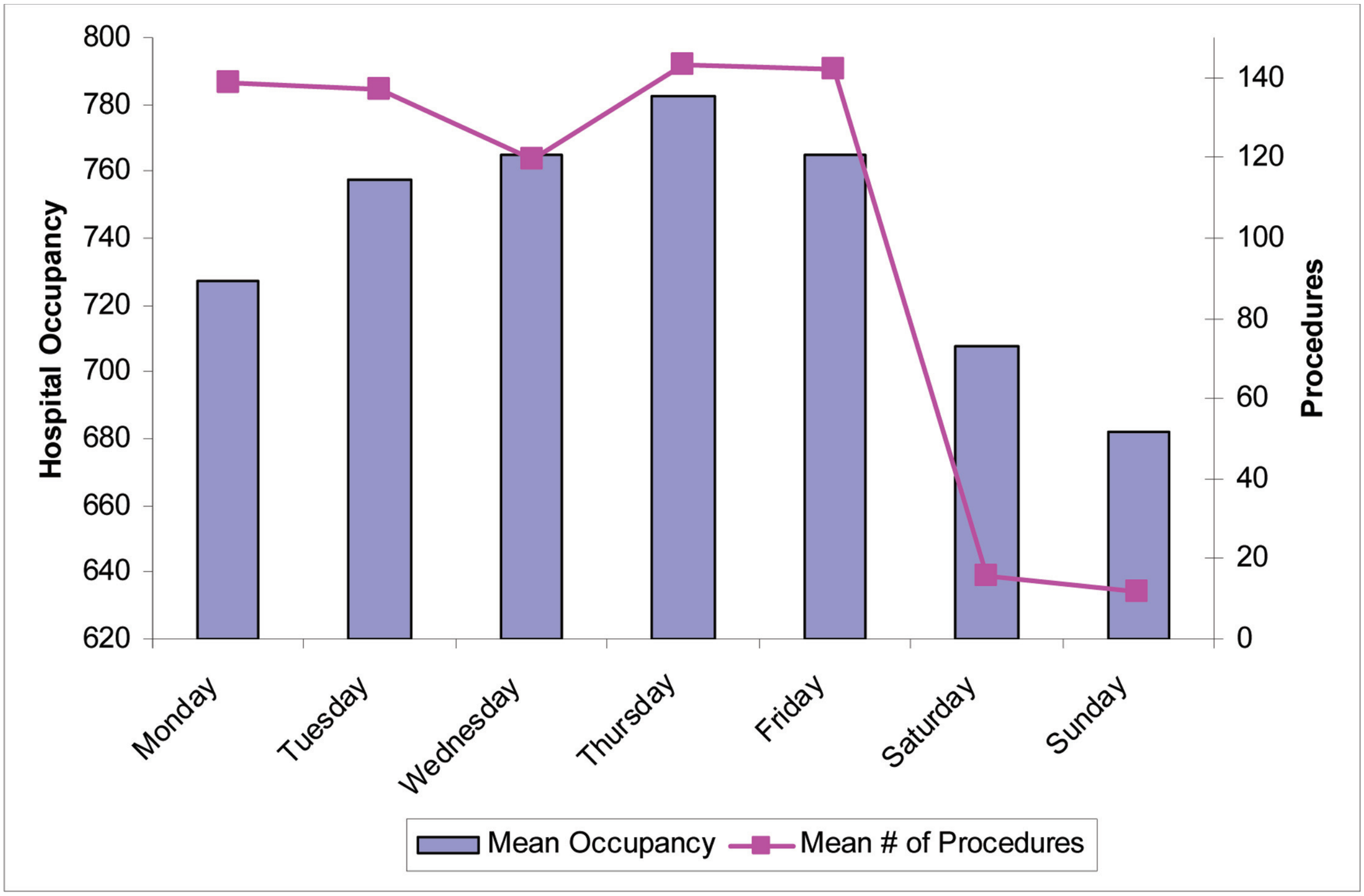

Figure 1—(Color online) Mean daily occupancy and number of procedures by day of week during sample period

did not fit into the *a priori* determined schema, a physician-in-training reviewed the medical chart to determine the appropriate category. Procedures with incomplete data, such as when length of stay could not be determined were excluded. To determine inter-rater reliability, all three reviewers rated the first 100 cases of the sample, and inter-rater reliability was calculated.

Occupancy was defined as the count of occupied beds at midnight. Maximal functional capacity was determined on the basis of 95th percentile highest occupancy during the study period, as this was thought to be more representative of the functional capacity than the number of licensed beds.[11]

The main outcome measure was the number of hospital beds (ICU and general medical/surgical) that could be made available in a 24-hour period by delaying procedures that would require an inpatient admission post-procedure, expressed as a percentage of the maximal functional capacity. The number of beds that could be made available was determined by counting the number of procedures that began on the day of the decision to cancel or postpone them. The secondary outcome measure was the number of beds that could be made available for one week from the date of cancellation.

Statistical processing for the number of inpatient beds created and the daily occupancy was described using means with 95% confidence intervals (CI) and comparisons done using Chi-square test (2 sided p-values <0.05 were considered statistically significant). Hospital length of stay was described as medians with interquartile ranges. Inter-rater reliability was calculated using kappa statistics. All data were abstracted from the administrative database into Microsoft Excel 2003 (Microsoft, Redmond WA), and SAS version 9.2 (SAS Institute Inc., Cary NC) was used for all statistical calculations. The institutional review board at the study hospital approved the study protocol.

Results

Peak mean hospital occupancy was on Thursdays, with a mean occupancy of 782 patients (95% CI = 770–794). This peak occupancy corresponds to peak admissions for procedures during the sample period. During the weekdays, mean occupancy was 759.2 (95% CI = 753–765) versus mean occupancy of 694.7 (95% CI = 687–702) on weekends. The 95th percentile occupancy during the week was 816, representing the maximal functional capacity at the study center. During the week, the mean occupancy rate (average occupancy/maximal functional capacity) was 93% (95% CI = 81.1% - 105.0%). On the weekends, mean occupancy rate was 85% (95% CI = 75.8% - 94.4%) (Figure 1).

During the four-week sample period, the categorization schema was applied to 2,821 procedures. Fifty-five procedures were excluded from the analysis due to incomplete data. Patient demographics of all patients undergoing procedures during the study period are listed in Table 2. The median length of stay for all procedures was one day (IQR = 0–5). The median length of stay for category B and C procedures was three days (IQR = 1–5).

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Median Length of stay in days (interquartile range)	1 (0–5)
Patient Characteristics	
Age ±SD	55.30 ±16.42
Sex (% male)	42
Race/Ethnicity (%)	
White, non-Hispanic	77.99
Black, non-Hispanic	8.6
Hispanic	5.2
Other	8.2
Primary Health Insurance (%)	
Private	58.1
Medicaid	6.2
Medicare	32.4
Self-pay	1.6
Other or missing data	1.7

Table 2—Demographic characteristics of patients entered into the study

The distribution of procedures during the study period show that majority of procedures occur during the week with greater than half of the procedures being category B and C (see Table 3a). By canceling or delaying these procedures, 5%–8% of addition capacity can be created during the week (see Table 3b). For the main outcome, a daily average of 51.1 general medical/surgical beds (95% CI = 50.6–51.5) and 8.7 ICU beds (95% CI = 8.1–9.3) could be created by delaying procedures during weekdays. On weekends, a daily average of three general medical/surgical beds (95% CI = 2.4–3.5) could be created using this strategy. As a percentage of maximum functional capacity, 7.3% of inpatient beds could be made available for surge capacity during the week, and 0.49% of inpatients beds could be made available for surge capacity during the weekend using the study strategy. The majority of the beds created were general medical/surgical beds (Table 3b).

In the event when sustained surge capacity is needed, postponing all category B and C procedures for one week could produce an inpatient surge capacity of 1,235 hospital bed days (95% CI = 989.6–1481.9). Inter-rater reliability was high (kappa = 0.74) indicating good agreement between all three raters.

Discussion

The requirement for surge capacity can be divided roughly into two categories based on the arrival rates and the time to peak demand for healthcare services. One-time events, such as the 11 September 2001 attacks in the US lead to peak demand for healthcare services in the 24–48 hours following the event.[13] These events require the rapid mobilization of resources to manage the spike in demand. Multiple events, such as a flu pandemic, lead to a gradual increase in demand for services, with peak demand occurring several days to weeks after the event began.[13] Once identified, these events allow for relatively more time to create surge capacity, although the generated capacity must be sustainable.

Surge capacity consists of multiple components, including human resources, equipment, supplies, operating rooms, and in-patient beds.[1,14] Depending on the incident, varied combinations of these components of surge will be needed to meet the increase in demand.

Hospitals and municipalities have created disaster or MCI plans that should include the steps required in order to generate inpatient surge capacity, and a key component of that plan usually includes provision for delaying or canceling scheduled procedures. However, the potential impact of this strategy on creating in-patient bed capacity has yet to be quantified.

This pilot study used a categorization system to identify cases that potentially could be delayed, and quantified the impact delaying these cases would have on in-patient capacity. At the study institution, the strategy of delaying scheduled cases was most effective on Monday, leading to a reduction in occupancy of approximately 65 beds, or 8% of maximal capacity. This strategy is least effective on the weekends, where two to five beds or <1% of maximal capacity could be made available by delaying procedures. While this strategy is least effective on weekends, there is an overall lower occupancy rate on weekends. Thus, the barrier to creating surge capacity on weekends likely will be related to staffing and equipment.

Applying a similar categorization mechanism, on a real-time and regional basis, may also allow for a rapid coordinated hospital response to create appropriate inpatient and ICU surge capacity in the event of a mass-casualty event or sudden surge in demand.

In addition to the reduction in occupancy, it also is important to consider the impact procedures have on the other components of surge capacity. While category A procedures do not impact in-patient occupancy, these procedures do impact staffing and equipment, which are significant resources that could be directed toward surge capacity. Extending the categorization scheme to include the impact on other resources besides in-patient bed capacity may allow for a better understanding of cancelling category A procedures. The findings of this pilot study suggest that future study in the development of a categorization scheme for cases, as well as other scheduled or elective medical admissions is warranted. As many hospitals and systems currently rely on delaying or canceling scheduled procedures as one component of a surge plan without a clear understanding of its true ability to generate capacity, this system could be applied to all hospitals in a municipality. This will allow for real-time

	Procedure Category			
	A	B	C	D
Mean # of Procedures ±SD				
Monday	54.5 ± 12.4	24.50(4.2)	41.0 (6.3)	6.78 (1.5)
Tuesday	63.5 ± 10.9	21.3(5.74)	38.3 (9.2)	14.3 (4.9)
Wednesday	60.6 ± 14.9	18.8 (2.1)	26.3 (2.2)	13.8 (2.2)
Thursday	68.5 ± 7.2	22.3 (6.4)	40.0 (8.3)	12.8 (5.3)
Friday	74.3 ± 8.54	16.5 (5.57)	35.8 (5.7)	15.8 (3.9)
Saturday	4.8 ± 1.0	3.0 (NA)	2.3 (0.6)	5.5 (3.0)
Sunday	2.3 ± 1.0	0	2.7 (1.5)	6.8 (1.5)
Total				
Median Length of Stay (Days) (IQR)	0 (0–0)	3 (2–4)	3 (1–6)	5 (2–10)

Table 3A—Daily procedures by category

	Total Surge by Delaying B & C	% of Maximum Capacity
Day of Week		
Monday	65.5	8.0
Tuesday	59.5	7.3
Wednesday	45.0	5.5
Thursday	65.3	7.6
Friday	52.3	6.4
Saturday	5.3	0.7
Sunday	2.7	0.33
Bed Type Post Op		
Intensive Care Unit		
Weekday	8.67	
Weekend	1.0	
General Med/Surg		
Weekday	51.04	
Weekend	3	

Table 3B—Inpatient surge capacity generated using study strategy

determination of the number of in-patient beds that could be created by delaying cases.

Limitations

As with many pilot projects, this study has several limitations. First, the analysis is limited to one institution with a large scheduled tertiary care procedural volume and acuity, making the ability to create surge capacity by delaying cases not specifically applicable to institutions with a typical operative and procedural schedule.

Secondly, categorization was done by a single physician and two research assistants. While there may be some inter-rater variability in categorization of procedures, high inter-rater reliability was observed between all three raters. In addition, we arbitrarily set the amount of time category C procedures could be delayed at seven days. This amount of delay was thought to be clinically appropriate based on clinical picture, duration of symptoms, and when the case was initially scheduled. In addition a delay of 7 days and the surge capacity created will provide sufficient time to allow for other interventions such as opening non-clinical areas, changes in admission policies, to come into effect in the event long-term surge capacity is needed. As this is a pilot, these weaknesses will be remedied in the future study design by utilization multi-specialty physician teams to create categorization methodologies and multi-center validation of this methodology.

Conclusions

At the study institution, the strategy of delaying scheduled procedures could generate inpatient capacity with maximal impact seen during weekdays and little impact on weekends. Future research will be needed to validate the categorization scheme and increase the ability to predict inpatient surge capacity across various hospital types and sizes on a regional level.

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