

Creation of Inpatient Capacity During a Major Hospital Relocation

Lessons for Disaster Planning

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Objective: To identify tools to aid the creation of disaster surge capacity using a model of planned inpatient census reduction prior to relocation of a university hospital.

Design: Prospective analysis of hospital operations for 1-week periods beginning 2 weeks (baseline) and 1 week (transition) prior to move day; analysis of regional hospital and emergency department capacity.

Setting: Large metropolitan university teaching hospital.

Main Outcome Measures: Hospital census figures and patient outcomes.

Results: Census was reduced by 36% from 537 at baseline to 345 on move day, a rate of 18 patients/d ($P < .005$). Census reduction was greater for surgical services than nonsurgical services (46% vs 30%; $P = .02$). Daily volume of elective operations also decreased significantly,

while the number of emergency operations was unchanged. Hospital admissions were decreased by 42%, and the adjusted discharges per occupied bed were increased by 8% (both $P < .05$). Inpatient mortality was not affected. Regional capacity to absorb new patients was limited. During a period in which southern California population grew by 8.5%, acute care beds fell by 3.3%, while Los Angeles County emergency departments experienced a 13% diversion rate due to overcrowding.

Conclusions: Local or regional disasters of any size can overwhelm the system's ability to respond. Our strategy produced a surge capacity of 36% without interruption of emergency department and trauma services but required 3 to 4 days for implementation, making it applicable to disasters and mass casualty events with longer lead times. These principles may aid in disaster preparedness and planning.

Arch Surg. 2009;144(9):859-864

PREPAREDNESS TO RESPOND effectively during a natural or manmade disaster has become a priority for hospitals in and outside the United States.¹⁻³ Thorough preparation requires a coordinated effort to determine the appropriate allocation of hospital resources to accommodate an acute influx of patients with needs for various services, including operative and other procedures.^{4,5}

Surge capacity is the term used to describe the ability to accommodate an acute influx of patients.⁵ Hospitals can create surge capacity through inpatient census management and adaptation of existing patient care capacity.⁶ Individual facilities may elect a graded response, where different actions are taken according to the number of expected casualties.⁶

Surge capacity is rarely tested, as most disaster drills terminate after triage and immediate treatment in the emergency department and operating rooms.⁷ Few stud-

ies have focused on the ability of hospitals to create capacity when continued inpatient management is required. As many hospitals, especially trauma centers, are currently operating at or near capacity, local or regional disasters of significant scale might overwhelm the health care system's ability to respond.

Census reduction during a hospital relocation is an exercise analogous to the generation of surge capacity during disaster planning. We recognized the planned relocation of the University of California, Los Angeles (UCLA) Medical Center as a major triage exercise and a unique opportunity to investigate these issues. The present study was undertaken to measure the reserve capacity of the local hospital and trauma system using regional data on hospital occupancy. Our hospital relocation methods were used to assess the effectiveness of census reduction plans and identify tools that might be of value in surge capacity planning and disaster management.

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Table 1. Hospital Census

	No. (SD) of Inpatients		Reduction, %	P Value
	Baseline	Move Day		
Total	537 (27)	345	36	<.001
Surgical services	217 (15)	118	46	<.001
Emergency	127 (7)	86	32	<.001
Elective	91 (10)	32	65	<.001
Nonsurgical services	322 (14)	227	30	<.001
Medical	223 (13)	153	31	<.001
Pediatrics	70 (5)	54	23	<.001
Obstetrics	29 (4)	20	31	<.001
Intensive care units	101 (5)	84	17	<.001
Medical/surgical units	436 (24)	261	40	<.001

METHODS

SETTING

The UCLA Medical Center is a tertiary academic hospital with a level I trauma center designated by the County of Los Angeles. The existing medical center, used without interruption for 53 years, had an average daily census of 525 patients. The new facility was constructed directly across the street and has a capacity of 455 beds. The new medical center was expected to operate at 90% or more of capacity.

STUDY DESIGN

This was a prospective study designed to evaluate the effectiveness of several components of a planned inpatient census management strategy during a major hospital relocation. Approval was granted by the UCLA institutional review board. Census data were collected for 2 weeks prior to move day on June 29, 2008. The study period was divided into the baseline period, beginning 2 weeks prior to move day (June 15-21), and the transition period, beginning 1 week prior to move day (June 22-28), when active census management was implemented.

Figures were collected to assess the reserve capacity of local hospital and trauma systems. Data regarding hospital closures and existing hospital capacity in southern California were obtained from the California Hospital Association and the Office of Statewide Health Planning and Development.^{8,9} Diversion statistics for Los Angeles County emergency departments were obtained from the Los Angeles Department of Health Services, Emergency Medical Services Agency.¹⁰ Population figures for southern California were collected from the US Census Bureau.¹¹

INTERVENTIONS

The transition to the new medical center was planned for more than 3 years in advance and was directed by a surgeon (J.B.A.). The final date for the move was fixed 3 months in advance; a Sunday was chosen to minimize disruption of regular hospital operations. Admissions, discharges, and lengths of hospitalization were monitored in real time during the transition process to project hospital census up to move day. A census of 350 inpatients was chosen as the target for move day based on projections of time required for the move and to assure our ability to reuse critical medical equipment during the move. When assumptions to test various levels of census were modeled, it was

found that the move sequence would fail quickly as the census exceeded 400 patients.

Three active census management interventions were developed during the planning phase for implementation during the transition period. First, the elective operative volume was drawn down 1 week prior to move day by limiting the number of operating rooms that could be scheduled. Second, the number of inpatient transfers accepted from outside institutions was reduced during the transition period. Finally, a multidisciplinary discharge planning team, including chief medical and surgical officers, nursing unit directors, and 2 ethicists, conducted daily rounds to identify the eligibility of inpatients for expedited discharge and for transfer from intensive care unit (ICU) beds to medical/surgical ward beds. Coordination with ancillary health care services, including nursing homes, rehabilitation centers, and home health services, was intensified during the transition period to overcome various barriers to patient placement and discharge planning encountered at baseline.

HOSPITAL RELOCATION

On move day, 345 hospitalized inpatients were relocated from the existing facility to the new hospital via 30 ambulances during a 7-hour move sequence beginning at 7 AM. Three move teams used 10 ambulances each, with a cadre of physicians, nurses, and professional relocation personnel. Two teams transported the more routine patients from intensive care and medical/surgical units on a strict departure schedule at intervals of 2 minutes. The third team transported less stable patients and neonates and was allowed a more flexible departure interval. These teams used nonintersecting routes with separate corridors, elevators, exits, and entrances assigned within each route.

The emergency department declared diversion status and accepted no new patients into the facility for an 11-hour period beginning 3 hours before the move was launched. Apart from those 11 hours, the emergency department and trauma services operated at full, uninterrupted capacity during the entire transition period.

OUTCOME MEASURES

The primary outcome measure was the average daily census during the study period. Censuses for the baseline and transition periods, daily hospital admissions and discharges, operative volumes, lengths of hospitalization, distribution of patients in ICU and medical/surgical ward beds, and mortality rates were compared for the baseline and transition periods. Non-elective and nonscheduled admissions and operations were defined as emergencies.

STATISTICAL ANALYSIS

Descriptive statistics were used to report averages and standard deviations of daily census, admission, and discharge figures. *t* Tests and χ^2 tests were used to compare the baseline and transition periods. All statistical analyses were performed using SAS 9.2 (SAS Inc, Cary, North Carolina).

RESULTS

UCLA HOSPITAL RELOCATION

The distribution of patients for each of the hospital services prior to and following implementation of the census management plan is shown in **Table 1**. During the

baseline period, the hospital was operating at 83% of the existing inpatient capacity, with an average daily census of 537 patients. During the transition period, hospital census was reduced by a rate of 18 patients/d to 345 patients on move day, a 36% reduction from baseline (**Figure**). While there was a significant decline in census for each service, reductions were greater for surgical services than for nonsurgical services (46% vs 30%; $P = .02$). Reductions in both medical/surgical ward and ICU censuses were significant, with greater reductions for the wards (40% vs 17%; $P < .001$).

The daily operative volume was reduced by 45% from baseline to transition periods (44 cases vs 24 cases; $P = .02$). This lower volume was entirely due to a reduction in elective operations (39 cases vs 18 cases; $P = .02$), as the volume of emergency operations was unchanged.

Average daily admission and discharge data were used to calculate differences in these figures when baseline and transition periods were compared (**Table 2**). Table 2 shows the change in numbers of patients admitted and discharged during the 2 periods. For discharges, Table 2 also shows the change in adjusted discharges per occupied bed to capture the proportion of the remaining patients discharged from each service.

ADMISSIONS

Daily admissions were decreased significantly for the surgical services and the medical service but not for pediatric and obstetric services. For the surgical services, reductions were significant both for elective and emergency admissions. Reduction in emergency admissions reflected a decline in acceptance of transfers, as the trauma service operated at full capacity and diverted patients only for a few hours prior to and during relocation. Comparing baseline and transition periods, the number of daily transfers from outside facilities decreased significantly for both surgical services (5 patients vs 2 patients; $P = .02$) and nonsurgical services (7 patients vs 3 patients; $P = .04$).

DISCHARGES

While the overall number of daily discharges was similar in baseline and transition periods, the adjusted discharges per occupied bed increased significantly. This increase was significant for both surgical and nonsurgical services overall. The surgical services and particularly the elective services made the majority of the contribution to the increase in discharges.

To investigate the acuity of our patients at the time of the move, we calculated the proportion of hospitalized patients in the ICU during the study period. This proportion was significantly higher on move day compared with baseline (24% vs 19%; $P < .001$) and was higher for surgical than for nonsurgical services (27% vs 23%; $P < .001$).

Duration of inpatient hospitalization was 6 ± 10 days during the baseline period and 7 ± 14 days during the transition period ($P = .52$). The lengths of stay remained unchanged because of the escalating acuity of patients as hospital census fell. Inpatient mortality was 3% for both baseline and transition periods ($P = .68$). There were no adverse events during the move sequence.

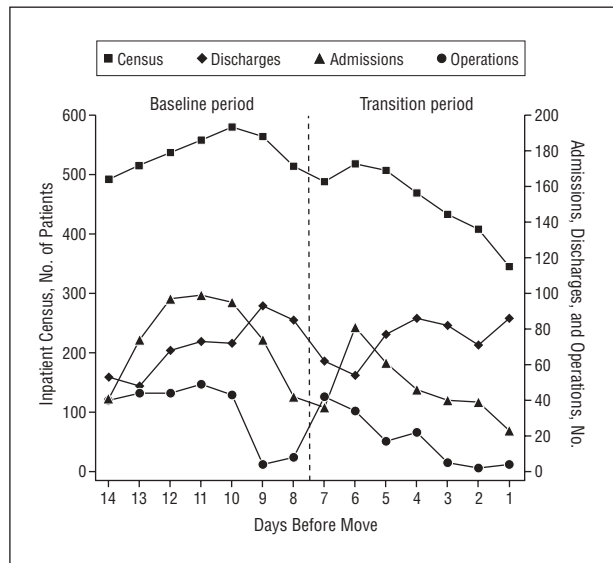


Figure. Daily census, operations, admissions, and discharges during the study period.

Within 1 week of move day, the new hospital was operating at more than 90% of its capacity. Since the relocation, the average hospital census has been 98% of capacity, with fluctuations between 81% on weekends and 110% on Wednesdays and Thursdays.

REGIONAL HEALTH SYSTEM

Information regarding hospital closures and bed capacity for southern California counties is shown in **Table 3**. Between 2003 and 2008, 17 of 146 southern California hospitals (12%) were closed permanently, with a net loss of 2745 licensed acute hospital beds in the region. There also was a steady decline of available beds within existing hospitals. Despite only 2 hospital closures after 2005 and an increase in bed capacity in some counties, the total number of licensed beds fell by 3.3% from 2006 to 2008. From 2000 to 2007, the population in southern California grew by 8.5%.¹¹

Emergency departments experienced substantial overcrowding. Of the 74 emergency departments in Los Angeles County that received emergency medical services traffic during 2007 to 2009, the overall diversion rate because of oversaturation was 13% of total hours, with a range of 9% to 18% for the various regions within the county.

COMMENT

Our local and regional data identify a health care system that is operating at or near capacity in southern California. During a period of population growth, there was a 12% reduction in the number of hospitals since 2003 and a 3.3% reduction of inpatient beds since 2006. Emergency departments are overcrowded, with an average diversion rate of 13% in Los Angeles County from 2007 to 2009. Census strains and overcrowding of emergency departments, in part because of a lack of acute care beds, are a national problem.¹²⁻¹⁵ Taken together, these data in-

Table 2. Changes in Daily Admissions and Discharges

	Admissions		Discharges			
	Change in Number, % ^a	P Value	Change in Number, % ^a	P Value	Change in Adjusted, % ^b	P Value
Total	-42	.01	0	.55	+8	<.001
Surgical services	-55	.02	-3	.77	+11	.001
Emergency	-46	.01	+27	.14	+7	.01
Elective	-61	.02	-22	.11	+24	<.001
Nonsurgical services	-27	.07	+4	.77	+7	.002
Medical	-36	.03	-6	.70	+6	.07
Pediatrics	-22	.21	0	.82	+5	.37
Obstetrics	0	.97	+30	.14	+21	.03

^aComparing baseline and transition periods.

^bComparing discharges adjusted per occupied bed in baseline and transition periods.

Table 3. Southern California Hospital Closures and Inpatient Bed Capacity^{8,9}

County	Hospital Closures, 2003-2008		Inpatient Capacity		
	No.	Beds Lost	2006	2008	Change, %
Los Angeles	12	2357	23 507	21 958	-6.6
Orange	3	284	5698	5972	4.8
San Bernardino	1	55	3342	3384	1.3
Ventura	1	49	1461	1554	6.4
San Diego	0	0	6061	5870	-3.2
Total	17	2745	40 069	38 738	-3.3

Table 4. Strategic Actions to Reduce Census for Inpatient Surge Capacity Creation

Action	Contribution to Census Reduction, % ^a	Interval to Realize Gain
Cancel operations	40-50	3-4 d
Cancel admissions	30-40	3-4 d
Expedite discharges	10	Immediate

^aBased on experience in the study hospital and may vary by service mix in other hospitals.

dicating a limited ability to absorb additional patients, or lack of surge capacity. A natural or manmade disaster of any scale has the potential to overwhelm our system's ability to respond despite preparedness for initial triage and management.

To our knowledge, ours is the first prospective analysis regarding creation of surge capacity. With a planned strategy, we were able to reduce the hospital census by 36% over a period of 1 week. This reduction occurred without interruption of emergency department and trauma services and with no increase in mortality of our hospitalized patients.

There were 3 components to our census management strategy. First, the elective surgery schedule was restricted beginning 1 week prior to move day, and operative volume was reduced by 45%. Second, incoming transfers were limited, leading to a reduction in both urgent and emergent admissions to medical and surgical services without limitation of trauma and emergency department admissions. Finally, a centralized multidisciplinary discharge team was used to enhance the efficiency of the discharge process. Daily discharges adjusted per occupied bed increased by 8%. This strategy required 3 to 4 days to observe a significant decline in hospital census and availability of new acute care beds.

Expedited discharge of hospitalized inpatients as a mechanism to create surge capacity has received little attention.^{5,16,17} Using a survey of nurse managers and phy-

sicians, Davis et al⁵ reported an availability of half of the inpatient beds within 72 hours by expedited discharges of existing patients. The clinical assessments of the suitability of patients for discharge were made theoretically and do not provide usable guidelines. Our prospective experience found expedited discharge to be an effective tool to generate bed capacity immediately, but early discharges became more difficult to achieve as census reduction escalated the acuity of remaining inpatients.

The concept of hospital inpatient surge capacity modeled in our study must be distinguished from immediate emergency department surge capacity during an acute disaster. Recent studies have focused on the ability of emergency response systems to accommodate the initial surge of injured patients immediately after a disaster^{1,17,18} but did not address the ability of receiving hospitals to house and care for injured patients after treatment in the emergency departments or operating rooms. Our study focused on inpatient hospitalization as the next stage of patient care.

Strategic options for creation of inpatient surge capacity are shown in **Table 4**. Estimates of potential census reduction are based on the experience reported for our hospital and will vary depending on the service mix in other hospitals, as opportunities for census reductions are greater for surgical than for medical services. As the intervals to realize census gains are different for each option, the options may be applied selectively for events with varying lead times.

The majority of our strategies required 3 to 4 days to achieve significant census gains and would be particularly useful during disasters, such as hurricanes or ill-

ness epidemics, with longer lead times. Elimination of elective admissions and operations have high yields, as do limitation of elective transfers and cancellation of complex elective operations for patients with high acuity, where postoperative hospitalization may be prolonged.

When lead times are brief, such as earthquakes, urban bombings, or other mass casualty incidents, strategies to bolster emergency department and trauma center preparedness are the first priority.^{1,17} Inpatient capacity for continued hospital care of injured patients must also be generated simultaneously, and our model provides useful tools for this purpose.

Both initial emergency department surge capacity described by Hirshberg et al¹ and the continued inpatient surge capacity highlighted in our model are complementary components of disaster planning, and thorough preparedness during both phases are critical. Hospitals can be overwhelmed if response to either phase is inadequate.

Strategies to create inpatient surge capacity similar to those described herein have been advocated by other authors.^{6,7,19} These reports represent retrospective postdisaster analyses without comment on predisaster hospital occupancy, acuity of inpatients, or patient safety during the surge. The present study has validated these retrospective and/or theoretical experiences with prospective data collection.

Declining inpatient and emergency department capacities significantly compromise disaster preparedness efforts.²⁰ A survey of hospitals in Los Angeles County showed that, despite routine disaster preparedness drills in most hospitals, both surge capacity and interagency planning were severely limited.²¹ Our experience and that of others identify surge capacity as an underrecognized component of disaster planning. We propose that health care systems should evaluate surge capacity in their region, that a measure of surge capacity may be an appropriate component of some disaster drills, and that hospitals should include surge capacity creation within their internal disaster planning. In addition, communications between command centers and hospitals during disaster events should include access to real-time hospital occupancy and ability to create inpatient surge capacity.

Our detailed report of hospital relocation joins others that are mainly descriptive.²²⁻²⁵ The proposed census management strategy produced a safe and potentially rapid reduction in hospital census without interruption of emergency department or trauma services. This strategy might serve as a model both for large-scale disaster inpatient surge capacity planning as a component of hospital disaster preparedness and for day-to-day census management in individual hospitals. Hospitals should create an internal plan using these principles of census management with modifications to reflect local characteristics. Finally, as many hospitals are currently operating at capacity, a regional and integrated systems approach to surge capacity creation is needed.

Accepted for Publication: April 3, 2009.

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Author Contributions: *Study concept and design:* Jen, Shew, Atkinson, Rosenthal, and Hiatt. *Acquisition of data:* Jen and Atkinson. *Analysis and interpretation of data:* Jen, Shew, Atkinson, and Hiatt. *Drafting of the manuscript:* Jen and Hiatt. *Critical revision of the manuscript for important intellectual content:* Jen, Shew, Atkinson, Rosenthal, and Hiatt. *Statistical analysis:* Jen.

Financial Disclosure: None reported.

Previous Presentation: This paper was presented at the 80th Meeting of the Pacific Coast Surgical Association; February 16, 2009; San Francisco, California; and is published after peer review and revision. The discussions that follow this article are based on the originally submitted manuscript and not the revised manuscript.

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DISCUSSION

Diana Farmer, MD, San Francisco, California: This paper describes the work of orchestrating a complex multifaceted migration of patients as a tool for modeling surge capacity in potential catastrophes. It shares strategies for both staged and more immediate inpatient census reduction. These strategies are useful, not only as a guideline for potential disaster management, but also for planned events as many of us (particularly in California) are facing major hospital moves as the seismic hospital replacement deadlines approach.

Several interesting questions arise from evaluation of your manuscript. First, regarding safety during your move, how did you decide which patients were appropriate and safe for discharge?

Do you have data on the fate of the discharged patients? Were patients transferred to other centers, and were other centers welcoming and helpful during this time?

Your paper reports that surgical services were more successful than nonsurgical services at census reduction. Do you have information or thoughts on why that was the case?

With respect to disaster management, since a major earthquake is predicted in California in the coming years, did your experience generate any specific recommendations beyond "duck and cover"?

How did you handle the sickest and most unstable critical care patients during the move, and what are implications for disaster planning? If an alternative site is considered for disaster management, how is that site selected? What are the logistical issues involved in the set up of such a site?

Finally, do you have any expense data regarding the move? How much extra staff was required?

Dr Atkinson: Safety was one of the highest priorities during planning of the move. The selection of patients for early discharge was made by a series of communications to the primary care team, including nurses and physicians. The nurse managers for all units met daily to discuss their census and identify patients for early discharge. During the final week, this was

supplemented by executive rounds in all critical care units led by the chief medical officer, senior leadership from nursing, surgery, medicine, and pediatrics and attended by the unit director. The team was also accompanied by 2 ethicists. The primary team was engaged when early discharge opportunities were identified or safety issues existed in regard to the pending move. This plan was quite successful in modifying care plans toward early discharge or stabilization for the move.

We do not have specific data in regard to the fate of the early-discharged patients. There was no increase in the readmission rate that we monitor routinely, but we cannot account for any patients that might have been admitted elsewhere.

Because the majority of elective admissions are surgical, the management of the surgical services was the major contributor to census reduction. Medicine, pediatrics, and obstetrics tend to have urgent or emergency admissions in greater numbers, while much of the less urgent care now has become ambulatory or short stay.

An earthquake is an example of a disaster that may have immediate casualties, as well as a more chronic surge in demand for disaster-related bed capacity. Seismic events may also damage the infrastructure of the hospitals themselves. All of these factors emphasize the need for better planning of disaster or mass casualty responses beyond the customary drill that only extends to the immediate management and does not consider inpatient care capacity issues. A careful plan to reduce beds occupied by existing patients and creation of additional surge capacity with alternate sites of care would be invaluable in the event of a major earthquake.

The most critically ill patients were moved by the "red" team, which had a higher level of personnel, larger ambulances, and more time allotted for each patient. We moved 10 patients on some type of ventricular assist device or ECMO [extracorporeal membrane oxygenation]. Specific mock drills were run to determine what equipment would fit in the ambulances and how much time would be required to move these patients. Back-up equipment was also organized so the patients could be safely managed in the event of an equipment failure during the move or shortly thereafter.

The overall cost of the move was \$5 million. The ambulances, EMTs [emergency medical technicians], rental equipment, and supplies amounted to \$2 million. The labor costs for the 5000 hospital personnel on move day was \$1 million. The estimate of lost revenue due to census management and lost care on the days preceding and after the move was estimated at \$2 million.

Financial Disclosure: None reported.