Hospital Bed Surge Capacity in the Event of a Mass-Casualty Incident

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Abbreviations:
EMT = emergency medical technician
ICU = intensive care unit
IMU = intermediate care unit
LVN = licensed vocational nurse
MCI = mass-casualty incident
NDMS = National Disaster Medical System
RN = registered nurse
SNF = skilled nursing facility

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Abstract

Introduction: Traditional strategies to determine hospital bed surge capacity have relied on cross-sectional hospital census data, which underestimate the true surge capacity in the event of a mass-casualty incident.

Objective: To determine hospital bed surge capacity for the County more accurately using physician and nurse manager assessments for the disposition of all in-patients at multiple facilities.

Methods: Overnight- and day-shift nurse managers from each in-patient unit at four different hospitals were approached to make assessments for each patient as to their predicted disposition at 2, 24, and 72 hours post-event in the case of a mass-casualty incident, including transfer to a hypothetical, on-site nursing facility. Physicians at the two academic institutions also were approached for comparison. Age, gender, and admission diagnosis also were recorded for each patient.

Results: A total of 1,741 assessments of 788 patients by 82 nurse managers and 25 physicians from the four institutions were included. Nurse managers assessed approximately one-third of all patients as dischargeable at 24 hours and approximately one-half at 72 hours; one-quarter of the patients were assessed as being transferable to a hypothetical, on-site nursing facility at both time points. Physicians were more likely than were nurse managers to send patients to such a facility or discharge them, but less likely to transfer patients out of the intensive care unit (ICU). Inter-facility variability was explained by differences in the distribution of patient diagnoses.

Conclusions: A large proportion of in-patients can be discharged within 24 and 72 hours in the event of a mass-casualty incident (MCI). Additional beds can be made available if an on-site nursing facility is made available. Both physicians and nurse managers should be included on the team that makes patient dispositions in the event of a MCI.

Davis DP, Poste JC, Hicks T, Polk D, Rymer TE, Jacoby I: Hospital bed surge capacity in the event of a mass-casualty incident. *Prehosp Disast Med* 2005;(20)3:169–176.

Introduction

Disaster management involves a coordinated effort between out-of-hospital and hospital personnel to determine the appropriate allocation of in-patient resources.[1] Although the initial assessment and triage of patients occurs in the field, decisions as to the destination of victims must be made in accordance with the ability of various receiving facilities to accept a particular number and type of patients.[2] This is important not only with regard to the area in which the event has occurred, but also for surrounding areas that may be required to receive additional victims.

For individual hospitals and the community, when knowledge is received that an incident has occurred that will generate large numbers of acutely injured and/or ill patients, the issue of bed availability becomes important for needs assessment and planning.[3–5] The ability of a hospital to accommodate a sudden influx of patients requiring hospitalization is called "surge capacity". An accurate estimate of the surge capacity also is critical when confronting

epidemics of infectious diseases, whether occurring naturally or as a result of bioterrorism.[2,6]

Although frequently overlooked, one component of most hospital disaster plans includes the directive to perform an assessment of in-patients to decide which patients are immediately dischargeable and to proceed with such discharges to make room for a surge of acutely injured and/or ill victims.[2,7] Protocols that are used for assessing bed availability by the National Disaster Medical System (NDMS) require hospitals to report information about the number of beds that are available, based on midnight bed counts and the number of beds that could be made available at 24 and 72 hours after the event. There are few guidelines, however, as to how to predict for planning purposes, the number of patients that are dischargeable from an in-patient facility. Guidelines for these assessments relate to the number of available, staffed beds, not just physical beds, and it usually is assumed that the number of beds reported are staffed. Unfortunately, reliable assessments have not been documented, with most estimates based on the natural discharge rate combined with cross-sectional, hospital census data.[6,8–12]

This method is inadequate for several reasons. First, the actual number of patients who could be discharged in the event of a mass-casualty incident is under-estimated. Second, it is likely that there are more than two choices for creating open beds beyond the discharge or non-discharge of patients. For instance, many in-patients could be safely transferred to a "step-down" facility staffed with medical or paramedical personnel. This possibility has not been studied, but could be a critical component of disaster planning.

In addition, many hospitals have areas or beds available for patient use that typically are not included in hospital capacity estimates because they routinely are not staffed. These beds could be considered for use in disaster management protocols in the event that additional medical and paramedical personnel could be made available or if traditional patient-to-staff ratios were not used. Third, the issues of the initial patient level of care or admission diagnosis have not been studied with regard to hospital bed surge capacity. Lastly, the category of personnel (nurse versus physician) making triage decisions has not been considered, but may impact upon the disposition of patients.

Given the need for data to be used for such planning decisions, surveying the actual patient-care units to determine the percentages of patients that could be discharged in these particular time frames would be useful information, if it could be demonstrated to be reproducible from hospital-to-hospital. A prospective, descriptive analysis of hospital bed surge capacity was performed using a representative sample of facilities in the San Diego community, incorporating in the analysis each of the factors listed above. The times selected for study were consistent with the NDMS hospital bed contingency plan; however, these concepts are relevant to hospitals anywhere when preparing for a MCI, whether from natural event, accident, or terrorist attack.

Parameter	% or mean	95% CI
Demographics		
Age (mean) (yrs)	54.2	52.8–55.7
Gender (% male)	46.7	43.4–50.0
Admission Diagnoses (%)		
Burn	2.1	1.2–3.4
Cardiac	16.5	13.9–19.4
Medical	19.1	16.3–22.2
Neurologic	1.2	0.6–2.3
Obstetrics	19.0	16.2–22.1
Orthopedics	4.4	3.0–6.2
Psychiatric	3.3	2.1–4.9
Respiratory	6.2	4.6–8.2
Spine	2.1	1.2–3.4
Surgical	20.0	17.1–23.1
Trauma	6.1	4.4–8.1

Table 1—Age, gender, and admission diagnoses for all 788 patients in this study (CI = confidence interval; yrs = years)

Methods

Design

This was a prospective, cross-sectional analysis designed to determine the number of acute-care hospital beds that could be made available at 2, 24, and 72 hours in the event an incident occurs. Approval was granted by the Investigational Review Board for each participating institution, including waiver of individual patient consent, as no direct patient contact was made and no patient identifiers were recorded. Consent was obtained from participating hospital personnel.

Facilities

Four San Diego County hospitals participated in this study. Hospital A is a 360-bed, university-affiliated, Level-I trauma center with the only designated Burn Unit in the county. In-patient teams are led by rotating house staff, who were approached for participation as part of the physician arm of the study. Hospital B is a 120-bed, university-affiliated, non-trauma center; where in-patient teams are led by academic faculty who were approached for participation as part of the physician arm of the study. Hospital C is a 372-bed, Level-II trauma center located in North San Diego. Hospital D is a 280-bed, Level-II trauma center located in Central San Diego.

Subjects

Data were collected from the overnight- and day-shift nurse managers for each in-patient unit at all four of the

Bed type	0 hours		2 hours		24 hours		72 hours	
	n	(%)	n	(%)	n	(%)	n	(%)
ICU	118	(15)	78	(10)	58	(7)	47	(6)
IMU	152	(19)	115	(15)	83	(10)	49	(6)
General care unit	467	(59)	325	(41)	229	(29)	113	(14)
SNF	52	(7)	151	(19)	177	(22)	188	(24)
Discharge	-	-	119	(15)	243	(31	392	(50)
Total	788	(100)	788	(100)	788	(100)	788	(100)

Table 2—Dispositions for all patients included in this study. A total of 1,479 assessments of 788 patients by 82 nurse managers at baseline (0 hours) and at 2, 24, and 72 hours are included. All values represent an average of the overnight- and day-shift nurse manager assessments (ICU = intensive care unit; IMU = intermediate care unit; SNF = on-site skilled nursing facility).

Parameter	Dischargeable (n = 225) (%)	Not Dischargeable (n = 501) (%)	*p*-value
Demographics			
Age (mean)	53.3	54.7	0.182
Gender (% male)	81 (36)	258 (51)	<0.001
Admission Diagnosis Category			
Burn	1 (0)	14 (3)	0.040
Cardiac	36 (16)	84 (17)	0.797
Medical	41 (18)	98 (20)	0.672
Neurologic	3 (1)	6 (1)	0.879
Obstetrics	78 (35)	60 (12)	<0.001
Orthopedics	13 (6)	19 (4)	0.228
Psychiatric	4 (2)	20 (4)	0.123
Respiratory	9 (4)	36 (7)	0.100
Spine	2 (1)	13 (3)	0.135
Surgical	27 (12)	118 (24)	<0.001
Trauma	11 (5)	33 (7)	0.375

Table 3—Dischargeability at 24 hours for various admission diagnoses. All values represent an average of the overnight and day shift nurse manager assessments. A total of 62 patients were excluded in whom no admission diagnosis was reported.

Bed type	0 hours				2 hours				24 hours				72 hours			
	Night		Day		Night		Day		Night		Day		Night		Day	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
ICU	120	(15)	109	(16)	82	(10)	68	(10)	66	(8)	45	(7)	50	(6)	39	(6)
IMU	149	(19)	118	(17)	121	(15)	132	(19)	91	(11)	87	(13)	61	(8)	45	(7)
Floor	467	(59)	412	(60)	298	(38)	273	(40)	204	(26)	186	(27)	83	(10)	107	(15)*
SNF	52	(7)	52	(8)	171	(21)	111	(16)*	179	(23)	148	(21)	187	(24)	163	(24)
DC	-	-	-	-	121	(15)	107	(15)	253	(32)	225	(33)	412	(51)	337	(49)
Total	788	(100)	691	(100)	788	(100)	691	(100)	788	(100)	691	(100)	788	(100)	691	(100)

Table 4—Overnight versus day nurse manager assessments. This includes patient assessments by overnight (n = 788 assessments) and day shift (n = 691 assessments) nurse managers at baseline (0 hours) and at 2, 24, and 72 hours. All values represent an average of the overnight- and day-shift nurse manager assessments (*p <0.01; ICU = intensive care unit; IMU = intermediate care unit; SNF = on-site skilled nursing facility; DC = discharge)

Bed type	0 hours				2 hours				24 hours				72 hours			
	Physician		Nurse		Physician		Nurse		Physician		Nurse		Physician		Nurse	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
ICU	55	(21)	55	(17)	43	(16)	37	(12)	35	(13)	25	(8)[a]	26	(10)	19	(6)
IMU	42	(16)	56	(18)	24	(9)	28	(9)	15	(6)	27	(8)	16	(6)	18	(6)
Floor	165	(63)	211	(66)	84	(32)	167	(52)[c]	42	(16)	147	(46)[c]	30	(11)	82	(26)[c]
SNF	-	-	-	-	43	(16)	51	(16)	60	(23)	57	(18)	56	(21)	74	(23)
DC	-	-	-	-	70	(27)	39	(12)[c]	110	(42)	66	(21)[c]	134	(51)	128	(40)[b]
Total	262	(100)	319	(100)	262	(100)	319	(100)	262	(100)	319	(100)	262	(100)	319	(100)

Table 5—Physician versus nurse patient disposition assessments. This includes assessments by physicians (n = 262 assessments) and nurse managers (n = 319 assessments) at baseline (0 hours) and at 2, 24, and 72 hours. All nurse values are averages of overnight- and day-shift nurse manager assessments. ([a]p <0.05; [b]p <0.01; [c]p <0.001; ICU = intensive care unit; IMU = intermediate care unit; SNF = on-site skilled nursing facility; DC = discharge)

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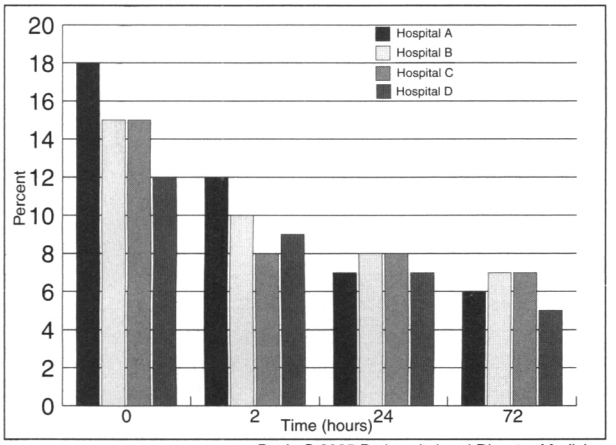

Figure 1—Dispositions of patients who initially were receiving intensive care unit-level care. This includes data for 0, 2, 24, and 72 hours at each of the four hospitals. All data represent a mean of day- and night-shift nurse manager assessments, expressed as a percentage of all patients included in this study. There were no statistically significant differences between the hospitals.

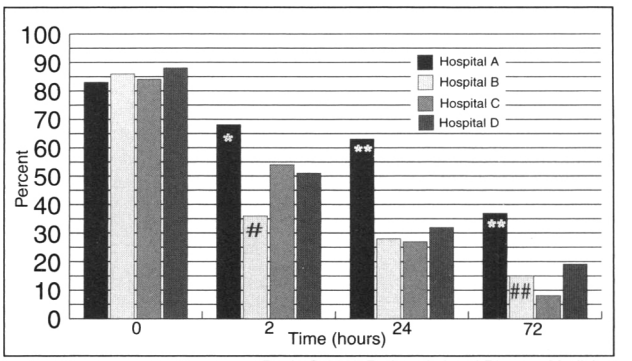

Figure 2—Dispositions of patients who initially were receiving non-intensive care unit-level care. This includes data for 0, 2, 24, and 72 hours at each of the four hospitals. All data represent a mean of day- and night-shift nurse manager assessments, expressed as a percentage of all patients included in this study. Statistically significant differences are indicated (*p <0.001 for Hospital A vs. Hospitals C and D, and p <0.01 for Hospital A vs. Hospital B; **p <0.001 for Hospital A vs. Hospitals B, C, and D; #p <0.001 for Hospital B vs. Hospitals A and D, and p <0.01 Hospital B vs. Hospital C; ##p <0.001 Hospital B vs. Hospitals A and D).

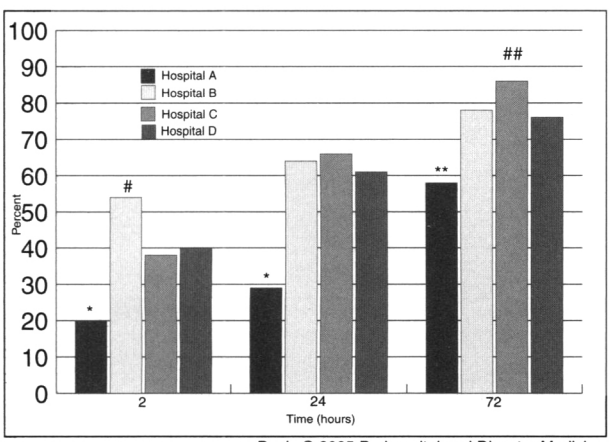

Figure 3—Creation of new hospital bed vacancies due to patient dispositions. This includes all patients dispositioned to an on-site nursing facility or discharged to home at 2, 24, and 72 hours for each of the four hospitals. All data represent mean values for day- and night-shift nurse manager assessments, expressed as a percentage of all patients included in this study.

Statistically significant differences are indicated (*p <0.001 for Hospital A vs. Hospitals B, C, and D; **p <0.001 for Hospital A vs. Hospitals C and D, and p <0.01 for Hospital A vs. Hospital B; #p <0.001 for Hospital B vs. Hospital A, and p <0.05 for Hospital B vs. Hospitals C and D; ##p <0.001 for Hospital C vs. Hospital A, and p <0.05 for Hospital C vs. Hospital D).

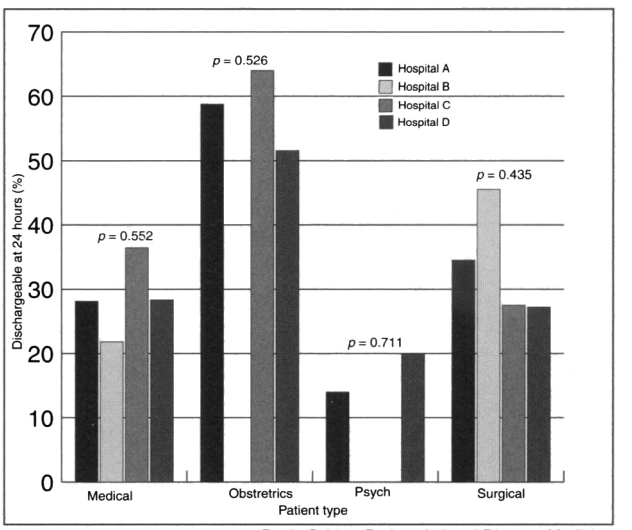

Figure 4—Patient dischargeability at 24 hours. This includes each of the four participating hospitals with patients stratified by admission diagnosis. There were no significant differences between hospitals for any of the admission diagnoses.

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Hospital	Hospital admits 24 hours	ED admits 24 hours	Hospital admits 72 hours	ED admits 72 hours
A	53	12	136	34
B	16	5	30	15
C	93	25	242	56
D	34	22	83	52
Total	196	64	491	157

Table 6—Total hospital and emergency department (ED) admissions. This includes each of the participating hospitals over the entire study period. Admitted patients were not assessed as to the urgency of admission or dischargeability within the study time frames.

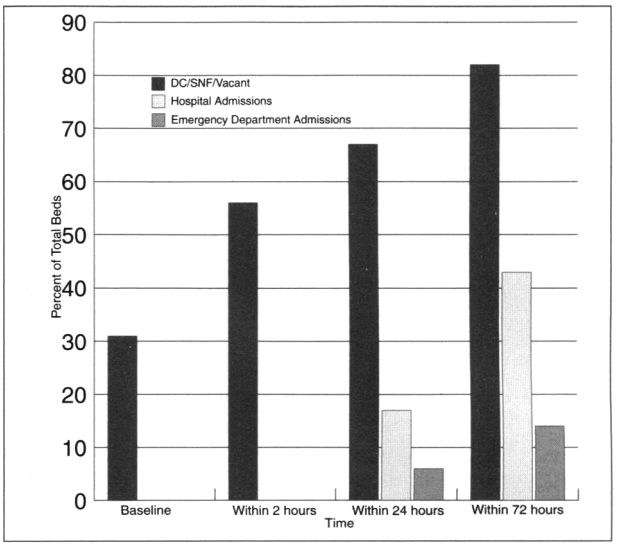

Figure 5—Cumulative hospital bed availability. This accounts for discharges home or to nursing facility, vacant staffed beds, hospital admissions, and emergency department admissions at baseline, and within 2, 24, and 72 hours for all hospitals together (DC = discharged; SNF = on-site nursing facility).

participating institutions. In addition, data were obtained from resident and attending physicians for each in-patient team at the two academic facilities. Each individual was asked to make assessments for all patients under his or her care.

Data Collection

A data collection day was assigned to each participating hospital. On the assigned day, the Director of Nursing was contacted before the exercise in order to define the current staffing pattern for his or her hospital, determine the number and type of beds (intensive care unit (ICU), intermediate care unit (IMU)/telemetry, and general surgical/medical beds) in the hospital, and identify additional areas located on the physical plant of the hospital that could be used as patient care areas in the event of a major incident.

On the designated day for data collection, the nurse manager for each in-patient unit was approached for study participation. Participation by all nurse managers and physicians was voluntary. Data were collected independently from the overnight team, representing a pre-rounds assessment, and from the day team following rounds. At the two participating academic institutions, the attending or resident physician responsible for each in-patient unit also was contacted for data collection. No patient identifiers were used so as to avoid potential breach of confidentiality with regard to protected health information. Each nurse manager and participating physician was asked to record the following information for every patient under his or her care:

1. Age, gender, and admission diagnosis; and
2. An assessment as to the potential 2-, 24-, and 72-hour disposition in the event of a mass-casualty incident with regard to the following categorizations
   A. Patient will require a more intensive level of care;
   B. Patient will require the same level of care;
   C. Patient can be transferred safely to a bed with less intensive monitoring;
   D. Patient can be discharged safely to a hypothetical on-site nursing facility, staffed with a supervising registered nurse (RN) and ancillary medical personnel, potentially including Licensed Vocational Nurses (LVNs), nursing assistants, and Emergency Medical Technicians (EMTs), as well as non-medical personnel; or
   E. Patient can be discharged safely to her/his home.

Finally, hospital admission records were examined for three consecutive days beginning on the designated data collection day for each hospital. The total number of hospital and emergency department admissions on each of the three days for each hospital were recorded.

Data Analysis

The primary outcome measures were the number of hospital beds that could be made available at 2, 24, and 72 hours as determined by nurse managers for each in-patient unit.

The reported disposition assessments were averaged between the overnight- and day-shift determinations for each unit and comparisons made between hospitals at each time point.

For inter-facility comparisons, hospital dispositions were reported as ICU versus non-ICU, since some variability exists in the way different hospitals define monitored and non-monitored beds. The creation of new bed vacancies was reported for any disposition to either a skilled nursing facility (SNF) or discharge to home. Inter-facility comparisons also were made with patients stratified by admission diagnosis. In addition, comparisons were made with regard to the assessments of overnight- and day-shift teams at all hospitals and between physicians and nurse managers at the two academic institutions.

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Alternative areas identified by the Nursing Director for potential use as on-site nursing facilities were assessed to determine whether enough space was available to accommodate patients dispositioned to these areas. Examples included cafeterias, conference rooms, and auditoriums.

Descriptive statistics were used to report averages for the assessments by overnight- and day-shift nurse managers, with the chi-square test used for all comparisons. Statistical significance of the differences was attributed to a p-value <0.05. Statistical calculations were performed using StatsDirect (StatsDirect Software Inc., Ashwell, UK).

Results

A total of 82 nurse managers from the four institutions participated in the study; in addition, 25 physicians at the two academic centers participated. A total of 1,741 assessments were made of 788 patients in 44 patient-care units. The mean value for the ages of the patients was 54 years; 47% of the patients were male (Table 1). Patients being treated for surgical, obstetric, or general medical conditions each comprised about 20% of the total patient population. Patients with cardiac problems constituted another 16% of the total. Patients with burns, neurological, orthopedic, psychiatric, respiratory, spine, and traumatic injuries each comprised <10% of the total patient population. Combined patient disposition assessments for all four institutions are listed in Table 2. Initially, 15% of the patients were receiving care in an ICU, 19% in an IMC, and 59% in a general care unit. Only 7% were residents in an SNF.

With increasing time, the proportion of the total patients in each unit decreased progressively, so that by 72 hours after the incident, half of the patients would have been discharged and another quarter of the number of patients would have been moved to the SNF. More than half of the number of patients in the ICUs and two-thirds of the number of IMC patients would have been transferred to a lower level of care. There were no statistically significant differences between the trends in the ICU populations between the four hospitals (Figure 1).

A large number of staffed, additional beds could be made available at 2, 24, and 72 hours based on nurse manager assessments (Table 2). The projected availability of new beds followed a similar pattern at each of the four participating hospitals for both ICU (Figure 1) and non-ICU beds (Figure 2). In addition, the overall percentage of beds that could be made available at each time point was similar for all four hospitals (Figure 3). Disposition at 24 hours was related to diagnostic category, with obstetric patients assessed as highly dischargeable (p <0.001) while surgical (p <0.001) and burn patients (p = 0.04) were assessed as non-dischargeable (Table 3). The differential distribution of patient diagnostic categories across the four hospitals likely accounts for the differences in patient disposition and bed availability between hospitals (Figure 4).

There was excellent agreement between overnight- and day-shift assessments (Table 4). The only significant difference between shifts were for the SNF assessments at two hours and for the floor assessments at 72 hours (p <0.01). At two hours, days would have transferred 171 patients while the night shift would have transferred 111. At 72 hours, the day shift would have had 83 patients remaining on the floors while the night shift would have retained 107. Physicians transferred more patients to either the hypothetical on-site nursing facility or discharged to home as compared with the nurse managers at all time points (Table 5). Interestingly, physicians were less likely than nurse managers to disposition patients out of the ICU; this reached statistical significance at 24 hours. In all other circumstances, the physicians were more likely to move patients to a lower level of care than were the nurse managers.

A large percentage of hospital beds were anticipated as being made available following or during a MCI at 2, 24, and 72 hours, even with consideration of the expected ED and total hospital admissions over the same time period (Figure 5). Admission from the emergency department was considered a surrogate for urgency of admission (Table 6). These admissions were not evaluated for length of stay or early dischargeability.

Alternate patient care areas were identified in each facility, with ample space to accommodate the volume of patients triaged to the hypothetical on-site nursing facility. These included unstaffed hospital wards, cafeterias, auditoriums, conference rooms, and clinic areas located on the hospital grounds.

Discussion

A prospective assessment of hospital bed surge capacity in the hypothetical event of a MCI was performed using both physician and nurse manager assessments of in-patient populations at four participating hospitals. Overnight- and day-shift personnel were included to represent pre- and post-rounds assessments, with no significant differences observed between the two groups. Nurse managers assessed approximately one-third of all patients as dischargeable within 24 hours and approximately one-half of patients as dischargeable within 72 hours. In addition, about 25% of patients were assessed as being transferable to a hypothetical on-site nursing facility at both time points, representing a potentially important component of hospital disaster planning. The physicians assessed more patients as either transferable to an on-site nursing facility or dischargeable to home than did the nurse managers, but were less aggressive in transferring or discharging ICU patients when compared to nurse managers. This has implications with regard to the personnel involved in making triage decisions. The disposition patterns were very similar across institutions when patients were stratified by admission diagnosis.

This process represents a comprehensive assessment of hospital bed surge capacity with disposition assessments made on all in-patients in multiple facilities. It is an improvement over simple determinations of available hospital beds using cross-sectional census data from single institutions.[12] In addition, the inclusion of admission diagnoses may allow these data to be extrapolated to other institutions with a slightly different distribution of diagnostic categories of patients.

This analysis is important in that it demonstrates that a large proportion of hospital beds could be made available in the event of a mass-casualty incident. While the discharge-

ability of many in-patients in a disaster situation should not come as a surprise, this factor is difficult to study and has not been approached systematically in previous analyses.[1,2,6,8–12] About one-half of all patients in this analysis were assessed as dischargeable at 72 hours. While other patients were admitted during this time, the surge capacity calculated in this manner still was substantially higher than what is identified with the use of hospital census data alone. In addition, it is likely that some of these admissions could have been avoided or discharged within 24–72 hours in the event of a mass-casualty incident. The two most important parameters to consider when predicting dischargeability appear to be the admission diagnosis and initial acuity as reflected by level of care. While dischargeability also was associated with gender, this likely reflects the high proportion of obstetrical patients included in this analysis.

The concept of an on-site nursing facility also was explored, which may represent an important consideration for future hospital disaster planning for several reasons. A large proportion of the total number of patients was determined to be transferable to such a facility, thus, clearing additional beds and personnel for the care of patients with higher acuity. In addition, having such a facility in the hospital complex offers the advantage of proximity and avoids dependence on outside facilities to receive patients in the event of a MCI. It also allows beds to be made available more quickly without the need for ambulance transfer—a scarce commodity during a disaster scenario—or the need to generate discharge prescriptions, since the patients presumably still would receive medications from the central pharmacy.

Furthermore, patients whose conditions worsen after transfer to the on-site nursing facility more easily can be re-triaged to the main hospital area with minimal delay. This introduces an issue regarding staffing of this facility; however, most nurse managers and physicians felt that paramedical personnel would be appropriate for help with the activities of daily living, medications, and wound care for those patients dispositioned to the on-site nursing facility. This would allow for the use of licensed vocational nurses, nurse assistants, emergency medical technicians, pharmacy technicians, or even non-medical personnel, if properly supervised.

The use of existing, non-traditional facilities within each facility, such as cafeterias, conference rooms, and auditoriums, has the advantages of rapid access, availability of water and electricity, and proximity to more experienced medical personnel. Temporary structures, such as tents, also could be used for such a purpose. This study did not estimate true surge capacity separate from the availability of either beds or medical personnel, which is substantially more complex, but equally important during a mass-casualty incident.

The difference between physician and nurse manager assessments is intriguing and warrants additional investigation. Several possible explanations exist for these differences. The physician directly responsible for the care of an individual patient might be expected to have a more complete understanding of the various factors that predict that patient's clinical course and therapeutic needs than would a nurse manager responsible for that particular patient-care unit on a given shift. It is not clear, however, why this would lead to a higher degree of conservatism among physicians for ICU patients and a lesser degree of conservatism for non-ICU patients. Alternatively, physicians may have an incomplete understanding of the needs of non-ICU patients with regard to nursing care and an underappreciation of the differences between care administered by nurses and other paramedical personnel. Based on these data, both physician and nurse representation are recommended when making patient disposition assessments while preparing for an influx of patients in the event of a mass-casualty incident.

There are several important limitations to this analysis. First, this was a cross-sectional analysis using only four facilities. The patient sample may not be representative of other hospitals and does not take into account seasonal variations in illness patterns. In addition, a large proportion of obstetrical patients were included; these patients are generally healthy and typically can be discharged within 24 or 72 hours. The inclusion of admission diagnoses should help when extrapolating these data to other institutions or adjusting for seasonal variability in illness patterns.

Second, no physiological parameters, injury or illness severity scores, medical histories, or outcome data were used in this study. Thus, it is not possible to validate the nurse manager or physician disposition assessments. A more comprehensive analysis could integrate more individualized patient assessments; however, this would be logistically challenging and could introduce consent issues.

Third, nurse manager assessments were used in the main analysis. While these individuals are familiar with each of the patients under their care, making them useful for triaging decisions in the event of a mass-casualty incident, the variation in physician and nurse manager assessments underscores the importance of selecting the appropriate personnel as part of a disaster plan. Additional research is needed to define better the ability of physicians and nurse managers to predict dischargeability in the event of a mass-casualty incident.

Finally, although admissions to the various hospitals during the study period are reported, these patients were not assessed as to the urgency of admission or their dischargeability within 2, 24, and 72 hours. Thus, the actual bed availability is likely to be underestimated. Future studies of actual dischargeability could be planned in advance of a multi-casualty incident, so that prospective data could be acquired during an actual mass-casualty incident. Perhaps such data could be utilized to develop a mathematical model of bed availability and surge capacity based upon dischargeability of patients, the number and acuity of hospital admissions during that time period, and hospital lengths of stay for particular diagnoses and patient characteristics.

Conclusions

The following conclusions can be drawn from this study: (1) hospital bed surge capacity as determined by either physicians or nurse managers is substantially higher than would be predicted by hospital census data alone; (2)

patients with higher levels of acuity and requiring more intensive monitoring are less dischargeable; (3) physicians are more aggressive in making hospital beds available than are nurse managers; (4) dischargeability of patients in similar diagnostic categories is similar from hospital to hospital and may allow further mathematical modeling of hospital bed surge capacity; and (5) the inclusion of an on-site nursing facility using non-traditional patient care areas may represent an important component of future hospital disaster plans.

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