

Annual Bed Statistics Give a Misleading Picture of Hospital Surge Capacity

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Study objective: I describe how annual hospital surge capacity is affected by within-year variation in patient volume and bed supply.

Methods: Surge capacity was measured as the percentage and total number of hospital beds that are not occupied by patients. Administrative data were used to calculate these bed statistics for 78 hospitals in New Jersey—statewide and by emergency planning regions—in 2003. Annual bed statistics were compared to more refined calculations for each day of the year. Calculated numbers of empty beds were compared to federal disaster planning benchmarks.

Results: Annual bed statistics showed no major limitations on surge capacity. Statewide occupancy rates were well below 80% (ie, more than 20% of beds were empty), and the number of empty beds that were set up and staffed (ie, maintained) was well above federal disaster planning benchmarks. In contrast, daily bed statistics reveal long periods in 2003 when regional and statewide surge capacity was severely strained. Strained capacity was most likely to occur on Tuesdays through Fridays and least likely to occur on weekends. On 212 days, statewide occupancy of maintained beds met or exceeded 85%. This occupancy rate met or exceeded 90% and 95% on 88 and 4 days, respectively. On 288 days, the statewide number of empty maintained beds fell below the federal planning benchmark.

Conclusion: Annual bed statistics give a misleading picture of hospital surge capacity. Analysis of surge capacity should account for daily variation in patient volume and within-year variation in bed supply. [Ann Emerg Med. 2006;48:384-388.]

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INTRODUCTION

Background

Emergency department crowding is a well-documented problem in the United States.^{1,2} This problem raises concern about the adequacy of hospital surge capacity to respond to mass casualty events such as natural disasters and terrorist attacks. Hospital surge capacity is often measured in terms of inpatient occupancy rates and the number of empty beds that would be immediately available in an emergency.

Importance

Although more detailed measures of surge capacity are under development,³ hospital bed statistics will continue to be used for a variety of planning and research purposes. The advantages of these statistics include wide availability of data and ease of calculation. A major disadvantage is that these statistics are

usually reported annually, which ignores day-to-day variation in patient volume and within-year changes in bed supply. As a result, annual bed statistics can give misleading information about hospital surge capacity.

Goals of the Investigation

This investigation aims to improve analyses of hospital surge capacity using administrative records. Surge capacity is measured by occupancy rates and the number of empty beds relative to disaster planning benchmarks recommended by the federal government (described below). Large occupancy rates and small numbers of empty beds are viewed as indicators of limited surge capacity. The key hypothesis is that surge capacity appears more limited when measured on a daily basis instead of annually. The addition of daily measures is considered meaningful if they reveal long periods (eg, several weeks or months) in which hospitals are extremely full (eg, above 90% occupancy) or the number of empty beds is below recommended levels.

Editor's Capsule Summary

What is already known on this topic

Hospital bed capacity is often reported as an annual average. This statistic may not capture fluctuations in bed capacity that could be important in disaster planning.

What question this study addressed

Surge capacity for new victims of a disaster or terrorist attack depends on real-time bed availability. The author used administrative records to calculate daily bed occupancy rates for the 78 acute care hospitals in New Jersey and compared them with annual occupancy figures.

What this study adds to our knowledge

When assessed annually, bed occupancy in New Jersey was below 80% and had significant open surge capacity. However, analysis of daily bed capacity demonstrated 90% occupancy (or greater) on 24% of all days, and empty maintained beds fell below the federal planning benchmark on 78% of days.

How this might change clinical practice

This study demonstrates that variability of bed occupancy data can be large when compared to longer-term averages and that these averages may conceal frequent occurrence of surge capacity less than federal benchmarks.

MATERIALS AND METHODS

Study Design and Outcome Measures

Because of space constraints, this section provides an abbreviated description of study methods and data sources. A more thorough description is found in Appendix E1 (available online at <http://www.annemergmed.com>).

The study is based on administrative data for 78 out of 82 total hospitals in New Jersey in 2003. Four hospitals were excluded because of incomplete data. As shown in Appendix E1 (available online at <http://www.annemergmed.com>), the 4 missing hospitals do not appear substantially different from those included in the study.

These data are used to calculate inpatient occupancy rates and the number of empty beds (defined below) at state and regional levels. Regions are defined by the Hospital Emergency Response Management Information System, which was developed within the New Jersey Department of Health and Senior Services for emergency planning. This system places hospitals into one of 5 regions: Northeast, Northwest, Central East, Central West, and South.

Annually measured occupancy rates and empty beds are compared to the corresponding daily measures. The annual occupancy rate is calculated as inpatient days/(365×beds). The annual number of empty beds is calculated as (1–occupancy

rate)×beds. Daily occupancy rates are calculated as the number of patients receiving inpatient care divided by the number of beds for each day in 2003. The daily number of empty beds is calculated as the total number of beds minus the number of inpatients for each day.

As explained in Appendix E1 (available online at <http://www.annemergmed.com>), occupancy rates greater than 85% are considered high, and occupancy rates greater than 90% and 95% are considered very high and extremely high, respectively. (In other words, surge capacity would be only 15%, 10%, and 5%, respectively.) Analysis of occupancy rates focuses on the number of regions and the number of days in each region that these levels of occupancy are experienced.

Annual and daily numbers of empty beds in each region are compared to federally recommended standards for surge capacity. Specifically, the Health Resources and Services Administration sets a benchmark of 500 beds per million people in an area.⁴ In this article, the benchmark number of beds is calculated as total population in a region (in millions) multiplied by 500. Analysis of empty beds focuses on the number of regions and the number of days in each region that the benchmark is not met.

Regulators in New Jersey make a distinction between licensed and maintained beds. Licensed beds are officially licensed for inpatient care by the New Jersey Department of Health and Senior Services. Maintained beds are licensed beds that are also “set up and staffed.”⁵ In theory, an empty maintained bed would be immediately available in an emergency. An empty bed that is licensed but not maintained may be brought into service if the required equipment and personnel are made available. However, in light of continuing shortages in the supply of nurses⁶ and emergency physicians,⁷ it is not clear how quickly a licensed bed could be set up and staffed. Therefore, bed statistics are calculated using both types of beds.

Data

Annual measures of occupancy rates and empty beds are derived from the Acute Care Hospital Annual Cost Report. Data for the daily number of inpatients is obtained from statewide uniform billing records. Hospitals must submit data to both of these systems, which are audited and maintained by the New Jersey Department of Health and Senior Services.

Because data on daily bed supply do not exist, the denominator of the daily occupancy rate is approximated by the number of beds in the relevant quarter, which is available in quarterly use reports that hospitals are also required to submit to the state. Although hospitals may change the number of beds within a quarter, daily variation in beds is expected to be small relative to daily variation in inpatient census.

RESULTS

When measured annually, hospital occupancy rates throughout New Jersey showed no major limitations on surge

Table 1. Comparisons of annual and daily measures of hospital occupancy in New Jersey, 2003.*

Region of New Jersey (Number of Hospitals)	Reported Annual Occupancy Rate, %	Average Daily Occupancy Rate, %	Number of Days With Occupancy of at Least 85%†	Number of Days With Occupancy of at Least 90%†	Number of Days With Occupancy of at Least 95%†
Calculations based on licensed beds[‡]					
Entire state (78)	60	68	0	0	0
Northeast (30)	59	65	0	0	0
Northwest (6)	65	81	153 (42)	37 (10)	4 (1)
Central East (17)	63	74	0	0	0
Central West (7)	56	64	0	0	0
South (18)	57	67	0	0	0
Calculations based on maintained beds[§]					
Entire state (78)	73	84	212 (58)	88 (24)	4 (1)
Northeast (30)	73	84	208 (57)	113 (31)	18 (5)
Northwest (6)	72	92	288 (79)	234 (64)	183 (50)
Central East (17)	77	86	234 (64)	120 (33)	22 (6)
Central West (7)	69	73	4 (1)	0	0
South (18)	70	82	183 (50)	51 (14)	0

*Sources: New Jersey Acute Care Hospital Annual Cost Report, uniform billing records, and quarterly use reports.

†Numbers in parentheses indicate the percentage of days in the year that occupancy meets or exceeds the given threshold.

‡Licensed beds are officially licensed for inpatient care by the New Jersey Department of Health and Senior Services.

§Maintained beds are licensed beds that are set up and staffed.

capacity (Table 1). All regions had annual occupancy rates below 85% for both licensed and maintained beds.

There is a difference when occupancy rates are calculated daily. Average daily occupancy rates were higher than annual versions for both types of beds. For maintained beds, 2 regions exceeded the 85% average occupancy threshold, and 1 exceeded the 90% threshold. Two other regions were just below the 85% average occupancy threshold for maintained beds.

The difference between annual and average daily occupancy rates is driven more by differences in beds (in the denominator) than patient-days (in the numerator). When based on daily occupancy data, the total statewide number of patient-days for the year is 2% less than the corresponding total in the annual cost report. In contrast, the statewide average number of beds (licensed and maintained) per day is 15% lower than the amount in the annual cost report. This difference may have to do with the way within-year changes in bed supply are accounted for in the annual cost report (see Appendix E1 [available online at <http://www.annemergmed.com>]).

For some parts of the year, occupancy rates are even higher than the average per-day calculations suggest. The Figure shows statewide occupancy rates for licensed and maintained beds for each day of the year. Although occupancy of licensed beds never exceeded 85%, occupancy of maintained beds exceeded this threshold in 212 of 365 days, occurring most often on Tuesdays through Fridays (at least 44 times for each day) and only once on a weekend. All regions experienced some time with their maintained beds at high occupancy, with the greatest strain on surge capacity appearing in the Northwest (Table 1).

Statewide occupancy of maintained beds above 85% was less likely during August and November compared to all other months except December. The dramatic decline in occupancy

rates in December (Figure) appears to be an artifact of how patients admitted at the end of the year are counted in billing records. Patients who were admitted in December and discharged in January appear in billing records for 2004 instead of 2003. Therefore, data patterns in the last few weeks of 2003 are deemphasized in this analysis.

Daily variation in occupancy affects the number of empty beds that would be immediately available in a catastrophe (Table 2). With the exception of the Northwest, the number of empty licensed beds usually or always met the disaster planning benchmark for each region. In contrast, the number of empty maintained beds typically did not meet the standard in all regions.

LIMITATIONS

The analysis above is limited by the availability of data from only 1 state. Because of differences in regulation and population characteristics, constraints on surge capacity may be different in other states. Nevertheless, the distinction between annual and daily measures of surge capacity is likely to be important for hospitals across the nation. Specifically, annual bed statistics are often derived from the American Hospital Association Annual Survey of Hospitals or the Medicare Cost Report. Both of these data sources record the annual number of patient-days and the number of beds on the last day of the reporting year. As a result, within-year changes in bed supply and inpatient volume are not accounted for.

Four hospitals were excluded from the analysis because of incomplete data. Although these exclusions may not bias the analysis of occupancy rates, they clearly lead to an undercount of empty beds, which is discussed further in Appendix E1 (available online at <http://www.annemergmed.com>). Since the

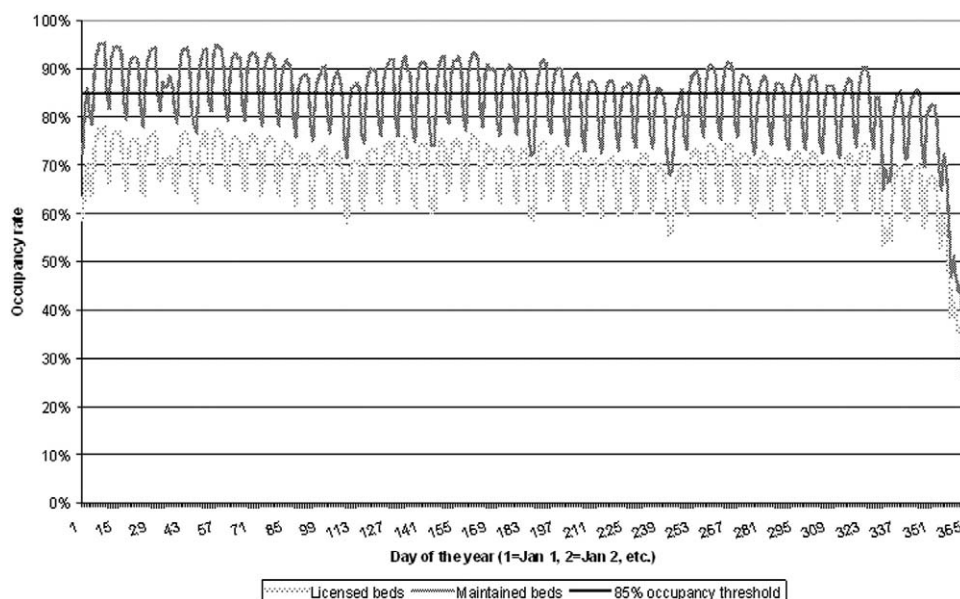


Figure. Statewide daily occupancy rate in New Jersey, 2003.

Table 2. Empty hospital beds versus federal disaster planning thresholds in New Jersey, 2003.

Region of New Jersey (Number of Hospitals)	Population*	Empty Beds Required for a Mass-Casualty Disaster [†]	Number of Days Empty Bed Standard Is Not Met With Licensed Beds ^{‡§}	Number of Days Empty Bed Standard Is Not Met With Maintained Beds ^{§ ¶}
Entire state (78)	8,638,396	4,319	0	285 (78)
Northeast (30)	2,799,658	1,400	0	245 (67)
Northwest (6)	743,515	372	303 (83)	358 (98)
Central East (17)	2,488,710	1,244	69 (19)	329 (90)
Central West (7)	801,846	401	0	164 (45)
South (18)	1,804,667	902	0	303 (83)

*Source: US Census Bureau.

[†]Based on the standard set by the federal Health Resources and Services Administration (HRSA). Specifically, HRSA suggests that there should be 500 beds available for every 1,000,000 residents to respond to a mass-casualty disaster.

[‡]Licensed beds are officially licensed for inpatient care by the New Jersey Department of Health and Senior Services.

[§]Sources: New Jersey Uniform Billing Records and quarterly use reports.

^{||}Numbers in parentheses indicate the percentage of days in the year that occupancy meets or exceeds the given threshold.

[¶]Maintained beds are licensed beds that are set up and staffed.

time of the study, however, hospital capacity in the state has been reduced by the closure of 2 hospitals, and another closure is under consideration.⁸ Because of developments like these, estimates of surge capacity need to be updated periodically, as hospitals may close or expand services, depending on local market conditions. Routine evaluation of surge capacity is especially important under these circumstances because hospital-level decisions about capacity are often driven by financial and strategic considerations, which may not account for regional surge capacity needs.

An implicit assumption of this article is that all beds are interchangeable and could be set up anywhere in the hospital. In practice, patients receiving certain types of care must be admitted near the appropriate “headboards” to ensure access to resources such as power, oxygen, and telecommunications. As a

result, surge capacity may be less than aggregate bed statistics would suggest. In addition, any disaster that directly affects hospital staff and infrastructure would limit surge capacity further.

Nevertheless, there are other unmeasured factors that would lead to greater surge capacity than the estimates provided in this study. These include the implementation of measures to free up capacity in the first hours and days of a crisis, such as cancellation of elective surgeries and accelerated discharge of inpatients.

DISCUSSION

This article shows how annual bed statistics give misleading information about the availability of hospital surge capacity. When measured daily, these statistics show much less

availability than one could infer from annual data. Also, surge capacity in New Jersey almost always meets federally established guidelines when measured in terms of "licensed" beds but usually does not meet these standards when measured in terms of "maintained" beds. This distinction is important because the conversion of a licensed bed to a maintained bed requires additional resources such as staff and equipment to be in place for patient care. If these resources are scarce, then a large supply of licensed beds that are not maintained would be of limited value. The article also finds that surge capacity usually appears plentiful on weekends but is often scarce on Tuesdays through Fridays.

Although more specialized information systems are being developed for disaster planning,³ analysis of hospital administrative data remains important for at least 2 reasons. First, more elaborate capacity measurement systems are still being developed and may not be available to researchers for several years, if at all. Second, administrative data may be all that is available for longitudinal and historical analysis.

In addition to the refinements in this article, measurement of surge capacity with administrative data could be improved further. An important topic for future research is the potential effects on surge capacity of early patient discharge or transfer. Future research should also address how elective and ambulatory surgeries affect hospital capacity. Although most of these surgeries would be cancelled during a crisis, surgeries in progress would divert resources at least temporarily from emergency response. Finally, a comprehensive assessment of surge capacity must include analysis of alternative settings such as recently closed hospitals, nursing homes, and ambulatory health centers. In all of these areas, daily variation in the demand for medical care will be a key variable in surge capacity planning.

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APPENDIX E1.

Additional details about data and methods.

Sources of Data

This appendix provides additional details about the data and methodology used for the study. As described in the body of the article, annual measures of occupancy rates and empty beds are derived from the Acute Care Hospital Annual Cost Report. All hospitals in the state are required to submit this report, which includes information about use, capacity, costs, and finances, to the New Jersey Department of Health and Senior Services. The New Jersey Department of Health and Senior Services conducts a routine audit of these reports and uses the data for ongoing regulatory and evaluation activities. This article uses the total number of inpatient days and the total number of licensed and maintained beds reported by hospitals in 2003. The annual occupancy rate is calculated as $\text{inpatient days}/(365 \times \text{beds})$. The annual number of empty beds is calculated as $(1 - \text{occupancy rate}) \times \text{beds}$.

Although the reporting of patient-days is straightforward, bed counts are less so because of the variability in licensed and maintained beds within the year. Instructions on the cost report require hospitals to prorate beds that were licensed or maintained for only part of the year.¹ For example, if 100 beds were in place for only 6 months, a total of 50 beds would be counted. Although this method allows for within-year variability in bed supply, it may be prone to error if prorating is not done precisely.

As described in the body of the article, daily occupancy rates and empty bed counts are derived from statewide uniform billing records and quarterly use reports, which are also part of New Jersey's mandatory reporting requirements for hospitals. For each day of the year, occupancy rates are calculated as the number of patients occupying a bed (at any time of day) divided by the total number of beds, which means that if a patient was discharged from a bed in the morning and another patient was admitted to the same bed in the afternoon, 2 patients would be counted in the same bed on the same day. Although this approach will overcount the total number of inpatients at a single point, it avoids the potential underestimate of occupancy that is inherent in the standard midnight census approach. For example, if a patient was discharged late in the afternoon and another patient was admitted to the same bed early the next morning, neither patient would be counted in the midnight census.

Calculation of daily inpatient census, which is the numerator of the occupancy rate, requires data elements for patient admission and discharge dates. Although these variables are reported in uniform billing records, concerns about patient confidentiality preclude the release of these dates on public use files. For this analysis, a special arrangement was made with the New Jersey Department of Health and Senior Services to create a database that contains daily inpatient census for every hospital in New Jersey in 2003. Because the database received from the state did not contain any confidential information about patients (and could not be linked to any), no institutional review board approval was necessary for the analysis in this article.

In principle, the calculations of daily occupancy rates and empty beds require enumeration of bed supply daily. Because data on daily bed supply do not exist, the denominator of the daily occupancy rate is approximated by the number of (licensed and maintained) beds in the relevant quarter, as reported in the hospitals' quarterly use reports. Although hospitals may change the number of beds within a quarter, daily variation in beds is expected to be small relative to daily variation in inpatient census.

Finally, all analyses exclude newborns. Inclusion of newborns would be inappropriate because separate billing records are generated for women with maternity admissions. Also, newborns are assigned to their own hospital bassinets, which are officially licensed beds designed to be occupied by newborns.

Defining High Occupancy

This article emphasizes the extent to which hospitals experience high occupancy. Although there is no commonly accepted definition of high occupancy, a study of hospital crowding in the British National Health Service provides some useful benchmarks.² The study concluded that as the average hospital occupancy approaches 85%, the risk of needing to turn away emergency patients and the number of days this is likely to occur increase significantly. In addition, if average occupancy exceeds 90%, the "system is regularly subject to bed crises." Therefore, in this article, occupancy rates greater than 85% are considered high, and occupancy rates greater than 90% and 95% are considered very high and extremely high, respectively.

Characteristics of Study Hospitals

The 78 hospitals in the study include a range of characteristics. Fifteen percent are members of the Counsel of Teaching Hospitals. The average number of licensed beds at the end of the fourth quarter of 2003 was 306 (25th percentile=202, 50th percentile=262, 75th percentile=388). The average number of maintained beds the end of the fourth quarter of 2003 was 250 (25th percentile=152, 50th percentile=225, 75th percentile=313). The average annual number of patient-days for 2003 was 76,299 (25th percentile=48,260, 50th percentile=65,364, 75th percentile=92,147).

As described in the body of the article, 4 hospitals were excluded from the study because of missing data. Three of these hospitals were involved with corporate restructurings or ownership changes that led to inconsistent reporting of data. The remaining facility had missing data for unknown reasons. To understand how these excluded hospitals compare to those included in the study, information about membership in the Counsel of Teaching Hospitals, the number of hospital beds, and region was obtained from hospital Web sites and the Web site for the Counsel of Teaching Hospitals. Hospital Web sites do not report whether beds are licensed or maintained and do not report the number of beds in place in 2003. For comparative purposes, these distinctions are not crucial, because the goal is to create only a rough comparison between included and excluded hospitals in terms of size (eg, small, medium, large).

None of the missing hospitals are members of the Counsel of Teaching Hospitals. In addition, the excluded hospitals do not appear systematically larger or smaller than the included hospitals. Two of the missing hospitals have bed counts (140 and 148) that fall below the 25th percentile for licensed and maintained beds among study hospitals. The bed count for another missing facility (241) falls between the 25th and 75th percentiles for both types of beds. The bed count for the remaining hospital (411) is above the 75th percentile for both types of beds.

The incidence of missing data is related to emergency planning region. None of the missing facilities are located in the Northeast or the Central West. Two of the missing hospitals are located in the Central East, 1 is in the Northwest, and 1 is in the South. To be conservative, bed counts for missing hospitals are compared to the number of maintained beds by region (Table). The number of maintained beds is less than the number of licensed beds for all hospitals in the study (18% less for all hospitals in the study combined). Therefore, the percentage of beds missing from the study will appear larger when calculated with maintained beds in the denominator.

Because it contains the smallest number of hospitals in the study, the Northwest is most affected by missing data in terms of the percentage of facilities that are excluded (Table). The Central East is the most affected region in terms of total beds not counted.

Table. Unmeasured capacity in regions with incomplete data.*

Region	Excluded Hospitals as a Percentage of Total Hospitals, %	Share of Beds in the Region That Are Unmeasured, %
Northwest	14	6
Central East	11	12
South	6	3

*Sources: New Jersey Acute Care Hospital Annual Cost Report, facility Web sites for hospitals with incomplete data.

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