ORIGINAL RESEARCH

Scheduled Admissions and High Occupancy at a Children's Hospital

Evan S. Fieldston, MD, MBA, MSHP[1,2,3,4]
Meera Ragavan[5]
Bhuvaneswari Jayaraman, MPH[6]
Kelly Allebach, BS[6]
Susmita Pati, MD, MPH[1,3,4,7]
Joshua P. Metlay, MD, PhD[2,4,8]

[1] Department of Pediatrics, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.

[2] Robert Wood Johnson Foundation Clinical Scholars, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.

[3] Division of General Pediatrics, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania.

[4] Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, Pennsylvania.

[5] Wharton School of Business Life Sciences and Management Program, University of Pennsylvania, Philadelphia, Pennsylvania.

[6] Analytics & Reporting, Department of Information Services, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania.

[7] PolicyLab at The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania.

[8] Department of Medicine, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.

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Meera Ragavan is an undergraduate student in a specialized program that combines health systems and biology training who will graduate in 2011 with a BA in biology and BSE in economics, and has training in operations management and statistics.

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BACKGROUND: High hospital occupancy is a challenge for quality of care and access, while low levels of occupancy may be inefficient in terms of resource utilization. Variability from scheduling decisions may affect occupancy and be amenable to alteration.

OBJECTIVE: Describe variability in admission, discharge, and occupancy patterns at a large children's hospital and assess the relationship between scheduled admissions and occupancy.

DESIGN: Retrospective administrative data analysis.

SETTING: One urban, tertiary-care children's hospital.

PATIENTS: A total of 22,310 consecutive patients admitted from July 1, 2007 to June 30, 2008.

MEASUREMENTS: Admission-discharge-transfer (ADT) data for 1 fiscal year were abstracted for analysis of admission and occupancy patterns.

RESULTS: Among 22,310 admissions, 78% were coded as emergent and 22% as scheduled. Variation in admission volume by day of week was high for scheduled admissions (coefficient of variation [CV] 65.3%), while it was more consistent for emergent admissions (CV 12.0%). For patients with length of stay (LOS) $\leq$7 days (84%), Mondays and Tuesdays generated 45.2% of scheduled patient hours. Wednesdays and Thursdays had the highest frequency of high occupancy.

CONCLUSIONS: Scheduled admissions contribute significantly to variability in occupancy and risk of mid-week crowding. Predictable patterns of admissions lead to high occupancy on some days and unused capacity on others, which can be addressed with proactive management of admissions (eg, greater use of unused capacity on weekends and in summer). Hospitals interested in optimizing patient flow should assess their admission and occupancy patterns. Further studies should link variation in occupancy to outcomes including quality of care, educational activities, and staff satisfaction. ***Journal of Hospital Medicine*** **2011;6:81–87.** *© 2011 Society of Hospital Medicine.*

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Patient flow in a hospital refers to the management and movement of patients through the facility. Optimizing patient flow is considered of great importance to improvement of quality (including safety, efficiency, timeliness, equity, effectiveness, and patient-centeredness), as well as finance, staff satisfaction, education and overall healthcare value.[1–8] Central to concerns about patient flow at hospitals is occupancy, which is the census (number of patients at a point in time) divided by the bed capacity. Occupancy that is too high is associated with challenges to quality and access,[9–13] while occupancy that is too low may underutilize resources and be costly.[14,15] Occupancy is determined by the pattern of admission and discharge, thus including length of stay (LOS) as a factor. While all related, admissions, census, occupancy, and LOS convey different aspects of hospital operations and may point to different opportunities to improve patient flow.

Variability in patient flow over time has been noted as a common occurrence in adult hospitals, due to uneven patterns of scheduled ("elective") admissions, as well as uncontrollable variability of emergent admissions.[2,4–5,16] Typically very few patients are scheduled to enter hospitals over weekends. In addition, when the admission is expected to be 5 days or less, clinical and operational staff may schedule those admissions early in the week to avoid patients staying the weekend. This "artificial variability" has been shown to lead to uneven levels of occupancy, with crowding on some days of the week more than others.[2,4–5,16] As hospital crowding adversely affects access to emergent and elective care, quality and safety of care, and patient and staff satisfaction, many groups are focusing attention on patient flow and strategies to avoid high occupancy.[1–9,17] This is true for children's hospitals, as well, particularly as these scarce resources have ever increasing demand placed on them.[18–20]

Patient flow improvements can be made by increasing efficiency of throughput, primarily measured by decreased LOS, or by addressing artificial variability in how hospital beds are used. As children's hospitals have short LOSs and are relatively efficient (as measured by standardized LOS ratios), we sought to evaluate how much artificial variability was active at 1 large children's hospital. We did this to both evaluate flow at 1 institution and to create methodology for other hospitals to use in order to better understand and improve their flow.

Our specific aims were to describe daily and monthly variability in admission, discharge, LOS, and occupancy patterns at a large children's hospital and assess the relationship between scheduled admissions and occupancy.

Methods

This retrospective administrative data analysis was performed with admission-discharge-transfer (ADT) data for inpatient admissions from one urban, tertiary-care children's hospital for the period July 1, 2007 to June 30, 2008. The dataset included the date and time of all arrivals and departures from all inpatient units (including observation-status patients), as entered by the unit clerks into the electronic ADT system. The dataset also included categorization of the admission as "emergent", "urgent", or "elective" (hereafter referred to as "scheduled.") Registration staff entered these codes at or prior to admission. Using the timestamps, LOS was calculated by subtracting admission date and time from discharge date and time. An SAS macro was applied to the timestamps to calculate a hospital census for every hour of each calendar day. Peak census figures were extracted for each day. Occupancy was calculated as census over number of beds in use (monthly average). Data for the hospital's peak daily census and occupancy were utilized to analyze patterns of occupancy by day of week and month of year. To express variability, coefficient of variation (CV) (standard deviation [SD] divided by its mean) was used, as it is helpful when samples sizes are different.[21]

Analysis of number of admissions per day of week and month by type was performed with descriptive statistics and *t*-tests for significant differences across seasons. We calculated a measure of patient hours generated by day of admission based on the LOS generated by each admission, in which the average number of admissions for each day of the week was multiplied by the average LOS (in hours) for those admissions. In order to remove outliers and focus on patients whose occupancy would affect weekly variation, we analyzed in detail the admissions with LOS $\leq$30 days and $\leq$7 days, respectively.

Statistical analyses were performed with SAS 9.2 (SAS Institute, Cary, NC), Stata 10.0 (StataCorp, College Station, TX) and Microsoft Excel (Microsoft, Redmond, WA). The study was approved by the Human Subjects Committee of the hospital's Institutional Review Board.

Results

A total of 22,310 patients were admitted over the period July 1, 2007 to June 30, 2008, including 4957 (22%) coded as scheduled and 17,353 (78%) coded as emergent. (Only 200 patients were registered as urgent and these were recoded as emergent for this analysis). Details on admission types and discharging departments are provided in Table 1. Overall, mean LOS was 5.6 days (median 2.29 days). For patients with LOS $\leq$30 days, mean LOS was 3.88 days (median 2.22 days). For patients staying $\leq$7 days, mean LOS was 2.4 days (median 1.98 days). Among patients with LOS $\leq$7 days, mean LOS for scheduled patients was longer for those admitted on Monday than on any other weekday (2.49 vs. 2.08 days, $P < 0.0001$). In contrast, mean LOS for emergent patients was longer for patients admitted on Friday and Saturday than the rest of the week (2.57 vs. 2.44 days, $P < 0.0001$).

Total admissions per month (Figure 1) averaged 1937 in October through April and 1751 in May through September ($P = 0.03$). Variation in the number of emergent and scheduled patients over months of the year were similar (CV 10%

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TABLE 1. Inpatient Population Characteristics by Patient Type

	All	Scheduled	Emergent
Total Admissions, n (%)*	22,310	4957 (22)	17,353 (78)
Median LOS (days)	2.29	1.93	2.50
Mean LOS (days) (95% CI)	5.60 (5.41, 5.79)	4.20 (3.95, 4.45)	5.78 (5.59–6.0)
% Patients with LOS ≤30 days (%)	97	98	96
% Patients with LOS ≤7 days (%)	84	89	83
Medical patients at discharge, n (%)	16,586 (74)	2363 (48)	14,403 (83)
Surgical patients at discharge, n (%)	4276 (19)	2450 (49)	1826 (10.5)
Critical care patients at discharge (NICU, PICU, CICU), n (%)	1433 (6)	140 (3)	1293 (7.5)

Abbreviations: CI, confidence interval; CICU, cardiac intensive care unit; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit.
*Includes all patients occupying inpatient beds, including observation-status patients.

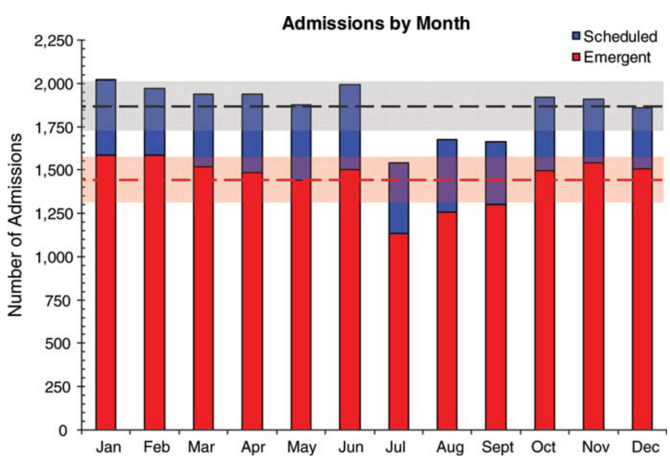

FIGURE 1. Admissions by month and type. Figure shows admission patterns by month, with emergent in red (bottom) and scheduled in blue (top). Dashed lines indicate mean number of emergent admissions (red) and total admissions (black). Shaded areas are ±1 SD around the mean (lower shaded bar is for emergent, upper shaded area is for scheduled). Includes all patients occupying inpatient beds, including observation-status patients. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

for each), but emergent admissions did decrease in summer (mean 1299 for June-September vs. 1520 for the rest of the year, $P = 0.003$). Conversely, scheduled admissions remained relatively stable all year-long: mean 423 per month for May through September vs. mean 413 per month for October through April ($P = 0.48$). Even just the summer months of June-August, when school-age children are on

TABLE 2. Variability on Admissions and Occupancy by Patient Type

	All (%)	Scheduled (%)	Emergent (%)
CV on admissions by month	8	10	10
CV on admissions over days of week (including weekends)	24	65	12
CV on admissions over days of week (excluding weekends)	6	10	5
CV on monthly occupancy over 12 months	4	14	2

Abbreviation: CV, coefficient of variation (standard deviation [SD]/mean).

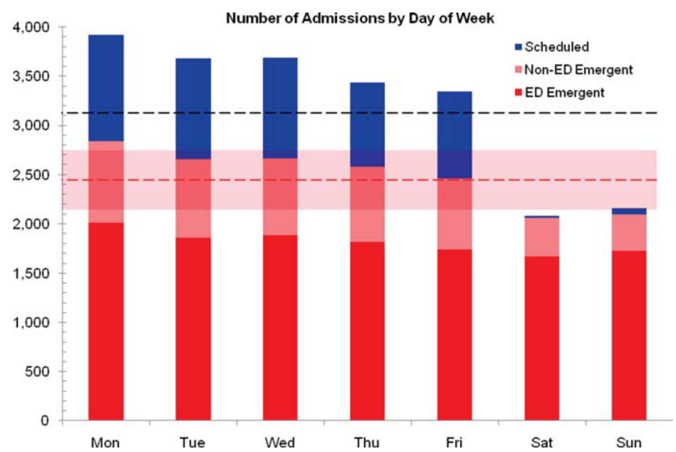

FIGURE 2. Admissions by day of week and type. Figure shows admission patterns by day of week, with ED emergent in red (bottom), non-ED emergent in pink (middle) and scheduled in blue (top). Each column represents the total number of admissions for each day of the week over the entire year. Dashed lines indicate mean number of emergent admissions (red) and total admissions (black). Shaded area is ±1 SD around the mean for total emergent admissions. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

vacation, were not significantly different from other months (440 vs. 404, $P = 0.2$).

Variation in volume of admissions was large over days of the week, driven primarily by the pattern of scheduled admissions (CV 65.3%), which dropped off completely on weekends (Table 2, Figure 2). In contrast, there was much less variation in the number of emergent admissions across days of the week (CV 12%). For both emergent and scheduled admissions, more patients came in on Mondays than any other day of the week, but even more so for scheduled patients. While emergent admissions did decline on weekends, it was driven primarily by a decrease in physician referrals (ie, direct admission) from clinics (mean 7.48 per weekday vs. 0.73 per weekend day for the entire year, $P < 0.001$), while emergency department (ED) admissions

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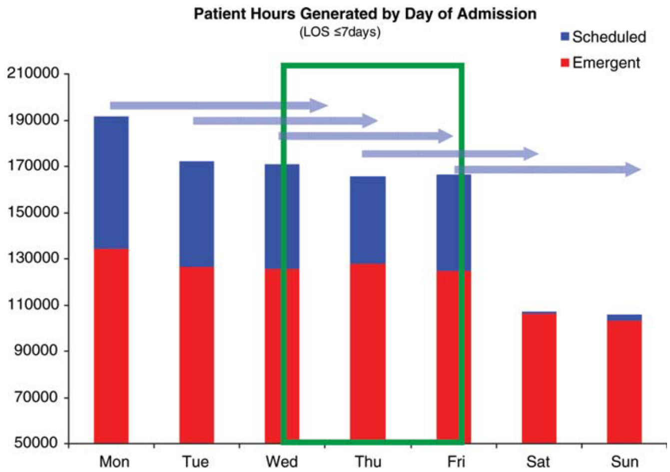

FIGURE 3. Patient-hours generated by day of admission among patients with LOS ≤7 days (84% of admissions) for emergent (bottom, red) and scheduled (top, blue) patients. Arrows represent mean LOS by day of admission (if LOS ≤7 days). Green box highlights overlap that contributes to mid-week high levels of occupancy from Wednesday to Friday. Includes all patients occupying inpatient beds, including observation-status patients. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

remained relatively stable (mean 35.8 per weekday vs. 32.7 per weekend day, $P = 0.08$). Emergency transports were also stable (mean 7.15 per weekday vs. 6.49 per weekend day, $P = 0.10$).

Although scheduled patients contributed less to the hospital's overall occupancy, they conferred most of the variability by day of week. Over the days of the week, variation for scheduled occupancy was nearly twice that for emergent occupancy (CV 19% vs. 10%). Within the higher-volume period of October to April, the differential was even more evident (CV 19% for scheduled occupancy versus 6% for emergent).

For scheduled patients with LOS ≤30 days (98% of scheduled patients), Mondays and Tuesdays together accounted for 42.5% of admission volume and 44.7% of the patient-hours generated. For scheduled patients with LOS ≤7 days (89% of scheduled patients), Mondays and Tuesdays together accounted for 42% of admission volume and 45.2% of the patient-hours generated. This combined impact of volume and LOS from admissions earlier in the week (restricted to patients with LOS ≤7days) is displayed graphically in Figure 3, which depicts the unevenness of scheduled admissions and their time in the hospital, with many patients overlapping in the middle of the week. Together with the more steady flow of emergent patients, this variability in scheduled occupancy contributed to mid-week crowding, with higher risk of the hospital being >90% and >95% occupied on Wednesday through Friday (Figure 4). Detailed hourly analysis (not displayed) showed this risk to be highest from Wednesday afternoon to Friday afternoon. Due to higher emergent census, certain months also had a

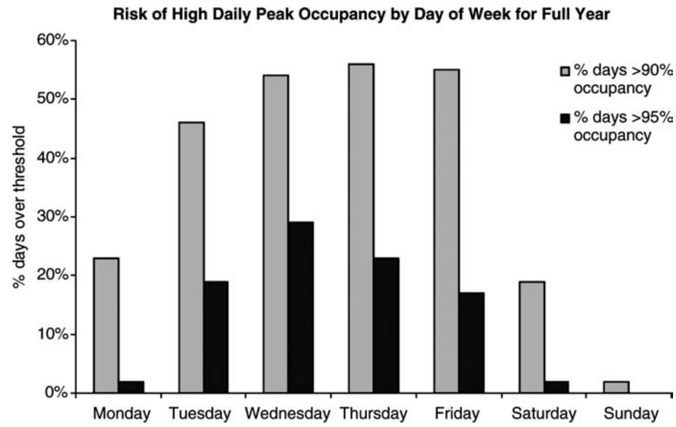

FIGURE 4. Risk of hospital peak daily occupancy exceeding 90% and 95% for 1 year. Percent of days the hospital exceeded 90% (light gray) and 95% (dark gray) thresholds for peak daily occupancy. Includes all patients occupying inpatient beds, including observation-status patients.

higher risk of high occupancy at daily peak. For example, while the entire year had 50% to 60% of Wednesdays and Thursdays with occupancy >90%, during the months of November through February, 70% to 85% of those days had occupancy at that level or higher (all these patterns were seen for both stays with LOS ≤30 days and ≤7days).

Discussion

In this study, we found that a large children's hospital was frequently at high occupancy in certain months and on certain days more than others, driven largely by predictable seasonal increases in emergent admissions and variability in scheduled admissions by day of week, respectively. Patient-hours generated by day of admission varied as a result of both volume and LOS, both of which were larger in the early part of the week and diminished as the week progressed for scheduled admissions. But, the cumulative effect of many admissions with relatively-longer LOS on Monday through Wednesday contributed to high occupancy on Wednesday afternoon to Friday morning, underscoring the importance of admission patterns on census later in the week. Our finding that the occupancy of scheduled patients—the result of both the admission pattern and their LOS—is also highly variable suggests that managing the inflow of scheduled patients could decrease crowding on weekdays, assure a consistent supply of capacity for regular admissions and surges, and improve the value of the delivery system.[1–8] This inflow management would ideally consider both admissions and associated LOS, since rescheduling patients with a longer LOS (eg, 3–4 days) would have a greater impact on occupancy than rescheduling patients with a shorter LOS (eg, 1–2 days).

Not surprisingly, total admissions decreased in summer months, especially in July and August, due primarily to fewer emergent admissions. In fact, scheduled admissions per month remained relatively stable over the entire year.

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The decrease in summer emergent admissions may present an opportunity to stepwise shift a proportion of scheduled admissions from the spring and fall into the summer months, and winter into spring and fall, to alleviate crowding in the winter (Figure 1). Assuming clinical conditions, families and staff members were amenable to this change, hospitals with similar patterns could use this method to reduce the crowding (eg, days over 90% or 95% occupancy) that occurs in the winter.

Using patient-hours (or days) generated by day of admission, it is evident that admission of more and longer-stay patients at the start of the week contributes to higher occupancy later in the week (Figure 4). Mid-week crowding could potentially contribute to a number of operational issues, including delays of new admissions, decreases in physician referrals and patient satisfaction, and an increased use of nontraditional beds (eg, treatment rooms, playrooms, doubling up single rooms) that lead to excessive patient to staff ratios and burnout for clinical staff.

The reasons for these patterns of admissions may include clinician or patient preference to avoid weekend admissions, lack of availability of particular services or resources on weekends, or concerns about safety and efficiency (due to relatively lower staffing on weekends in many hospitals).[22–30] While clinicians may prefer to avoid additional work on weekends, there are benefits to smoothing occupancy, including less risk of excessive work mid-week and potential revenue opportunities. In addition, when contrasted with the estimated $1 million to $2 million cost per bed of construction, the marginal cost of staffing to provide safe, high-quality care on weekends is dramatically lower than that of adding more beds (when faced with mid-week crowding and unused weekend capacity). In addition, empty beds also do not generate revenue to cover fixed or variable costs, meaning that hospitals are not matching revenue to cost when there is unused capacity due to artificial variability.[15,31] Hospitals looking to make greater use of weekends, however, must be sensitive to staff concerns and the organizational dynamics of 7-day operations, including the risk for burn-out and attrition. Such factors should not be perceived as insurmountable barriers, particularly in light of opportunities for flexible scheduling and gain-sharing.

Patients' and parents' preferences may partially drive admitting patterns, but a reasonable proportion of them may prefer to minimize the number of work and school days missed by being admitted near or on weekends. For example, an expected 3-day admission could start on Friday and end on Sunday or Monday, rather than the current practice which appears to be to admit on Monday and discharge before the weekend. This may not only meet preferences among some parents to avoid missing work or school, but also by consideration of educational outcomes for hospitalized children.[32]

In addition, higher mean LOS for emergent patients on the weekends suggests that some services are currently unavailable on weekends to treat patients who are admitted on Fridays through Sundays.[2,25,29,33] More even staffing and provision of diagnostic and therapeutic services on weekends (eg, advanced radiology, consult, and laboratory services) would not only remove the barrier to weekend occupancy, it would also improve efficiency, timeliness, patient-centeredness, and potentially effectiveness and safety for emergent patients. Running hospitals at full functionality on only 5 days of the week means that 2 out of 7 days puts patients at risk for disparate care, which may be appearing in this analysis as prolonged LOS due to lack of services over the weekend—a pattern reported in the literature for adult hospitals.

Operations management and queuing theory suggest that systems function well up to 85% to 90% of capacity.[34] Hospitals that plan ahead and ensure a buffer for unscheduled admissions during months or days when that demand is known to rise are less likely to cross into high occupancy. On the other hand, hospitals that do not anticipate increases in unscheduled admissions are more likely to encounter excess capacity problems.[35] Aligning incentives with all staff can assist in this planning and maximize control of capacity.

Adopting the use of CV in health care operations would also be of value as a way to better express and track variation in admissions, occupancy, and discharges. Since different patient populations, different units, different hospitals, and different months have different scales, SD is not easily comparable across these settings. CV allows for comparison of variation by normalizing on the mean. In this study, it clearly differentiated the variation in elective admissions (CV 65%) over days of the week from the relative stability of emergent admissions (CV 12%). As variability and its management are important to operations, quality control, and quality improvement, use of CV can play an important role in hospital management and health services research. As days with high levels of activity may put more stress on the system, tracking this variation could lead to improvements in quality and value.

This study has several limitations. Data were analyzed for 1 children's hospital, so the analysis may or may not generally apply to other hospitals. However, in a separate study, we analyzed data from the Pediatric Health Information System database, and observed similar patterns.[18] In addition, the proportion of elective patients shown in this study was similar to the national data in Kids Inpatient Database (KID, about 15% of all admissions elective).[36] Moreover, the methods are reproducible for other settings, which would be useful to clinical and hospital leadership. Second, the trends depicted in the data only reflected data for one year. Third, coding of the admission as emergent or elective was done by registrars at or before arrival and may not reflect actual clinical need. In addition, those admissions coded as "elective" included a heterogeneous population (eg, chemotherapy to research studies).

Further studies should analyze trends for other hospitals and evaluate the effect of high peak census and high levels

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of variation with quality, safety, efficiency, patient satisfaction, financial, and educational outcomes for those receiving care, working, or learning at hospitals. In addition, a qualitative study that develops insights into clinician and patient/parent preferences would help answer questions in regard to usage of weekends for scheduled patients.

Conclusions

Scheduled admissions drive most variability in day-to-day occupancy despite the fact that they are a smaller proportion of the inpatient population. Variation in scheduled admissions by day of week provides hospitals with an opportunity to address crowding without adding beds or delaying admissions. Rather, fully utilizing capacity by smoothing occupancy over all days of the week can reduce the risk of high occupancy and thereby improve accessibility and patient/parent satisfaction. While family and staff preferences need to be considered, some combination of within-week smoothing and shifting admissions towards summer are likely to achieve dramatic improvements in patient flow without large expenditures of capital. The key, then, is to ensure that organizational dynamic factors support these changes, so that staff members do not become stressed working at a 7-day facility. Taken together, these strategies would better match revenue to capacity, and ultimately increase the quality and value of healthcare operations.

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Address for correspondence and reprint requests:
Evan S. Fieldston, MD, MBA, MSHP, The Children's Hospital of Philadelphia, 34th & Civic Center Blvd, CHOP North Room 1516, Philadelphia, PA 19104; Telephone 215-590-1000; Fax 215-590-0426; E-mail: fieldston@email.chop.edu Received 13 April 2010; revision received 18 May 2010; accepted 30 May 2010.

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