In 2004, The Joint Commission issued its first accreditation standards—effective January 1, 2005—for managing patient flow.1

The current Leadership Standard, LD.04.03.11, states, “The hospital manages the flow of patients throughout the hospital.”2

When first issued, the standard served as a call to action for hospitals to focus more formally on patient flow issues. Yet, many hospitals still lack the processes and structures to admit or transfer patients to an inpatient bed on a timely basis. This often results in emergency department (ED) overcrowding,3–5 because the beds are being used by patients waiting to be admitted. Such overcrowding has been shown to have an adverse effect on patient outcomes and the well-being of health care workers.6–8

To address the Joint Commission standard, many hospitals established flow committees to identify the major barriers to patient flow and then embarked on improvement projects focused on these barriers. In our observations, three issues affecting the results from this approach have surfaced, as follows:

1. The improvement projects selected are often not connected to the true bottlenecks identified at the time that problems with patient flow occur.9

2. The changes that result from the projects may optimize only part of the system but may not optimize flow throughout the hospital.10

3. Few hospitals have the resources or the capability to work on the numerous proposed projects.11

Given those issues, in 2006 the Institute for Healthcare Improvement (IHI), in the context of its Improving Hospital-wide Patient Flow Community began developing a method to improve hospitalwide patient flow on the basis of a more structured approach to patient flow management.

Article-at-a-Glance

Background: The Joint Commission’s accreditation standard on managing patient flow, effective January 2005, served as a call to action for hospitals, yet many hospitals still lack the processes and structures to admit or transfer patients to an inpatient bed on a timely basis. In 2007 the University of Pittsburgh Medical Center (UPMC) at Shadyside, a 526-bed tertiary care hospital, began testing and implementing real-time demand capacity management (RTDC) at an initial pilot site. The hospital had identified improved patient flow as a strategic goal in 2002, but a series of patient flow projects failed to result in improvement.

Implementing RTDC: Standard processes for the four RTDC steps—Predicting Capacity, Predicting Demand, Developing a Plan, and Evaluating a Plan—and standard structures for unit bed huddles and the hospital bed meetings were developed. The neurosurgery (NS) service line’s ICU and step-down unit were designated as the first pilot sites, but work was quickly spread to other units.

Results: Improvements were achieved and have been sustained through early 2011 for all measures, including (1) the unit-based reliability of discharge predictions; (2) overnight holds in the postanesthesia care unit, a problem eliminated two months after RTDC work began; (3) the percentage of patients who left without being seen (LWBS), routinely < 0.5% by May 2008; (5) the emergency department median length of stay for admitted patients, routinely < 4 hours after March 2008; and (6) aggregate length of stay (ALOS), generally maintained at < 5.75 days.

Conclusions: RTDC represents a promising approach to improving hospitalwide patient flow. Its four steps, integrated into current bed management processes, are not an add-on to the work needing to be accomplished everyday.
focused approach to matching patient demand to hospital capacity. This community brought together multiple hospitals with the common aim to improve patient flow as called for in the Joint Commission standard. Matching capacity and demand is not a new idea. A structured approach to this concept had been applied extensively in industry.12,13 The key question was whether a more structured approach to matching capacity to demand could assist hospitals in improving patient flow. The structured approach described in this article is referred to as real-time demand capacity management (RTDC), as represented by the experience of the University of Pittsburgh Medical Center (UPMC) at Shadyside, which was a participant in IHI’s Patient Flow Community (which ended in 2009). UPMC Shadyside, as the first pilot site, began testing and implementing RTCD in early 2007.

Initial Patient Flow Efforts at University of Pittsburgh Medical Center Shadyside

UPMC consists of 18 hospitals, most of which are located in Western Pennsylvania. UPMC Shadyside is a 526-bed tertiary care hospital with 70 ICU beds and 20 separate units. Approximately 50% of admissions come through the ED. UPMC Shadyside is an academic teaching hospital with a case mix index (CMI) that approaches 2.0.

UPMC Shadyside identified improved patient flow as one of its strategic goals in 2002. A patient flow improvement team was formed to manage patient flow projects. From 2002 to 2006, the team developed a red-yellow-green system to identify units in trouble. The system called for patients to be held in the ED or the postanesthesia care unit (PACU) rather than being admitted to “red” units. Although the system benefitted the red units, it worsened problems elsewhere. Other projects focused on bed turnaround time, ED length of stay (LOS), and efficiencies in surgery. Work on ED LOS centered on the front-end processes of improving “door to doc” time. Although the efforts helped to improve that segment of the ED LOS, it did not improve overall ED LOS because there was no focus on creating the capacity in the hospital for the patients requiring admissions. In surgery, attempts were made to smooth admissions from elective surgery throughout the week. Despite presenting convincing evidence that the elective surgical schedule created bottlenecks at various times, the team was unable to gain the support necessary to alter the surgeons’ schedules. Other surgical initiatives resulted in improvements in first-case start times but had a minimal effect on hospital flow. UPMC Shadyside was still overwhelmed from 3:00 P.M. to 8:00 P.M., and key hospital patient flow measures did not show any improvement.

In 2006 a strategic flow oversight committee, which is chaired by the chief operating officer and includes vice presidents and department heads, created the flow improvement team, which signaled a new beginning to improving hospital-wide patient flow. In a change from the makeup of past improvement teams, middle managers and frontline staff from the inpatient units formed the core of the team. The senior administrative director for ancillary services and capacity management [D.K.] has served as facilitator of the team, which has continued to report regularly to the strategic flow oversight committee on progress toward hospital flow goals.

Implementing Real-Time Demand Capacity Management

UPMC Shadyside joined the IHI Patient Flow Community in 2006 and became a pilot hospital for the development of RTDC. The four steps of RTDC are depicted in Figure 1 (above). Standard processes for these four steps and standard structures for unit bed huddles and the hospital bed meetings were needed.

Before making any changes, the UPMC Shadyside flow team observed the daily hospitalwide bed meeting to better understand the current way in which way patients were assigned to beds. The observations revealed several opportunities for improvement, including the following key ones:

1. The bed meeting usually ended without a specific plan to accommodate patient demand that day.
2. What one unit called a discharge or an available bed was not necessarily the same as that of another unit.

A foundational element of RTDC is the need for agreed-on definitions so that all units convey their bed needs in a standard
format. At UPMC Shadyside, the following definitions were established:

- **An available bed** was defined as one that was cleaned, staffed, and ready to accept a patient.
- **A discharge** was defined as a patient who had left a bed and would not return.
- **Capacity** was defined as discharges plus available beds.
- **An admission** was defined as a patient who had been physically placed in a bed.

Selecting pilot units to test RTDC is an important initial step. Because Shadyside’s neurosurgery (NS) service line had consistent problems with bed capacity, the flow team determined that the NS ICU and step-down unit would be good places to begin testing RTDC. The flow team met with the leadership and frontline staff of these units. The units agreed that proactively planning for discharges would make a big difference in their evening work load, and they agreed to begin testing the four RTDC steps in January 2007.

**STEP 1. PREDICTING CAPACITY**

**NSU and Step-Down Unit.** The first tests of RTDC should be focused on developing a process to predict capacity. On the NS ICU and the step-down unit at UPMC Shadyside, the process to be tested consisted of case management’s development of a list of patients who were potential discharges for the next day. Initially, the list was simply written on a piece of paper and posted at the nurses’ station. The evening and night-shift nurses updated it on the basis of new knowledge from late-rounding physicians or a patient’s changing medical condition. The goal was to have an accurate list of potential discharges by 7:00 A.M. This initial test presented a few challenges. Discharge lists already existed in some units. The existing lists took on a variety of forms that could be found in various places. Therefore, a standardized template for the discharge list was developed and agreement was reached on a standard location. A second challenge was to have the care managers predict discharges on the basis of their knowledge of what *would* happen versus what *should* happen. Feedback to the care managers on the accuracy of their predictions helped overcome this challenge.

To further develop the process of predicting discharges, the NS ICU and the step-down unit each tested an early morning huddle (8:00 A.M.) to review the list of potential discharges. The objective of this unit huddle was to have the unit care team realistically decide how many of the patients could be discharged on that day—including how many by 2:00 P.M. The flow team hypothesized that if the capacity and demand could be better matched within the 8:00 A.M.-to-2:00 P.M. time frame, then the overcrowding typically seen in the late afternoon and evening would be eased.

The unit huddle was initially attended by the unit manager, care manager, unit secretary, and the staff nurses. Following some testing, it was decided that staff nurses would attend only when one of their patients was being discussed. Best practices for unit bed huddles were developed by observing key units. It was then required that all unit huddles be attended, at a minimum, by the charge registered nurse (RN), care manager, social worker, and staff RN. The huddles were to be held in a public area versus a conference room with participants standing, not sitting. Each potential discharge was to be discussed with an actionable item identified to complete the discharge. The huddle lasts approximately 10 minutes.

During the initial testing phase, the existing 8:30 A.M. hospitalwide bed meeting at UPMC Shadyside continued to occur each day. Immediately following this meeting, the unit managers from the NS ICU and the step-down unit, the bed coordinator, and the flow team met to test a “new” version of the bed meeting. For this new version, the unit managers of the test units reported only their capacity (available beds and discharges). The results of the previous day’s predictions were also reviewed. The accuracy of predictions—calculated on the basis of whether specific patients predicted to be discharged were actually discharged by 2:00 P.M.—was a key measure in the early stages of testing the process of predicting discharges. The goal was to attain about 80% success. An important lesson learned from reviewing the results of the previous day’s predictions was that the units needed to identify the specific patients who were the potential discharges. Those patients could then be “connected” to the specific actions required to successfully achieve the discharge.

It was also important that someone be assigned the responsibility for those actions. Figure 2 (page 220) shows the discharge worksheet developed to document the actions needed to discharge each patient. A sample unit-level RTDC recording form is shown in Figure 3a (page 221).

**Spread to Other Units.** The process of predicting capacity was spread to other units at UPMC Shadyside in late January 2007. Groups of units were brought on in approximately one-week intervals—surgical/procedural units first and the medicine units in the last group. By late February 2007, all units were predicting their capacity daily. A process for predicting discharges was provided to the unit managers on the basis of the work achieved by the NS ICU and the step-down unit. The process was as follows:
Discharge Worksheet

<table>
<thead>
<tr>
<th>RM #</th>
<th>Patient Name</th>
<th>Needed for Discharge</th>
<th>Responsibility</th>
<th>By 10:00 A.M.</th>
<th>By 12:00 P.M.</th>
<th>By 2:00 P.M.</th>
<th>After 2:00 P.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. The discharge worksheet was developed to document the actions needed to discharge each patient. The worksheet also contains a column for who was responsible. Rm #, room number.

- Case management develops a potential discharge list for the next day.
- Evening- and night-shift nurses update the potential list on the basis of new knowledge.
- Units hold daily unit-based huddles.
  Most of the units rapidly reached 80% accuracy in their discharge predictions. For those units that did not, the flow team heightened the focus on implementing the standard process and on learning from predictions. Tips for predicting discharges are shown in Sidebar 1 (right).

**STEP 2. PREDICTING DEMAND**

The objective of Step 2 is to reach 80% accuracy in predicting admissions by unit. To accomplish this, all sources of potential demand (admissions) need to be reviewed. At UPMC Shadyside, unit managers of the NS ICU and the step-down unit made calls to the ED and to the admissions department to determine if there were any current patients awaiting admission to their units. The operating room (OR) schedule was reviewed, as were potential transfers. A prediction was then made regarding the number of admissions to their units before 2:00 P.M. The admission information was entered on the unit-level RTDC recording form. As shown in Figure 3b (page 221), the sample unit predicted seven admissions before 2:00 P.M.

The NS ICU and the step-down unit gathered the information they needed for the hospitalwide bed meeting. During testing, however, these units reviewed the information together in the “new” bed meeting that took place after the existing meeting. As with predicted capacity, once the flow team, the NS ICU, and the step-down unit were satisfied with the process for predicting demand, the flow team started spreading Step 2 to other units in late February 2007, with a date for conversion to the “new” hospitalwide bed meeting using RTDC set for mid-March 2007.

Tips for predicting demand are shown in Sidebar 2 (right).

**Sidebar 1. Tips for Step 1: Predicting Capacity**

1. From experience, the best units to select for initial testing in order of preference are (i) connected units (for example, ICU and step-down or PACU and a surgical floor), (ii) service lines (all the medical units, for example), or (iii) a willing unit. The goal should be for all units in the hospital to be predicting discharges within four weeks.
2. The prediction should be a single number, rather than a range, of how many patients will be discharged each day by 2:00 P.M. Each predicted discharge should be connected to any action needed to accomplish the discharge within the time frame.
3. Predict the current reality. Do not try to change behavior or processes at this step.

* PACU, postanesthesia care unit.

**Sidebar 2. Tips for Step 2: Predicting Demand**

1. Consider known admissions first, such as patients already in the ED or PACU, patients on the surgery schedule, or patients scheduled for a direct admit or an internal transfer. Historical data on admissions can be used to refine the prediction.
2. The ED is a primary source of admissions for all other units. This requires the ED to be involved with the predictions.
3. Multiple like units, such as medical units, will need to accommodate patient admissions in an equitable and clearly defined way.

* PACU, postanesthesia care unit.

**STEP 3. DEVELOPING A PLAN**

After processes are established to predict both capacity and demand, units can assess their status. If predicted demand in the 8:00 A.M.-to-2:00 P.M. time frame is greater than predicted capacity, a plan to achieve a match is needed. During testing at UPMC Shadyside, it was determined that ownership by the units was stronger when a detailed plan was written down. For example, the statement “The case manager will try to get one more discharge” did not constitute an acceptable plan. The
“who,” “what,” “where,” and “by when” needed to be included. It also became apparent that two sources for plans—at the unit and system levels—needed to be considered. Any resource shared (for example, laboratory and x-ray) by units in the hospital was considered to be a system-level resource. If a unit manager was unable to develop a plan to match capacity and demand using the unit’s own resources, the nursing supervisor was to decide which system-level resources to deploy. Examples of unit- and system-level plans are shown in Table 1 (page 222).

In the sample RTDC recording form shown in Figure 3c (above), demand was predicted to exceed capacity on the unit. Because the unit was not able to devise a plan, a system-level plan was needed: The plan was to transfer one off-service patient to another unit by 10:00 A.M. The units involved then needed to develop the details for executing this plan—who will do what, by when, for which patient to accomplish the transfer. During testing, it was learned that for plans to be successful, specific time needed to be set aside after the bed meeting for staff on the units to discuss the details. Tips for developing a plan are shown in Sidebar 3 (right).

From the initial selection of test units in early January 2007, Steps 1 to 3 of RTDC were spread throughout the hospital in approximately 10 weeks. At this point, the “traditional” hospitalwide bed meeting was replaced with the “new” bed meeting.

**STEP 4. EVALUATING THE PLAN**

A key component of RTDC is the evaluation of and feedback on the actions taken. At UPMC Shadyside, after RTDC...
Steps 1 to 3 were spread housewide by late March 2007, the flow team turned its focus to testing and standardizing the process for Step 4. Although feedback on the success of predictions and plans was given to units during testing, formalization of this process was needed across all units. To start, units were requested to review any plan they developed the previous day. Each unit was to ask the same question, “Did what we plan to happen really happen?” The success or failure of the plan was to be documented in the final column of the unit-level RTDC recording form. The number of units consistently reviewing their plans and documenting whether they were successful increased rapidly. This increase was fueled by a test to review the success or failure of plans from the previous day at the beginning of the hospital bed meeting. This review became part of the process for evaluating plans.

After most of the units were consistently evaluating their plans, the flow team focused on having the units determine why a plan failed. Tests were run to incorporate a more detailed discussion on the plan from the previous day into the unit bed huddle. Unit staff quickly realized that making the actions in the plans more specific made it easier to determine why the plan failed—as seen, for example, in changing “Arrange for a physical therapy session for patient X” to “John will call physical therapy by 9:00 A.M. to arrange for a physical therapy session by noon for patient X.”

Besides using the information from evaluations to improve predictions and plans, the UPMC Shadyside flow team also used the evaluations of plans and predictions to identify barriers to patient flow. These barriers then became the focus of improvement projects. Sample barriers and the subsequent process changes are shown in Table 2 (page 223). Once the barriers surfaced, the changes needed could often be implemented quickly.

Tips for evaluating the plan are shown in Sidebar 4 (above).

**Sidebar 4. Tips for Step 4: Evaluating the Plan**

1. Evaluate the plan on the basis of the actions documented at the hospital bed meeting. Do not evaluate the plan based on the success of matching demand and capacity throughout the time interval, which might also be affected by poor predictions.

2. Focus improvement efforts only on barriers found to be common occurrences. Working on a barrier that is seldom observed would be a waste of resources and would not substantially contribute to improving patient flow.

**Evaluating Real-Time Demand Capacity Management**

**OUTCOME MEASURES**

To determine the impact of RTDC on patient flow at UPMC Shadyside, the flow team gathered data on the measures shown in Table 3 (page 224). At the unit level, data on the reliability of predictions and on measures of flow between units (that is, number of patients held overnight in the PACU, cardiothoracic [CT] ICU to 3 Main transfer time) were collected and shared on a daily, weekly, and monthly basis. Hospitalwide measures (for example, percentage of leaving [hospital] without being seen, ED median LOS for admitted patients, and aggregate length of stay [ALOS]) were reported monthly and reviewed by the strategic flow oversight committee and the flow team to evaluate overall progress.
The Joint Commission Journal on Quality and Patient Safety

Table 2. Sample Barriers and Process Changes

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Process Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dialysis patients who were potential discharges often</td>
<td>The dialysis unit created treatment slots in the morning to be used for hospital staff.</td>
</tr>
<tr>
<td>had afternoon treatment times scheduled and could not be included in</td>
<td>patients requiring treatment on their day of discharge.</td>
</tr>
<tr>
<td>the before-2:00 P.M. discharge predictions.</td>
<td></td>
</tr>
<tr>
<td>Discharges were routinely delayed because of the need for</td>
<td>Outpatient scheduling was adjusted to ensure one add-on per day,</td>
</tr>
<tr>
<td>magnetic resonance imaging that could be done on an outpatient basis.</td>
<td>thus ensuring that a patient could receive an appointment within four days of discharge.</td>
</tr>
<tr>
<td>Delays in getting postoperative craniotomies delayed patients</td>
<td>All postoperative computed tomography scans for craniotomies were scheduled for 5:00 A.M. on postoperative day 1.</td>
</tr>
<tr>
<td>being discharged from the neurosurgery ICU.</td>
<td></td>
</tr>
</tbody>
</table>

ANALYTIC METHODS

The flow team used time-series designs14 to analyze the data for the outcome measures. Data were plotted over time on run charts. Patterns in the data were observed to determine the impact of interventions on the outcome measures.15 Observing the data over time also allowed the team to monitor whether improvement in the outcome measures was sustained.

RESULTS

Improvements were achieved and have been sustained through early 2011 for all measures.

Unit-Based Reliability of Discharge Predictions. As stated, the process of predicting discharges was introduced in the NS ICU and its step-down unit at UPMC Shadyside in January 2007. As shown in Figure 4 (page 225),* the reliability of the predictions started at approximately 50% in these units and increased quickly. The prediction of discharges was spread to other units in late January 2007. Starting in March 2007, the data in Figure 4 represented the accuracy of predictions for all units. By July 2007, the reliability of predicting discharges reached 80% throughout the hospital. In January 2009, the goal was increased to 85%, a level at which performance was maintained through 2009, which led to the decision to discontinue formal aggregation and reporting of data on the measure. Missed predictions, however, were still reviewed for learned opportunities.

Holds in the PACU and the Transfer Time from the CT ICU to 3 Main. Indicators of delays in flow between units were monitored. Data for two such measures are shown in Figure 5 (page 225) and Figure 6 (page 225). Overnight holds in the PACU were occurring on the average of once a week through March 2007. Two months after RTDC work started, this problem was eliminated. Because of the success of the NS ICU and its step-down unit, the CT ICU and 3 Main became early adopters of RTDC. The transfer time between these units was > 100 minutes before March 2007 (Figure 6), which was reduced to < 80 minutes by April 2007 and to < 70 minutes by January 2009.

Percentage of Patients Who Left Without Being Seen in the ED. Because overcrowding in the ED was a priority for UPMC Shadyside, the percentage of patients who left without being seen (LWBS) was monitored. A goal of < 1% for LWBS was established in 2007. As shown in Figure 7 (page 226), LWBS was routinely < 0.5% by May 2008.

ED Median LOS for Admitted Patients. A goal of four hours was established for the median LOS in the ED for admitted patients. After improvement work was undertaken in the ED before the implementation of RTDC, the median LOS decreased to approximately 4.5 hours at the end of 2006, as shown in Figure 8 (page 226). With the implementation of RTDC, the median LOS was routinely < 4 hours after March 2008.

ALOS. As shown in Figure 9 (page 227), the upward trend in ALOS began to reverse, starting in 2007. Since then, the ALOS has generally been maintained at < 5.75 days. There is a need, though, to continue to focus on times of high census and higher than normal CMI to maintain the budgeted ALOS, which was reduced to 5.75 in July 2008.

Discussion

Reports of the design of systems to better match capacity to demand in health care settings are emerging. Some hospitals have focused on reducing the variation in patient demand by making the status of the hospital visible to admitting physicians16 or by thoughtful scheduling of elective surgeries.17,18 These load-leveling techniques are useful but not sufficient because they do not include the actions needed to efficiently manage the transition of patients each day. Nor are these tech-

* Figures 4–9 are also available in online article.
techniques designed to identify the key barriers to patient flow. Other approaches to match capacity to demand have included development of color-coded indicators (usually from green to red) that signal the ability of each unit in the hospital to accept additional patients. The status of each unit is then linked to actions to correct any mismatches in capacity and demand. Nor do green-yellow-red systems routinely include an evaluation of whether the actions occurred, so that the effect on patient flow usually remains unknown. As described earlier, UPMC Shadyside tried a similar intervention with a lack of success. Overall, the various redesign systems that depend on making unit status visible are often reactive, in which actions are signaled only after patient flow in the hospital is severely stressed. They also usually contain a generic list of actions focused on all areas of the hospital. In contrast, RTDC calls for development of a proactive plan focused on the specific actions needed to create sufficient capacity that day. Lessons from traffic flow indicate that improving the matching of capacity and demand for a few patients earlier in the day will relieve congestion later.

One of the authors [R.R.] had earlier attempted to improve patient flow with the prediction of demand and capacity for individual inpatient care units—an approach that acknowledged the importance of involving frontline staff. If the staff of a unit predicted that their demand would be greater than their capacity, the unit was able to limit new admissions. RTDC builds on this work by including formal steps at the unit, and when needed, the system level to develop a specific plan to match demand rather than limit admissions. RTDC also adds an evaluation step so that the prediction and planning process can be improved and barriers to patient flow identified.

Implementation of RTDC has also been described by Northwest Community Hospital (NCH; Arlington Heights, Illinois). NCH, which joined the IHI Patient Flow Community in 2008, reported three other elements that are also useful for optimizing patient flow: a bed management process, long-range forecasting and planning, and an early warning and response system (termed its peak census policy). To optimize patient flow, an effective bed management process is needed so that the patients can be efficiently transferred within the hospital when available beds are identified. Long-range forecasting and planning can inform the establishment of staffing levels on the basis of predicted demand. Predictions of demand would take into account previous day-to-day, month-

### Table 3. Measures of Hospital Patient Flow*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Definition</th>
<th>Source</th>
<th>Pre–RTDC Performance Level</th>
<th>Post–RTDC Performance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overall Monthly Unit-Based Reliability of Discharge Predictions</td>
<td>(Total number of discharges predicted at the hospital bed meeting / total actual discharges for the day) X 100</td>
<td>Unit-Level RTDC Recording Form and the electronic bed tracking system</td>
<td>&lt; 60%</td>
<td>&gt; 80%</td>
</tr>
<tr>
<td>2. Monthly Number of Patients Held Overnight in the PACU</td>
<td>Number of NS ICU patients remaining in the PACU at 6:00 A.M. who met criteria for discharge before 2:00 A.M.</td>
<td>PACU Daily Report</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>3. Cardiothoracic ICU to 3 Main Transfer Time</td>
<td>Average time from bed assigned to bed occupied for patients transferring from CT ICU to 3 Main</td>
<td>Electronic bed tracking system</td>
<td>110 minutes</td>
<td>&lt; 70 minutes</td>
</tr>
<tr>
<td>4. Percent of Patients Who Left Without Being Seen (LWBS) in the ED</td>
<td>(Number of patients who left the ED without treatment after registration / total ED visits for the time period) X 100</td>
<td>ED Tracking System</td>
<td>1.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>5. ED Median LOS for Admitted Patients</td>
<td>Median time for all admitted ED patients from arrival (registration) to departure (leave ED for inpatient bed)</td>
<td>ED Tracking System</td>
<td>&gt; 5 hours</td>
<td>&lt; 4 hours</td>
</tr>
<tr>
<td>6. Aggregate Hospital LOS</td>
<td>Total inpatient days / monthly total admissions</td>
<td>Admission Discharge Transfer (ADT) System</td>
<td>Approaching 6 days</td>
<td>&lt; 5.75 days</td>
</tr>
</tbody>
</table>

* RTDC, real-time demand capacity management; PACU, postanesthesia care unit; NS, neurosurgery; CT, cardiothoracic; ED, emergency department; LOS, length of stay.
to-month, and seasonal variation. RTDC can then assist in making the adjustments needed on a daily basis as actual demand varies from historical trends.

With regard to NCH’s peak census policy, many other hospitals have similar high-census alerts, known by such terms as code red or code purple. At UPMC Shadyside, large fluctuations in demand (Step 1) or capacity (Step 2) are predicted and planned for (Step 3), and actions are evaluated (Step 4) as part of RTDC, but UPMC Shadyside does not use separate processes for times of high census. Two other issues distinguish RTDC as practiced at NCH and UPMC Shadyside. First, NCH uses a formula for predicting discharges (for example, predicted discharges = 80% of confirmed discharges [that is, orders written] plus 50% of potential discharges).19 However, we believe that after gaining some experience in implementing RTDC, hospitals should move to the method used at UPMC Shadyside, where, as stated, predicting the number of discharges is based on what needs to be accomplished to discharge a specific patient on that day and whether that can be accomplished by 2:00 P.M. Second, at UPMC Shadyside, as described earlier, but not at NCH, evaluation of plans (Step 4) is performed separately from the evaluation of predictions (Steps 1 and 2). That is, plans to match capacity to demand are evaluated on the basis of whether the actions to discharge specific patients by 2:00 P.M. on that day actually occurred. If the plan was accomplished but capacity did not match demand by then, then a prediction problem exists that can be studied.

RTDC improves on other approaches for patient flow because it assists in creating resilience in a hospital. (Resilience represents the ability to anticipate system breakdown and deal with it proactively rather than reactively.)22) RTDC promotes the improvement in the ability to anticipate capacity and demand for a fairly short time horizon, which is accomplished by systematically having people make predictions and plans and by then giving feedback. Predictions are based on what is likely to happen
rather than what should happen. The near-real-time observability for many players as to these predictions is also centrally important. RTDC also assists in creating resilience by allowing hospitals to decide when to relax production pressure to reduce risk.23 In contrast, the commonly used “out by 10” (A.M.) strategy, for example, maximizes production pressure whether the beds are needed or not on a given unit. The operating rule and the essence of RTDC is the “right number of patients transitioned at the right time.”

As stated, RTDC is based on creating standard processes and structures, and organizations will most likely see gains weaken over time if they do not adhere to them. It is also important that someone be designated to lead and organize the work day-to-day. At UPMC Shadyside, this person [D.K.] has helped to implement RTDC in other hospitals in the UPMC system.

Conclusions
On the basis of the results shown at UPMC Shadyside, RTDC represents a promising approach to improving hospitalwide patient flow. Hospitals will find in implementing and sustaining RTDC that the four steps are integrated into current bed management processes and are not an add-on to the work needing to be accomplished everyday.

The authors acknowledge the conceptual contributions of their colleagues Diane Jacobsen and Marilyn Rudolph to this work. They also acknowledge the numerous organizations in the Institute for Healthcare Improvement (IHI) Community on Improving Flow through Acute Care Settings for their willingness to test and contribute to the development of the approach described in this article.

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See the online version of this article for Figure 4. Monthly Accuracy of Discharge Predictions, January 2007–November 2009 [color version]
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Aggregate Length of Stay (ALOS), July 2004–August 2010

Figure 9. The upward trend in ALOS began to reverse, starting in 2007, and has generally been maintained at < 5.75 days.

References
Figure 4. Data shown represent all units, except for January 2007, for which the data represent only the neurosurgery intensive care and step-down units. In January 2009, the goal was increased to 85%, a level at which performance was maintained throughout 2009.

Figure 5. Overnight holds in the PACU were occurring at an average of once per week through March 2007, but this problem was eliminated two months after work on real-time demand capacity management began.
**Cardiothoracic (CT) ICU to 3 Main Transfer Time, January 2006–September 2010**

Figure 6. The transfer time between the CT ICU and 3 Main of > 100 minutes before March 2007 which was reduced to < 80 minutes by April 2007 and to < 70 minutes by January 2009.

**Percentage of Patients Who Left Without Being Seen (LWBS), January 2006–September 2010**

Figure 7. A goal of < 1% for LWBS was established in 2007, and by May 2008, LWBS was routinely < 0.5%.
Figure 8. With the implementation of real-time demand capacity management, the median LOS was approximately 4.5 hours at the end of 2006 and was routinely < 4 hours after March 2008.

Figure 9. The upward trend in ALOS began to reverse, starting in 2007, and has generally been maintained at < 5.75 days.