



# Using Tracking Tools to Improve Patient Flow in Hospitals

---

## Executive Summary

Hospitals in the United States are experiencing financial and operational stress. Margins are thin and bed capacity is at a premium. Experts project the need for new bed capacity to rise 20 percent by 2012.<sup>1</sup> Adding new physical capacity is often out of the question. In some urban areas, the estimated cost of adding physical capacity can exceed \$1 million per bed. For a facility with an average length of stay of five days, each additional bed accommodates only about 70 extra admissions annually.<sup>2</sup>

Rather than increasing physical capacity to meet growing patient volumes, hospitals can increase their service capacity by improving their ability to move patients through the treatment system, a measure known as “throughput.” New patient tracking technologies help caregivers work more efficiently by providing them with real-time information on patients and updates about labs, orders, and other notifications that are crucial to their workflow. Patient tracking technologies provide information to improve the “flow” of patients in the emergency department (ED), the inpatient setting, and by increasing the number of acute care transfers coming into the facility.<sup>3</sup> Use of technology to improve patient flow in the inpatient and outpatient surgical environment is uncommon.

Inpatient tracking systems are technology-based solutions used to improve patient flow in hospitals. Some solutions provide information about patients through the use of real-time location systems (RTLS), while others use a combination of existing

data sources and manually entered status updates to track patients. Adoption of these technologies is presently low (less than 5 percent) but is expected to grow as awareness of the solutions rises.

There are a moderate number of RTLS vendors. They differentiate themselves by the underlying technology they use (e.g., radio frequencies, infrared light, ultrasound), although at the user level they are roughly equivalent. There are only a few vendors of integrated software-based patient flow solutions, and they are fragmented. Few large clinical vendors offer inpatient tracking solutions, which tend to be very similar in features and functionality.

The benefits of implementing patient flow solutions are fairly well documented. They include increased throughput, decreased average length of stay, improved recording of treatment costs (charge capture), fewer ambulance diversions, and higher patient satisfaction ratings. Some industry analysts have characterized the net gains generated by patient tracking systems as moderate, particularly for RTLS-based ones, which can entail a significant upfront investment in hardware (e.g., sensors, tags, and devices on the network).

The success rate for patient flow technologies is unknown, but implementations are considered relatively straightforward, low-risk, and highly customizable to fit the needs of organizations.

Regardless of the technology chosen, it is crucial that hospitals also carefully review key processes and workflows. Good change management

practices dictate that this should always be done, but patient flow is an especially sensitive area. The review may include process redesign, workflow optimization, the application of Lean Manufacturing principles, predictive modeling, or the use of simulation tools.

The solutions on the market today are automated and passive, so they require little additional attention from staff. RTLS-based systems track location automatically. Integrated software-based systems pull data primarily from existing clinical information sources. The important thing for hospitals to recognize is that low patient throughput can be caused by many factors, and that they should understand the underlying processes and measure what they want to manage.

Best practices for improving patient flow with technology include:

- View patient flow as a system-wide phenomenon requiring system-wide attention;
- Introduce technology *after* you have reviewed your processes and fixed any broken or outdated workflows;
- Select a system based on the accuracy and precision you need;
- Set goals and parameters for the processes you track;
- Use a multidisciplinary team to identify opportunities to improve patient flow;
- Reassure staff that tracking is to improve care, not to monitor productivity; and
- Closely examine the variation in your processes and in patient volume.

The experiences of early adopters of patient tracking systems show that success is possible in a variety of settings. When used in combination with traditional process improvement methods, patient flow technologies can boost productivity and throughput.

This issue brief examines the technologies and techniques that are helping hospitals improve their patient throughput in this demanding environment. The analysis also touches on industry adoption, implementation decision factors, and benefits. The brief ends with a series of short case summaries showing real-world use of these technologies.

## Technologies for Improving Patient Flow

This examination organizes patient tracking technologies into two categories: (1) those that use real-time location systems (RTLS), and (2) those that use existing event-driven data. The two approaches are complementary, not mutually exclusive. In addition, for either approach to succeed, it needs to be implemented as part of a broader effort to review processes and optimize workflows.

Figure 1 (page 3) shows how these approaches interrelate.

For a 275-bed hospital, reducing the average length of stay by four hours is equivalent to increasing physical capacity by ten beds.\*

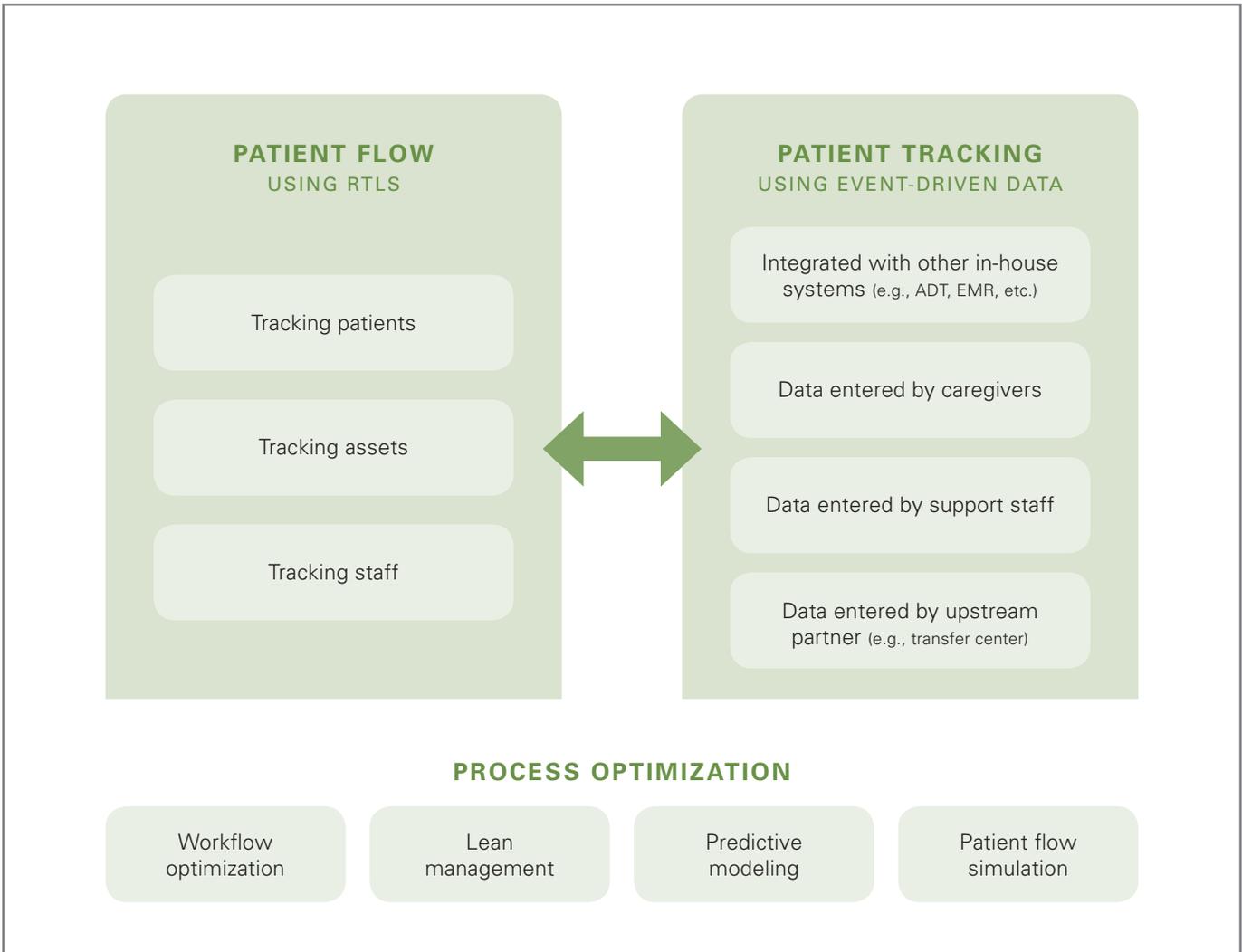
\*CSC calculation based on CDC data on U.S. averages for inpatient care (non-Federal short-stay hospitals) [www.cdc.gov](http://www.cdc.gov).

## Patient Flow Using Real-Time Location Systems

Real-time location systems improve patient flow by tracking patients, assets, or staff members. These systems consist of tags that are deployed on the person or item being tracked and a network of sensors and transceivers installed throughout the hospital that detect where the tags are in real-time. This information is then shown on a display near the nurse's station or accessed from a workstation.

There are several technologies to choose from when considering RTLS. The leading technologies are radio-frequency identification (RFID), infrared (generations one and two), and ultrasound. The technologies differ

**Figure 1. Technology-Based Patient Flow Solutions**



primarily in cost, infrastructure requirements, and precision.<sup>4</sup> They are roughly equally suitable for patient flow initiatives.

The practice of using of RTLS to track patients is relatively new and not widespread. Systems that track patients this way record patient locations, times, characteristics (e.g., fall risk, selected diagnoses), and status (e.g., waiting for x-ray, ready to be discharged). Real-time information is typically overlaid onto a drawing of the floor plan of a given unit. Physicians, nurses, other caregivers, and members of environmental services staff can refer to this “electronic whiteboard” for the latest status, location, and indicators for each patient.

Patient tracking systems communicate with the hospital’s information systems, including the bed management system, through the automated exchange of messages using the HL7 standard. This provides data to decision makers, which enables them to make informed decisions about patient admissions and placements. Bed managers can see which units have available beds and what the expected wait times are for dirty rooms to be cleaned.

The ability to track patients means that any patient can be located in the facility at any time. This saves staff the time they normally spend looking for patients who may have been brought to another department for a test or imaging, or who may be walking about to see visitors or

get some exercise.<sup>5</sup> Also, notifications can be set to alert caregivers when patients have waited too long relative to some predefined service standard, or when a lab result is ready. The availability of detailed information at a glance improves throughput by reducing the cost of looking up information (e.g., instead of calling to check if an order is ready, a nurse sees an icon appear when the order becomes ready).

In hospitals today, RTLS is more commonly used to track equipment and staff than to track patients. However, the former also improves flow by speeding the ability to locate key equipment used to move or discharge patients, such as wheelchairs and portable IV pumps, and by more quickly alerting nurses and environmental services personnel to needs that arise.<sup>6</sup> Studies have shown that nurses spend up to 48 percent of their time managing supplies, tracking down equipment, doing paperwork, directing other staff, and handling admissions and discharges.<sup>7</sup> RTLS helps recover a portion of that lost time.

Albert Einstein Medical Center (AEMC) in Philadelphia is an example of a facility that uses RTLS to locate patients, employees, and medical devices. AEMC uses ultrasound tags from a hardware RTLS vendor coupled with tracking software from a patient tracking vendor to monitor people and assets across its campus. Every patient who comes into the ED receives a tag, as does all equipment essential to patient transfers. The nursing units and ED display the real-time information on electronic “scoreboards.”<sup>8</sup>

Another benefit of implementing real-time tracking is detailed reporting. Doctors can receive automatically generated reports showing the number of patients treated by the physician, the time it took to treat those patients, how often each person was visited, the length of time before each was discharged or moved out of the ED, and more.<sup>9</sup> This level of detail is difficult to obtain through any other means.

Patient tracking systems can be integrated with electronic medical records (EMR), but this has not yet taken hold in the industry.<sup>10</sup> As RTLS patient tracking systems continue to evolve, organizations may begin to use them as portals through which an increasing amount of patient data can be viewed, including real-time location, charts, and diagnoses, treatment plans, age- and weight-based medication dosing, and medication alerts.

### Patient Tracking Using Event-Driven Data

Another approach to improving patient flow is to track patients by deducing their location through changes in their last-known status. Some tracking systems require staff to make manual entries to record that a patient has moved from one room to another. Other systems import event-based data automatically from hospital information systems (e.g., ADT, lab, radiology, PACS, and CPOE). If a patient’s record shows that an x-ray has just been taken, that patient can most likely be found in the radiology department.

The ability to accept data and messages in standardized formats such as HL7, Observational Report/Unsolicited (ORU), and General Order Message (ORM) is a universal capability across vendors in this space. (HL7 is the main message format; ORU and ORM are generally used only to communicate orders and allergies.) Almost all systems allow users to make manual updates and for data to be imported. Vendors have designed their systems to work with as little duplicate data entry as possible.

Whereas EMRs are designed to drill down into the records of a single patient, tracking systems emphasize visibility and provide a broad, quick, dashboard-like snapshot of what is going on with all the patients at a given time on a given floor.

Hospitals can use color, highlighting, and icons to convey different information. They can also set timers to trigger events such as discharge and configure the system to email, text message, or page staff.

### The Versatility of Tracking Systems:

#### Tracking Patients Before They Arrive

Some inpatient tracking systems are specifically designed to improve patient flow surrounding pre-admission and admission. These systems are used in hospital transfer centers. A transfer center is a nurse-staffed call center that serves as a single point of reference for incoming referrals, and handles all or most of the admission decisions, including facility routing, bed placement, and OR requests. This function is new and appears to be growing, especially among health systems.

These types of tracking systems feature a dashboard showing a snapshot view of all the admissions, transports, and discharges underway for a hospital or health system. Nurses in the call center can push and pull information to and from the patient registration or bed management systems without the need to rekey data. They also have access to staffing schedules and information about current capacity, including knowing when a particular ED is diverting ambulances to other hospitals.<sup>2</sup>

When a patient is admitted to a unit, a nurse or care coordinator assistant enters the patient into the tracking system manually or imports the data from the ADT system. The nurse can view, and possibly edit, all information about a patient—for example, whether the patient has been registered, when the patient was registered, which room the patient was assigned to, and how long the patient has been waiting for a given service (e.g., an order to be filled, to be discharged). All vendors offer highly customizable screens.

These systems help improve workflow, but they do not tell nurses what to do. Rather, the systems show nurses what is happening, so they can use their own judgment as to what task to do next. Consequently, the systems improve patient flow indirectly by enabling caregivers, case managers, and other staff to make better decisions.

### Traditional Process Improvement Complements Technology

No patient flow technology can be properly implemented without a careful review of a hospital's processes. As with any system, overlaying technology upon broken processes will merely magnify throughput issues, not correct them.

Industry reports estimate that most hospitals can increase their effective bed capacity from 5 to 20 percent by redesigning their processes, centralizing patient placement, and introducing technologies to help staff track the status of patients.<sup>1,35</sup>

For that reason, patient tracking systems are almost always implemented as part of a broader effort that includes process evaluation and redesign. Most patient tracking vendors offer some process review service to complement their technology solution. One leading vendor pursues only enterprise-wide engagements (i.e., it will not address just the nursing units, or ED, or OR), and requires a minimum five-year commitment from the client, including a detailed pre-implementation assessment and twice-annual audits. This particular vendor also requires that the client undergo a “process go-live” to introduce the newly reengineered processes several months before undergoing a separate “technology go-live.”

Hospitals interested in patient flow technologies should first review their current processes, evaluating how each affects the whole system.<sup>11</sup> This review may show, for instance, that it would be beneficial to introduce bedside registration or create a discharge lounge. Other nontechnical changes may include scheduling elective admissions when the emergency volume is known to be light and scheduling more procedures on weekends.

In the ED, many hospitals turn to process improvement before they consider how technology can help improve flow. “Fast tracking,” a method of performing triage

in which low-severity patients are quickly treated and released, is a popular approach to addressing patient throughput.<sup>12</sup> Additional gains can be achieved by setting up a miniature registration area where caregivers can care for patients privately without doing a full registration and without assigning each patient a bed.<sup>13–15</sup>

While process redesign is necessary in order for technology-based solutions to work, technology can also help organizations get the most out of process redesign. Tracking tools can provide deep insight into how processes actually work and where bottlenecks occur. Tracking systems capture valuable timestamps and location data, which can be used in queuing models, forecasting tools, and discrete event simulation.<sup>16</sup>

### The Importance of Reducing Variation

Improving the way one manages variation in patient volume can also improve patient flow. Variation in patient arrivals, coupled with nonstandardized processes, strains physical resources and makes workflows less predictable.\* In most hospitals, peak bed demand does not naturally align with peak bed availability. Peak bed demand is driven by ED activity, OR schedules, and seasonality. It tends to occur early in the day. By contrast, peak bed availability is driven by discharges, which are highest in the afternoon.

Variation cannot be eliminated, but it can be reduced.† Traditional process improvement methods can reduce the peaks and valleys occurring in the patient census, enabling nurses and case managers to schedule patients more efficiently.‡ This helps hospitals increase patient throughput without physical expansion, costly capital investments, or adding to the workforce.§

\*See endnotes 16 and 18.

†See endnote 26.

‡Enrado, Patty. "Hospitals Use Business Intelligence to Boost Patient Throughput." *Healthcare IT News*. June 2, 2009.

§Dempsey, Christy and Madden, Susan L. "Improving Patient Flow." *Hospitals and Health Networks*. August 19, 2008. Also, see endnote 1.

## Industry Adoption of Patient Flow Technologies

Industry adoption of patient tracking and patient flow systems is difficult to estimate, as various technologies adopted for this purpose are in different stages of maturity. It has been projected that the market for RFID tags and systems in health care will rise from \$90 million in 2006 to \$2.1 billion in 2016. The fastest growing areas are item-level tagging for drugs, and RTLS for staff, patients, and assets to improve efficiency, safety, and availability.<sup>17</sup> Similar projections for patient flow systems, however, are unavailable.

Interest in these solutions among hospital executives is high. A national survey conducted by a patient tracking vendor found that 68 percent of respondents believe that patient flow and logistics solutions have the greatest potential to improve patient throughput at their facility. Another survey conducted by an industry association found that three-quarters of executives say they lack the appropriate tools to measure, monitor, and predict events critical to patient flow.<sup>18</sup>

Overall awareness of the technological solutions is low but growing. Studies show that most health care executives know that real-time location systems exist for use in hospitals, but fewer than half know specifically which type of RTLS technology they would use.<sup>19</sup> Name recognition of RTLS vendors also remains moderate to low.

Piecing together various estimates, market data, and survey responses, industry adoption of patient flow technologies is between 1 and 5 percent.<sup>20–22</sup>

## Improving Patient Flow in the ED and OR

The ED and OR are two departments that are crucial for patient throughput. Roughly half of all patients who are admitted go through the emergency department.<sup>23</sup> Good throughput and efficient placement of patients coming out of the ED set the tone for the rest of the hospital. Likewise, ORs are the top producers of revenue and margin for most hospitals. Healthy throughput in the OR is essential to overall financial health.

## Patient Tracking Technologies Have Started to Enter the ED

EDs are overloaded. ED visits in 2006 rose to 119.2 million (up from 90.3 million in 1996), while the number of hospital EDs to handle these patients decreased 4.6 percent from 4,019 to 3,833 in the same period.<sup>24,25</sup> Average ED waiting times are rising, and ambulance diversion has unfortunately become common.<sup>26,27</sup>

Patient tracking systems have begun to appear in the ED, but they are not yet in widespread use. At the Albert Einstein Medical Center in Philadelphia, software tracks the location and status of patients in the ED. Every patient is associated with a tag upon admission. Whenever the patient is moved to a new room, the system is updated in real time. Physicians, nurses, and residents also wear tags. This allows the department to generate detailed reports on who treated whom. Notes and treatments ordered by physicians are also documented in the tracking system, allowing data to be sent to the inpatient system (e.g., EMR) without the need for retyping.

Industry research indicates that ED crowding is typically a symptom of poor patient flow, not the cause. Crowding is a hospital-wide problem, not just an ED problem.<sup>28,29</sup>

## Patient Tracking Technologies Are Not Yet Used in the OR

Patient tracking systems have not yet spread to the OR. Although administrators are aware that the OR and its

pre- and post-care areas can be the source of bottlenecks, this market segment has not become a priority for vendors.<sup>30</sup> The barriers to entry tend to be more cultural than technical.

Most patient flow initiatives in the OR involve traditional process improvement methods such as Lean Manufacturing and Six Sigma. Strategies include smoothing the number of scheduled elective cases per day, designating separate ORs for scheduled and unscheduled surgeries, and scheduling for off-peak hours.<sup>31</sup> Some hospitals reward the surgical teams that have the fewest cancellations with more favorable time slot.

### Real-World Example: UCSD Medical Center Studies RTLS Patient Tracking

The University of California San Diego (UCSD) Medical Center is pilot testing the use of RFID-based real-time location systems in three of its facilities: Hillcrest UCSD Medical Center, Thornton Hospital, and Moores UCSD Cancer Center. Each system employs active RFID tags that allow users to locate patients, other staff members, and equipment anywhere in the facility.

So far, UCSD has benefited from a reduction in time spent searching for equipment and a reduction in equipment inventory and rental costs. Better management of equipment helps to improve patient flow, especially in situations when locating mobile medical equipment (e.g., gurneys and wheelchairs) is the cause of patient flow bottlenecks.

In one component of the study, the hospital used the system to track patients moving through the OR. Looking at the timestamp data, they followed patients from the time they walked through the door to the time they left the post-anesthesia care unit. The study confirmed that some delays could be traced to paperwork issues originating in the preadmission testing center. Fixing this led to better first-case on-time starts.

In another component of the study, the Moores Cancer Center gave patients RFID tags and tracked the time they spent in each area of the facility: the scheduling department, the lobby, the cafeteria, the education center, the lab, imaging, oncology, and other locations. They plotted the utilization of each physical space and

### Real-World Example, *continued*

found bell curves at various points in the day. Then they adjusted staffing schedules to mirror the rise and fall of patient volume for each of these services.

Disaster management capabilities also improve with the introduction of a tracking system. During the 72-hour Code Orange of the 2007 San Diego fire disaster, Thornton Hospital cared for more than 50 injured victims—in addition to the normal inpatient population of about 350—and was able to keep its clinics and emergency rooms continuously open. The UCSD Incident Command Center relied on the equipment tracking system to direct staff to the exact location (with room-level specificity) of key equipment, including gurneys, IV pumps, and wheelchairs.

UCSD will use the results of their studies to determine whether to continue, and perhaps expand, their use of the tracking systems.

## Benefits of Patient Tracking

One of the most commonly cited benefits for patient flow technologies is decreased length of stay. By making the processes for moving patients through the facility more efficient, hospitals can eliminate the delays and waste that occur at admission, during handoffs and transports, and at discharge. Shorter lengths of stay result in cost reduction for hospitals. Organized into direct and indirect savings, common benefits include:<sup>32–35</sup>

Direct benefits:

- Decreased length of stay;
- Improved utilization of resources and reduced inventory costs;
- Nursing time saved looking up information and looking for equipment;
- Physician time saved looking up information;
- Registration personnel time saved;
- Better charge capture and faster revenue generation;

- Fewer ambulance diversions and increased patient referrals;
- Improved claims and denial management (through greater accuracy); and
- Reduced costs associated with preprinted paper forms and templates.

Indirect benefits:

- Improved understanding of processes and visit progression;
- Improved staff morale and lower employee turnover;
- Automatically generated interaction reports and increased accountability;
- Improved performance with accreditation agencies and quality measures;
- Better recordkeeping and decreased potential liability;
- Increased patient safety;
- Increased patient satisfaction and better Press Ganey scores; and
- Improved patient education (e.g., through use of the discharge lounge).

The precise investment return of patient tracking is not well documented, as few organizations conduct detailed baseline studies before system implementation. Some industry analysts view the monetary benefits of patient tracking systems as moderate.<sup>36</sup> This is due in part to the sometimes significant capital expenditures needed for RTLS systems. Software-based tracking systems are less costly but also less feature-rich.

Overall, tracking systems reduce costs by improving operational efficiency, but they need to be supplemented with traditional process improvements. The return on investment can be good, but it is also likely to be spread out over many areas, making it difficult to quantify.

## Decision Factors for Implementing Patient Tracking

The first question to ask is what kind of patient flow challenges does your organization face? Indications of patient flow problems include long waiting times, delays in the availability of resources, time and effort spent by nurses to obtain the latest status on a patient's location or lab results, and high occupancy.<sup>37,38</sup> In the ED, indicators include frequent periods of ambulance diversion, long admission times, and high left-without-being-seen rates. In the OR, key indicators are low on-time starts and long waiting times for patients to be moved in and out of the post-anesthesia care unit (PACU).

If considering an RTLS-based patient tracking solution, the main implementation decisions will involve the technical details of the transceivers, network devices, and tags.<sup>39</sup> Some transceivers plug directly into standard electrical outlets and communicate wirelessly with devices housed in existing network equipment closets. By contrast, infrared RTLS systems require a transmitter to be installed in the ceiling of each room for which coverage is desired. All RTLS patient tracking systems also involve the issuing and managing of physical tags, whether worn around the neck, integrated into a wristband, or attached to the patient chart and moved around with the patient.

If considering a software-based system, the main implementation decisions will involve integration and availability of desired features. Messaging standards defined by HL7 and other organizations have made integration increasingly easy. All vendors accommodate additional customization when necessary. When possible, decisions about features should be left to frontline staff.

To summarize, key implementation questions for patient flow technologies include:

- Do you need a tracking system to improve patient flow?

- What will you track and how often will you analyze the data?
- Do you need automated real-time data, or will existing data sources suffice?
- If using RTLS, what technology is best for your environment? How many tags do you need?
- If using existing data sources, how easy is it to integrate with those systems, and what is their accuracy?
- Will frontline staff accept this new technology? How will it change their workflows?

## Best Practices for Implementing Patient Tracking

To implement patient flow technologies successfully, organizations first need to view patient flow as a system-wide phenomenon requiring system-wide attention. Consider using a cross-functional, multidisciplinary team to analyze key processes and identify opportunities for improvement. Once traditional process improvement methods have removed broken processes, then technology solutions can be introduced that will help caregivers move patients through the facility safely, effectively, and efficiently.

### Best Practices

- 1. View patient flow as a system-wide phenomenon requiring system-wide attention.** All flows in the hospital are interconnected. The root cause of a patient flow problem may be several steps removed from where the effect is noticed. For example, patient flow issues in the inpatient units may be a result of poor bed placement coming from the ED or poor adherence to discharge procedures. Bed control is a shared responsibility of the admissions department and nursing. The more broadly the tracking system is implemented, the better transparency users will enjoy.
- 2. Conduct a detailed review of processes and workflows prior to implementing technology**

**solutions.** Before you implement technologies to improve patient flow, first understand what processes you are trying to fix, which performance parameters you are targeting, and why. Your vendor may be able to help. Some vendors offer pre-implementation consulting because they understand that technology alone cannot fix bad processes.

- 3. Select a system based on your needs.** If you require a high level of accuracy and can afford the upfront capital expenditure, consider an RTLS-based patient tracking system. In addition to tracking patients, you will be able to track assets and equipment, which also improves patient flow. If you already have a rich information environment and do not require real-time accuracy, consider a software-based system that works with your existing systems.
- 4. Set objectives and goals for the metrics you track.** Tracking systems make status updates, time stamps, and trends highly visible and easily accessible. However, caregivers need to know what the performance targets are to know whether they are meeting the hospital's objectives. In the ED, for example, hospitals should track initial assessments, anticipated discharge times, admission-to-bed times, admission-to-physician times, and transfer times between facilities. Patient outcome metrics help quality managers and case managers understand how throughput relates to care. Service quality metrics are needed to ensure that patient care quality and services do not suffer as a result of increased throughput.
- 5. Focus on using tracking technology to reduce delays and coordinate care.** With patient tracking in place, one event can trigger another event without delay. Communication between departments can be done with automated alerts and notifications instead of manual processes that require staff to enter data, telephone another staff member, or send a fax.
- 6. Link patient tracking to discharge planning.** Discharge planning reduces the average length of stay

and frees up beds for incoming patients. Discharge planning should begin as soon as a patient is admitted. Use the timers in the patient tracking system to show the amount of time remaining before a scheduled discharge. Enable the notification features to alert staff to start discharge tasks on time.

- 7. Use a multidisciplinary team to identify opportunities to improve patient flow.** When reviewing processes or analyzing the data provided by tracking systems, teams should be composed of participants occupying different roles in different departments, including nurses, physicians, and environmental services staff. Stakeholders need to collaborate so that overall coordination is improved, not just the processes in their own departments. When possible, team participation should extend to preadmission, registration, and discharge.
- 8. Reassure staff that tracking technologies are for assisting with care, not for monitoring productivity.** Staff acceptance is essential. It is natural for staff to be concerned that the system will be used strictly to monitor individual productivity. While data can be used for rewards and acknowledgement, they should not be used to drive individual productivity.
- 9. Examine the variation in your processes and in patient volume.** Variation is the enemy of high throughput. Try to reduce process variation by standardizing on one or two processes for initiating a bed request instead of accommodating many. Or, actively manage variation in patient volume by using patient tracking data to forecast staffing models more accurately.

Finally, although training is always important when rolling out a new system, it should be noted that tracking systems generally require very little training.<sup>40</sup> Vendors have succeeded in making systems highly intuitive through the use of visual diagrams, icons, and color-coded symbols. Most staff members find tracking systems very easy to use.

## Case Summaries

As part of the research for this publication, interviews were conducted with several health delivery organizations that have explored the use of technology to improve patient flow. The following case summaries provide a glimpse of the types of transformations that are possible.

### 1. RTLS-BASED TRACKING FOR PATIENTS, STAFF, AND EQUIPMENT

CHRISTIANA HOSPITAL (Newark, DE)

#### Context and Objectives

Christiana Hospital is a 913-bed facility in Newark, Delaware, and home to the only Level I Trauma Center on the East Coast corridor between Baltimore and Philadelphia. In 2003, the hospital started to see large increases in the number of patients it served. The effects of rising demand were felt in the ED and the inpatient units. Patients were increasingly becoming difficult to keep track of. Family members were occasionally told the wrong floor or room number. Physicians working with old information could not find their patients. Transport services would arrive with a gurney or a wheelchair and not be able to find the right patient.

At the time, Christiana had a basic tracking system that relied on manual input, but it was not very accurate. Caregivers tried to deduce patient location based on patient status recorded in charts (e.g., last caregiver seen), but records often lagged patient movement. Data fields that were not updated automatically tended to be unreliable, as manual updating took a back seat to direct patient care.

An audit revealed that the patient locations contained in the patient tracking system were accurate just 80 percent of the time. The rest of the time, clinicians needed to make multiple phone calls or walk the hallways to locate admitted patients. With this in mind, the hospital set out to find a solution that would bring more automation to their patient tracking process.

#### Solution

After conducting several site visits to other hospitals in the region, Christiana selected an RTLS system that uses infrared tags and paired it with new patient tracking software. For maximum interoperability, both of these systems are also integrated with the hospital's inpatient bed management system.

Now the location of patients, staff, and equipment are tracked in real time. When patients arrive at the ED, they receive a small badge that clips to their clothing. As patients move from one room or department to the next, clinicians view the updates on a map of the building. Key information such as patient acuity levels and isolation codes are always visible to any caregiver who looks at the display.

The high level of integration between the systems helps Christiana to optimize patient flow from the time that patients enter the ED through the time they are placed in an inpatient bed. Information is updated automatically as bed assignments are made.

#### Results

Christiana's ability to manage patient flow improved noticeably. The hospital has experienced reductions in patient visit length, reductions in patients leaving without being seen, and improvements in patient and staff satisfaction. In the 12-month period after implementation, the average time to be treated and released was reduced by 14 minutes, and average time to be treated and admitted was reduced by 36 minutes.

Post-implementation data show that during the first flu season after implementation, patient turnaround time in the ED decreased 5 percent despite an increase in volume of over 7 percent. The number of patients who left the ED without being treated fell by 24 percent, and patient satisfaction rose. ED availability also improved: The number of hours that the hospital was diverting

ambulances dropped from more than 60 hours per month to 11 hours per month.

Overall, patient tracking has improved bed turnover times and increased bed utilization. Staff members say the bottleneck of matching available bed inventory to patient demand has improved. Another major benefit is knowing the time intervals associated with care. Whereas before they used graduate students with clipboards and stopwatches, now they have reliable timestamp data with which to do resource planning.

Caregivers also benefit from the capability of the system to perform surveillance for infectious diseases. Managers can print out interaction summaries to see who may have come into contact with anthrax or tuberculosis. This safety feature helped leaders get buy-in from staff.

In 2008, Christiana integrated patient tracking software across two of its hospitals to achieve enterprise patient flow management. The two hospitals can share bed request information, thereby eliminating many phone calls and other manual interventions relating to transfers and admissions. Now patients can be placed where caregivers can best meet their needs.

## 2. PATIENT TRACKING THROUGH SOFTWARE INTEGRATION

PROVIDENCE HOLY CROSS MEDICAL CENTER  
(Greater Los Angeles, CA)

### Context and Objectives

Providence Holy Cross is a 254-bed, nonprofit facility and a magnet-designated, ACS verified Level II Trauma Center in Mission Hills, California. Like many hospitals, Providence has experienced a growing volume of patients. With occupancy rates typically ranging from 80 percent to 110 percent, capacity management was a key concern in both the ED (which is a Magnet-recognized Level II Trauma Center) and the inpatient units.

Between 2004 and 2008, the hospital instituted a total of 52 changes designed to improve patient throughput. For instance, they redesigned how they conducted morning bed huddles to take into account the severity of the patient. These efforts led to some successes, but hospital leadership knew that there were still opportunities to improve efficiency in bed turnover and to reduce patient waiting times.

Ultimately, Providence decided it needed a more unified approach to patient throughput. They looked to available technologies for a solution that would help tie their processes together and to sustain the gains they achieved through traditional process improvement.

### Solution

In May 2008, after a short implementation cycle of about 100 days, Providence went live with a software-based patient tracking system. The system was integrated with the hospital's clinical information system, ADT, housekeeping, and other systems so that no additional (or duplicate) data entry is required.

To make full use of the capabilities, they added a touch-screen interface to connect the tracking system directly to staff workflow at the bedside. Now the environmental services staff can indicate changes in bed status as soon as they happen, and physicians can set flags to indicate new orders.

Providence did not roll out the patient tracking system to the OR because it already has another type of perioperative management system in place, but it does use the system to optimize bed requests in the PACU, catheterization lab, and ED. Rather than calling the house supervisor to ask *whether* a bed is available, clinicians can check the tracking system and see precisely *which* beds are available before making a request.

## Results

In the first three months post-implementation, the hospital experienced a 53 percent decrease in bed turnaround time and an 85 percent decrease in admission turnaround time. Other results from the first three months of use include:

- 11.5 percent increase in inpatient admissions;
- 10.6 percent decrease in the average length of stay;
- 16.3 percent increase in ED visits; and
- 25.3 percent decrease in the number of patients who left without being seen in the ED.

The facility estimated that the system resulted in \$1.7 million in savings and increased revenue in the first full year. That figure is calculated based on the following:

- \$613,000 in additional inpatient margin due to increased admissions;
- \$556,000 in additional ED margin based on an 18 percent increase in ED visits over the first year and an 8.5 percent reduction in hours diverting ambulances to other hospitals; and
- \$543,000 in savings from reduced average length of stay (ALOS) across all DRGs.

In addition to the above quantitative results, Providence noticed a reduction in delays at shift changes, fewer calls and pages between departments, and fewer crisis scenarios. The real-time data provided by the system also helped with reporting and trend analysis.

Leaders at Providence found that it was important to manage the information they put up on the tracking board. Because the system is customizable, it is tempting to add icons for every possible variable and parameter. However, for the system to remain an effective tool for communication, visual clutter needs to be minimized. Only important, actionable information should be represented.

## 3. IMPROVING PATIENT FLOW AND OPERATIONS THROUGH TRACKING SOFTWARE

ST. VINCENT'S (Birmingham, AL)

### Context and Objectives

St. Vincent's Hospital is a 372-bed nonprofit acute care hospital in Birmingham, Alabama. In 2004, hospital leaders were frustrated with making decisions about resources and staffing based on data that were 24 hours old. Similarly, members of the frontline staff were frustrated that they had to put patient care on hold in order to go look for the information they needed (or to compile the data manually).

Communication between nurses and environmental services staff was inefficient and led to delays. For example, requests for rooms to be cleaned and notifications of cleaned rooms were communicated by phone, pager, or by walking the halls to find people. Operations managers could not direct resources fast enough to sustain high patient throughput.

The hospital wanted a technology-based solution that would help them track patients in the following two ways:

- Display to the nurses the current status and assigned location of patients, and let them know when changes occur (or are scheduled to occur). For example, the system should indicate both that a lab result has been returned and when a patient is scheduled to be discharged.
- Record for the administration detailed data about bed utilization, including bed-level status indicators and time diverting ambulances from the ED. Among other things, managers wanted the ability to view and compare utilization across departments on a red-yellow-green scale.

## Solution

In September 2004, St. Vincent's went live with a software-based patient tracking system. Data from existing systems, including environmental services, the clinical system, and the pharmacy, automatically feed the display. The information is pulled from these systems and overlaid onto a graphical representation of the hospital floor plan. Now when the status of a room changes, one update is made via the computer system, and the information becomes immediately visible to everyone in the unit.

As one of the earliest adopters of this type of system, St. Vincent's was able to have a hand in the development of the system. They designed a set of icons and color codes that they could use for sensitive indicators such as fall risk, reason for admit, abnormal results, or MRSA. They also created a procedure so that when a doctor says that a patient can go home but has not issued the official discharge order, nurses can change the patient's status to "intent to discharge." This triggers the start of discharge preparation activities by up to four hours earlier than they would have been, helping to open up beds sooner.

Real-time updates about patient location are also triggered by the integrated RFID tag system already in use.

## Results

Patient tracking at St. Vincent's enhanced communication between departments, improving throughput and enabling managers to monitor team performance. Key results include:

- The environmental services staff reduced bed-cleaning response time from 30 minutes to 10 minutes;
- Observation time decreased from 50 hours to 24 hours;
- Two to seven hidden beds per day are "found" by the bed control staff;

- Patient volumes have increased from a high of 6.88 bed turns per month to an average of 8.20 bed turns per month sustained over the first five months of use; and
- Increased patient volume accounted for an estimated \$5.5 million increase in revenue; and
- Registration tracking and discharge planning.

The patient tracking system also improved performance in the ED. Over the first six months of implementation, the amount of time during which the hospital diverted ambulances dropped from an average of 3,000 hours (per six months) to just 300 hours.

Another way in which the system benefits patient flow is the time saved by housekeeping. Prior to the installation of the electronic tracking boards, housekeeping staff had no way of knowing when a patient was scheduled to be discharged. As a result, they often performed unnecessary room cleans near the end of a patient's stay. Now they can eliminate unnecessary "routine cleans" by doing one "comprehensive clean" after the patient has been discharged.

Similarly, improved notification from the blood bank was cited as another key satisfier. Prior to implementation, nurses had to keep calling the blood bank to see whether their order was ready. Now an icon appears on the display to indicate that a patient's order is ready.

## 4. IMPROVING PATIENT FLOW WITH TRACKING TECHNOLOGY IN THE ED

SANTA CLARA VALLEY MEDICAL CENTER (Santa Clara, CA)

### Context and Objectives

Santa Clara Valley Medical Center is a 574-bed tertiary medical center and safety net hospital owned and operated by Santa Clara County. Over a decade ago, they began a long transformation of their Level I Trauma emergency department. Physically, the ED was spread

out over nearly 8,000 square feet and was not easy to navigate. A basic triage system was in place, but it did not support patient tracking, orders, or documentation. This forced nurses to do a lot of walking to find patients, track down EKGs, images, and notes.

At the time, Santa Clara's ED served about 60,000 patients per year (with a median of about 200 patients per day). Finding patients and keeping them associated with their paper charts was a challenge that cost nurses and physicians valuable time. The legibility of written orders was also an issue, and the lack of operational reports meant that it was difficult to identify the sources of bottlenecks.

They decided they needed to track patients more closely and provide caregivers with easier access to patient information. They determined that this would reduce rework, increase their ability to handle large volumes of patients, and increase patient safety.

### Solution

Rather than implementing a system to do just patient tracking, Santa Clara selected an ED information system that included built-in tracking as one of several core functions.

For Phase I of their initiative, the hospital implemented:

- A full triage system integrated with the hospital information system (HIS);
- A patient tracking system to capture and show the physical location of each patient; and
- A patient education module to allow caregivers to print out personalized instructions for home care.

After these functions were put in place and incorporated into routine processes, the hospital began Phase II, first implementing nurse documentation and then implementing physician documentation. In Phase III, modules were added to supported lab ordering, radiology,

medication ordering, and reporting. Later, they added admissions tracking.

Today, as patients enter the ED and are moved about within the department, changes in their status are updated by nurses and physicians using the electronic tracking system. For instance, when a patient is taken to the radiology department for an x-ray, the last known location for the patient is updated. Computer screens show nurses and physicians where patients are, what services they are waiting for, and how long they have been waiting.

The hospital also implemented registration tracking early on and financial tracking more recently. With tracking, nurses can start the patient's record while the patient is still en route to the hospital (as soon as the ambulance calls ahead) and then hand off the record later without the recipient having to re-enter the data. Past information, such as allergies, can also be pulled up, and fields can be prepopulated if the patient has been treated at the hospital before. With financial tracking enabled, the hospital can set up a visit with a financial counselor while the patient or family is still onsite.

### Results

Approximately nine years since the long series of improvements began, the ED now handles over 140,000 patients per year, with volume on some days exceeding 400 patients. About 100 to 150 patients per day go through the main ED. Another 75 patients per day are seen in a special evaluation area, and an additional 160 patients per day are seen by the Express Care clinic. Overall, this represents more than a doubling of total patient volume despite an expansion of physical capacity of only 30 percent. At the start of the transformation, the average length of ED stay was 8 to 10 hours. Today, it is 3 to 4 hours. Likewise, the number of ambulances the ED can handle has increased. Today it can handle 40 ambulances per day, in addition to walk-ins and patients who arrive by helicopter.

This increase in throughput would not have been possible without the gains from patient tracking. Improved bed placement puts patients in the right bed on the first attempt. Instead of making a blind call, submitting a written request, or faxing, nurses can initiate an admission and see immediately when it is accepted. The requesting physician can send information on diagnosis, precautions, step-down criteria (for ICU patients), admit condition, and more, and the recipients can respond more quickly because they do not have to re-enter the data. Today, the hospital sees 30 to 40 admissions per day from the ED, higher than ever before.

Likewise, the automation of many data-intensive tasks provides a substantial benefit to the hospital. For instance, having an ED, they need to produce a log for the Title 22 requirement. Prior to the patient tracking system, staff compiled these logs by hand. Now they are generated automatically. Prescriptions and medication reconciliation summaries are also now generated by the system rather than written manually. Information on a patient's visit and status can be auto-faxed to the patient's primary care physician (PCP). Even work excuse letters can be generated automatically from information contained within the system.

Santa Clara also found that documenting and tracking patients electronically rather than by hand eliminated legibility issues in notes and orders. In one written testimonial about the ED system, a nurse at Santa Clara said that the system was very well accepted and that none of her colleagues "can stand the thought of documenting by hand again."

## 5. OPTIMIZING PATIENT PLACEMENT THROUGH INTELLIGENT TRANSFER TRACKING

BAPTIST HEALTH SOUTH FLORIDA (Doral, FL)

### Context and Objectives

Baptist Health is a five-hospital system near Miami. In 2009, the CEO launched an initiative to improve the way the organization transfers and admits patients to its facilities. The impetus came from the challenges faced by the on-call administrator dealing with transfer issues that occurred the previous week. It was determined that many of these less-than-optimal placements could be avoided if there were a way to share real-time patient information among staff.

The goal of the initiative, therefore, was to improve operational efficiency and quality of care by implementing a system to route patients intelligently. At the outset of the project, Baptist did not have a centralized ability to track its transfers, and administrators did not even know how many transfers there were in a typical month. They also had no way of knowing whether they were transferring patients in the most efficient manner.

### Solution

To address these issues, Baptist implemented a patient tracking system and set up a centralized "transfer center" staffed with two nurses, one EMT, and one supervisor. Now, instead of physicians calling other physicians ad hoc to arrange for patients to be moved, transfers between the five hospitals are managed by the transfer team using the tracking system.

The tracking system can be integrated with ADT and EMR so that information can flow directly to and from various hospitals' patient registration and bed management systems. Because the system communicates using standardized HL7 messages, the transfer center integrates seamlessly with the other hospitals, even though each hospital has its own bed board system.

The team also maintains detailed information on which doctors are on call, what their preferred method of communication is, and which facilities have spare capacity at any given time. With the aid of phone scripts, the team can solicit all of the important clinical information for each reported problem (e.g., chest pain, numbness) to build a complete admission record that is passed along electronically to the receiving hospital.

## Results

For Baptist, establishing a centralized function to handle admissions and transfers frees up staff to see more patients, improving overall throughput. Caregivers are no longer asked to make transfer and placement decisions without the proper information; the transfer center makes those decisions because it has the best view of the multiple hospitals and departments.

Prior to implementation, hospital administrators did not even have an accurate count of how many transfers took place each month. They estimated 200 to 300 transfers per month. After the system went live, they found they could do 700 per month. Administrators now get detailed reports on transfers, and they can run queries based on any combination of parameters (e.g., “How many maxillofacial surgeries are we transferring in and out, and to where?”).

Centralized patient tracking also means that expensive orders—such as ambulance requests, which cost a minimum of \$500 to \$600 each—can be better managed. There are fewer rejected arrivals now that information on ambulance diversion is centrally known, and trips and routes can be planned more efficiently.

One unexpected benefit reported by Baptist is that since all transfer-related phone calls are automatically recorded by the system, there are fewer “he said, she said” incidents with insurance companies. The system also enables them to track patients with nonparticipating insurance. Overall ROI numbers have not yet been calculated by Baptist,

but anecdotally they believe that their tracking system has made a large financial impact.

In addition to improving everyday operations, Baptist’s experience with centralized patient tracking and transfers has also helped their emergency preparedness and ability to meet surge demand. During the Haiti earthquake episode, the Baptist Health hospitals were getting calls about patients and requests for patient transfers “without any rhyme or reason where the calls were coming from.” The hospital routed those calls to the transfer center so the hospitals would not get overloaded and to minimize the dissemination of misinformation. Using the transfer center, patients were flown into local Air Force bases and then transferred intelligently to one of Baptist Health’s hospitals based on resource availability.

---

## ABOUT THE AUTHORS

Erica Drazen is the managing partner of Emerging Practices, the applied research arm of CSC, based in Falls Church, Virginia. Jared Rhoads is a senior research analyst in the Emerging Practices group.

## ABOUT THE FOUNDATION

The California HealthCare Foundation works as a catalyst to fulfill the promise of better health care for all Californians. We support ideas and innovations that improve quality, increase efficiency, and lower the costs of care. For more information, visit us online at [www.chcf.org](http://www.chcf.org).

## Appendix A: Case Summary Interviews

### Derek Berz

Assistant Administrator  
Providence Holy Cross Medical Center  
Mission Hills, CA

### Kay Buchwald

Clinical Systems Manager  
St. Vincent's Hospital  
Birmingham, AL

### Leslee Gross

Director of Transfer Center  
Baptist Health South Florida  
Doral, FL

### Tom Hamelin

Senior Vice President of Business Process Improvement,  
Awarepoint  
(Former Associate Administrator, UCSD)  
San Diego, CA

### Linda Jones

Vice President of Emergency, Trauma, and Aeromedical  
Services  
Christiana Care  
Newark, DE

### Scott Williams

Vice President of Operations  
Mercy Hospital  
Toledo, OH

### Diane York

ED Health Care Program Analyst  
Santa Clara Valley Medical Center  
Santa Clara, CA

## Appendix B: Representative Vendors in the Patient Tracking Domain

	CONTACT INFORMATION	VENDOR CATEGORY
<b>Allscripts</b> (formerly Eclipsys)	222 Merchandise Mart Plaza Suite 2024 Chicago, IL 60654 <a href="http://www.allscripts.com">www.allscripts.com</a>	Software
<b>Awarepoint</b>	600 W. Broadway Suite 250 San Diego, CA 92101 <a href="http://www.awarepoint.com">www.awarepoint.com</a>	RTLS
<b>CareLogistics</b> (formerly StatCom)	2655 Northwinds Parkway Alpharetta, GA 30009 <a href="http://www.carelogistics.com">www.carelogistics.com</a>	RTLS
<b>Central Logic</b>	10653 S. River Front Parkway Suite 150 South Jordan, UT 84095 <a href="http://www.centrallogic.com">www.centrallogic.com</a>	Software
<b>Cerner</b>	2800 Rockcreek Parkway North Kansas City, MO 64117 <a href="http://www.cerner.com">www.cerner.com</a>	Software
<b>Hill-Rom</b>	1069 State Route 46 East Batesville, IN 47006 <a href="http://www.hill-rom.com">www.hill-rom.com</a>	Software
<b>McKesson</b>	One Post Street San Francisco, CA 94104 <a href="http://www.mckesson.com">www.mckesson.com</a>	Software
<b>MEDHOST</b>	5055 Keller Springs Road Suite 400 Addison, TX 75001 <a href="http://www.medhost.com">www.medhost.com</a>	Software (ED)
<b>NovaSim</b>	P.O. Box 30278 Bellingham, WA 98228 <a href="http://www.novasim.com">www.novasim.com</a>	Simulation
<b>PatientTrak</b>	<a href="http://www.patienttrak.net">www.patienttrak.net</a>	Software
<b>Patient Care Technology Systems</b>	11325 North Community House Road Suite 500 Charlotte, NC 28277 <a href="http://www.pcts.com">www.pcts.com</a>	Software
<b>Patient Focus Systems</b>	P.O. Box 7082 Ann Arbor, MI 48107 <a href="http://www.patientfocussystems.com">www.patientfocussystems.com</a>	Software
<b>Versus</b>	2600 Miller Creek Road Traverse City, MI 49684 <a href="http://www.versustech.com">www.versustech.com</a>	RTLS
<b>WellSoft</b>	27 Worlds Fair Drive Somerset, NJ 08873 <a href="http://www.wellsoft.com">www.wellsoft.com</a>	Software (ED)

---

## ENDNOTES

1. Chartis Group. *Patient Throughput: A Critical Strategy for Success*. Fall 2007.
2. Bryan, Barbara. October 2009. "Keep 'em Moving: Nine ES Strategies to Help Improve Patient Flow." *Health Facilities Management* 22 (10); 35–37.
3. Bolch, Matt. "Finance: Pinching Pennies." *Health Executive*. April 1, 2008.
4. Bacheldor, Beth. "UCSD Medical Center Expands its RFID Deployment." *RFID Journal*. October 29, 2008 ([www.rfidjournal.com](http://www.rfidjournal.com)).
5. Zimmerman, Tim and Ken Dulaney. *When You Need to Know Where Everything Is: Assessing In-Building WLAN Location Technologies*. Gartner. August 20, 2009.
6. Swedberg, Claire. "Trident Health System Boosts Patient Throughput, Asset Utilization." *RFID Journal*. April 21, 2010 ([www.rfidjournal.com](http://www.rfidjournal.com)).
7. Institute for Healthcare Improvement. *Transforming Care at the Bedside*. Cambridge, MA: 2004 ([www.ihl.org](http://www.ihl.org)).
8. Bacheldor, Beth. "Philly Hospital Uses RTLS to Track Patient Flow, Care, and Training." *RFID Journal*. May 29, 2009 ([www.rfidjournal.com/article/view/4934](http://www.rfidjournal.com/article/view/4934)).
9. Ibid.
10. Ibid.
11. Bryan, Barbara. October 2009. "Keep 'em Moving: Nine ES Strategies to Help Improve Patient Flow." *Health Facilities Management* 22 (10); 35–37.
12. Wilson, Marcia J., Bruce Siegel, and Mike Williams. *Perfecting Patient Flow: America's Safety Net Hospitals and Emergency Department Crowding*. National Association of Public Hospitals and Health Systems. Washington, DC: May 2005.
13. American Hospital Association. *ED Improvements Led by Team*. 2009.
14. American Hospital Association. *Improving Patient Flow in the ED*. 2009.
15. American Hospital Association. *Ongoing Transformation in the ED*. 2009.
16. Lewis, Holly S. March 2000. "Understanding Patient Flow." *Decision Line* 31 (2); 8–10 ([www.decisionsciences.org](http://www.decisionsciences.org)).
17. "Rapid Adoption of RFID in Healthcare." *IDTechEx*. Cambridge, MA: May 8, 2006 ([www.idtechex.com](http://www.idtechex.com)).
18. American Hospital Association. *Results and Report of the 2009 Patient Flow Challenges Assessment*. Spring 2009.
19. KLAS Research. *Much Education Still Needed before RFID and Other Positioning Solutions Hit Healthcare Mainstream*. Orem, UT: February 17, 2009.
20. American Hospital Association. *Results and Report of the 2009 Patient Flow Challenges Assessment*. Spring 2009.
21. HIMSS Analytics. *RFID Patient Tracking Market Share Report (Custom Report by Product)*. July 2010.
22. Runyon, Barry et al. *Hype Cycle for Healthcare Provider Technologies and Standards, 2009*. Gartner. July 28, 2009 ([www.gartner.com/DisplayDocument?id=1098412](http://www.gartner.com/DisplayDocument?id=1098412)).
23. Agency for Healthcare Research and Quality. *Patients Admitted to Hospitals on a Weekend Wait for Major Procedures*. March 4, 2010 ([www.ahrq.gov](http://www.ahrq.gov)).
24. Dietrich, Damon. "Electronic Patient Tracking Systems: A Healthy IT Investment for Emergency Departments." *American Academy of Emergency Medicine* 16 (6); 16–18.
25. Conn, Joseph. "Docs Weigh In on Use of Scribes in Primary Care." *Modern Healthcare*. February 9, 2010 ([www.modernhealthcare.com](http://www.modernhealthcare.com)).
26. Institute for Healthcare Improvement. *Optimizing Patient Flow: Moving Patients Smoothly through Acute Care Settings*. Boston, MA: 2003.
27. American Hospital Association. *Ongoing Transformation in the ED*. 2009.
28. Institute for Healthcare Improvement. *Optimizing Patient Flow: Moving Patients Smoothly through Acute Care Settings*. Boston, MA: 2003.

29. Briggs, William T., Brian Selig, and Suzanne Stone-Griffith. "ED Crowding: What Works." *Health Facilities Management*. July 1, 2009.
30. Institute for Healthcare Improvement. *Optimizing Patient Flow: Moving Patients Smoothly through Acute Care Settings*. Boston, MA: 2003.
31. Ibid.
32. Dietrich, Damon. "Electronic Patient Tracking Systems: A Healthy IT Investment for Emergency Departments." *American Academy of Emergency Medicine* 16 (6); 16–18.
33. Chartis Group. *Patient Throughput: A Critical Strategy for Success*. Fall 2007.
34. Conn, Joseph. "Discharge Planning Systems Improve Operations." *Modern Healthcare*. April 10, 2007 ([www.modernhealthcare.com](http://www.modernhealthcare.com)).
35. Kloehn, Patricia. "Demystifying Patient Throughput to Optimize Revenue and Patient Satisfaction." Zimmerman. Hales Corner, WI: 2004.
36. Runyon, Barry et al. *Hype Cycle for Healthcare Provider Technologies and Standards, 2009*. Gartner. July 28, 2009 ([www.gartner.com](http://www.gartner.com)).
37. Roberson, David A. "Patients First: A Team Approach to Improving Throughput." *Health Facilities Management*. February 15, 2008.
38. American Hospital Association Quality Center. *Patient Throughput*. 2009.
39. "Understanding the Benefits of Active RFID for Asset Tracking" *Hi-Tech Security Solutions*. August 2008 ([www.securitysa.com](http://www.securitysa.com)).
40. University of Utah Hospitals and Clinics and TeleTracking Technologies. *A Discussion on Automating Patient Flow*. March 11, 2009 ([www.modernhealthcare.com](http://www.modernhealthcare.com)).