WIRELESS AUTOMATIC TRACKING IN A HIGH VOLUME EMERGENCY DEPARTMENT

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ABSTRACT

Increasing patient volumes have challenged emergency departments’ ability to deliver care efficiently and to be prepared for mass-casualty events. New automation technologies offer the potential to increase capacity by wirelessly tracking all patient movement and their interactions with staff and mobile medical equipment. Ranked among the top 25 busiest EDs in the nation, Christiana Care Health System redesigned existing workflows and overcame staff concerns of Big Brother to integrate an automatic patient tracking system at Christiana Hospital. The automatic tracking system involved assigning infrared badges to patients and staff, and installing infrared readers throughout the ED to track patient movement and staff interactions. Dedicated software collects the information sent from the badges and displays on a department map. Care milestones are interpreted based on the interactions between patients, staff and mobile medical equipment, time-stamped and displayed to caregivers. Granular patient flow data is continuously collected to facilitate retrospective analysis of department throughput.

Since implementing automatic tracking, functional capacity and service efficiency has been maximized. Patient location is now accurately identified 100% of the time. Patient length of stay was reduced by 20 minutes for discharged and admitted patients. A 24% decrease in patients leaving without treatment was achieved and ED diversions have also been reduced. Other significant results included improved staff satisfaction related to the knowledge of patient location, diagnostic results availability and ED room status. Nursing staff vacancies are at zero percent. The department has an enhanced state of preparedness for emergency situations through the capabilities of the automatic tracking software to quickly sort patient by acuity in mass casualty events as well as generate a staff encounter summary for interactions with contamination/infectious agents.

Christiana Hospital

Christiana Hospital, part of the Christiana Care Health System, is a 780-bed suburban teaching hospital located in Newark, Delaware with multiple residency programs, including emergency medicine and surgery. It is an American College of Surgeon’s-verified Level 1 adult and pediatric trauma center. At the time of automatic tracking implementation, the emergency department treated 92,000 patients. Today, census has risen to 97,000 visits.

There are 76 total treatment areas in the ED categorized into 5 main “core areas” and a 6-bed fast track. The core areas are subdivided by functionality which is primarily based upon patient acuity. For example, one core is dedicated to patients with high acuity needs such as trauma patients and those needing ICU or step-down level care. Another core is used for general ED patients who require medical/surgical admission or for those who can be treated and released. There is also a 4-bed pediatric area in this core. An observation core is used for patients awaiting a disposition decision from the ED or availability of an inpatient bed.

In 2001, the American College of Emergency Physicians ranked Christiana Care Health System #21 in the top 25 ED’s in the US for patient volume.
Baseline State Prior to Automatic Tracking

When we implemented automatic tracking in 2004, we were well into an ED expansion project that ultimately would add 17 additional ED rooms by October of 2005. Staffing was available for about 55 treatment bays. Because the ED was so spread out in the 5 core areas, tracking the location of patients manually was very difficult. A casualty of the construction project was the loss of our electronic system at triage that indicated room availability via a button in the patient room that turned a light green or red on a panel at triage. A very basic light box was used in its place with switches activated by the triage nurse to track occupied rooms. It gave no indication of which patient was in the room, the acuity, or whether or not the patient was admitted. If communication with the cores broke down and a room emptied without triage knowing about it, efficiency suffered. Thus, overall ED LOS was above norms at 4-6 hours and frustrated patients left without treatment at a rate of 4%-5% of our total ED census.

A significant patient care issue that we faced was the challenge of identifying which staff cared for certain individuals. Staff exposure to infectious and even chemical agents must be carefully tracked for effective employee safety, illness and injury prevention. The only method at our disposal was to review the clinical record for the names of providers who documented on it and then interview those staff members to determine who else may have been present based upon their recollections. Similarly, identifying which employees cared for a patient who offered either compliments or complaints proved difficult and was a barrier to the service excellence and performance improvement process.

Another frustrating issue was our inability to efficiently track whether or not the results of diagnostic studies were available—a key factor in making disposition decisions and reducing LOS. Elaborate plans were devised involving checklists on the ED record that indicated which studies were back as opposed to which were still pending. In addition, keeping patients informed about delays, a key aspect of our patient satisfaction initiative, was often neglected due to the onerous task of collecting this information.

Manual versus Automatic Tracking?

Along with the light board at triage to show room availability status, we used an electronic but manual patient tracking methodology via our HIS system to track patient room location. ED clerical staff entered the current location of the patient when they were given a patient sticky label with a corresponding room number written on it. Problems accurately locating patients occurred when patients left their original room to go for diagnostic testing or even moved to a different room location within the department. With the volume and acuity of the patients we saw on a daily basis, clerical staff could not keep up with the patient movement within the various core areas. The end result was that the room location noted in our HIS system was only correct 70%-80% of the time when audited.
Again, we tried elaborate manual systems to track the movement of patients such as the construction of acrylic boards with pockets for patient sticky labels representing patient rooms and diagnostic testing areas but we did not achieve sustainable improvements in accuracy.

Finally, the physician department chairman and I came to the same conclusion— an automatic method of patient tracking, where caregivers do not have to manually update location and care progression information, was the only solution we’d pursue for a total system redesign.

After diligently investigating various ED-based patient tracking systems, we decided to purchase Amelior EDTracker® - automatic patient and asset tracking software from Patient Care Technology Systems in conjunction with an infrared sensory network and hardware from Versus Technology Inc. because it was automatic and had a successful track record in the other EDs we site-visited. The software seemed quite intuitive and met our overall business requirements for a work flow redesign which included knowing patient acuity and real-time location, elapsed wait times for various care intervals, who came into contact with the patient and for how long, the status of lab and radiology results, and enhanced communication with other departments such as Bed Board and Patient Escort.

We realized that simply overlying the new system on top of the incumbent, dysfunctional processes would not yield our anticipated results. Thus, a fresh business design needed to be developed that would fully incorporate the capabilities of the new software and hardware. We also recognized that infrared tracking had its technology limitations. However, at the time of this system change, radio frequency identification locating systems (RFID) had not developed applications where it could be utilized clinically. The decision was made to implement the infrared system immediately and then upgrade to RFID when it was operationally feasible to do so in our institution.

**Automatic Tracking System Profile**

Patient and staff badges as well as the infrared sensors that are installed in the ceiling throughout the ED and radiology areas constitute the triad of devices that enable automatic tracking. Whenever patients and staff who are wearing badges come together under a sensor, the interaction is captured and logged. A map view of the ED reveals patient location and acuity. Multiple real-time status views of individual areas of the department (e.g. triage, not in ED, in the ED) provide more detailed data regarding the patient’s process of care, including the status of lab and radiology results as well as the staff members who have been automatically assigned as care providers. Having this information instantly available drives workflow efficiencies and allows leadership staff to better organize the allocation of resources.
Patients and staff wear the same type of infrared badges with two main differences: 1) the patient badge has an antitheft device that will cause activation of an alarm if the patient attempts to leave the area through security sensors that are strategically placed at key locations within the confines of the ED; and 2) we place a circular plastic backing on the patient’s badge holder to keep the badge in an upright position. A badge that is upside down will not track properly and will cause inaccuracies in the system. The circular backing also makes the badge readily visible to staff as a means of preventing badge loss.

The staff badge does not have the antitheft device or the plastic backing. Staff are taught to wear it so that remains in an upright position. Our plan is to upgrade our system to implement RFID tracking within the fiscal year. With RFID technology, the orientation of the badge will not be as much of an issue as with the current infrared system.

All staff are required to wear their badges. The badge is considered to be part of the staff uniform and essential to work functions in the ED.

This is the map view designed for the Christiana Hospital emergency department in the automatic tracking software. The icons representing patients show that the rooms that are occupied; the color of the “patient” clothing reveals triage acuity. The bed icon shows that a patient has been admitted. A moon and stars icon indicates that a room is in “down-time”. The red circle with an “X” in the middle designates an area that is closed or out of service. In this particular picture, “Core E” was under construction and was not yet in service as a patient treatment area. There are a variety of other icons in the system which represent actions such as room cleaning, patient discharge, maintenance work and even a room reservation for an incoming patient.
The map view is especially helpful to triage nurses in making rapid decisions regarding where to place patients. It even helps them avoid placing too many high acuity patients in the same general location to avoid overwhelming the nurse assigned to that area whenever possible.

The real-time status view displays more patient-specific information such as the chief complaint, age, caregivers automatically assigned, the status of laboratory and radiology results, the elapsed time since entering the ED and any alerts that have either come across the HIS interface, been generated by the system based upon pre-programmed rules, or have been added manually by staff. Alerts that come across the HIS interface automatically include an animated isolation icon if the patient has tested positive for MRSA or VRE in the past, and a flag or alarm icon which indicates the patient has had previous ED visits. Staff can also add an alert to designate a patient as “confidential” when necessary.

This view allows staff with the required systems permissions to post a patient for admission and request a bed, request a patient transporter to assist with a transfer, change room status, add comments, view a patient visit summary, search for a previous visit and display the location of assets that are tagged for tracking.

Leadership staff with higher level system permissions can also access a staff interaction summary and generate administrative reports. Figure 3 represents an example of the real-time status view. Names of patients and staff are fictitious and are used for illustration purposes only.
Project Scope

The scope of the project encompassed ED patients and all ED personnel who had direct contact with patients, including physicians, nurses, clerks, patient care technicians and radiologic technologists. Interfaces were built with the HIS registration system as well as with the laboratory and radiology information systems to enable displaying the status of results.

Staff from Admitting, the Bed Board and Patient Escort were also involved in project design from the inception of the initiative to improve communication and improve interdepartmental work flow processes. The vendor developed a customized transport cue based upon our special request since the admission process and the need for transporters were so closely linked in our institution.

Implementation

Implementation was broken down into three distinct activities: 1) building an infrastructure with the sensors, concentrators and network connections; 2) hardware and software installation with database, server and interface designs and builds; and 3) the business process analysis. The first two activities are typical of all IT implementation processes. Prior to the automatic tracking implementation at Christiana Care, these steps represented the typical
project end points with the expectation that the IT initiative would function as anticipated and resolve whatever system issues generated the need for the technology in the first place.

A radically different approach was instituted with the automatic tracking implementation at Christiana Care. Through a collaborative effort with our IT department and vendor, the business process analysis which mapped the current state process flow and then the future state flow with integration of the technology, became of equal importance in the overall project plan.

The current state process flow analysis maps out every activity in a department and within the institution that may be impacted by the new technology. Key stakeholders are identified from each work group that will have a defined role in the process change and then are invited to participate in the analysis sessions. This step was very time consuming in that all steps in the process of ED care delivery and patient flow in the current system had to be diagramed and studied. It was essential to involve front line staff at this juncture so that all of the workarounds and informal, undocumented processes could be identified and either formally integrated into the final business plan with technology integration, revised or eliminated.

ED care was categorized under three separate headings: intake (triage and initial assessment), care management (diagnostic and intervention activities) and disposition (discharge or hospital admission). At the end of this exercise, realistic scenarios were created to depict all processes involved in patient care to test whether or not the process maps were comprehensive and inclusive of the situations staff could encounter on a daily basis.

The future state planning session considers the current state process flow but recognizes the capabilities of the technology and revises processes as necessary. This phase is also very time consuming and requires the participation of not only front-line staff but high-level project decision makers who can drive system change when necessary.

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<th>Business Process Scope</th>
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<td>Patient Location known</td>
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<td>Accurate 100% of time</td>
<td>10 – 15 hrs/mth</td>
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Figure 4. Business Process Planning
As a means to gain focus, it is helpful to decide upon the key outcomes of the project at the outset. Once everyone has an image that represents what success looks like, the real work of mapping a new system can begin. It is at this point that conflict can erupt when personnel are wedded to a particular process or activity that ultimately must be reconfigured for the technology to function in the desired way. Change is difficult to accept for many people. Control issues arise and must be successfully negotiated to achieve the full buy-in of the system users without alienating any individual or group in the process. There are no short-cuts to this phase of the project. Unresolved issues can sabotage the overall success of the endeavor. Trained mediators may need to be employed if an impasse arises.

Once the new process flow has been outlined integrating the new technology, a conference room pilot should be performed using the realistic scenarios on paper with front-line staff from the various departments that will be impacted to test future state assumptions before the project is fully implemented. The conference room pilot helps to determine whether or not the system will work as it is expected to. Potential roadblocks can be uncovered and addressed. Aspects of the project that were previously unrecognized can also be factored into the final plan.

As a final step, the actual system should be activated in a test environment so that user acceptance testing can be performed by front-line staff to mitigate any problems before “go-live”.

Project Timeline

This project was funded in part by federal bioterrorism grant money that was allocated to the State of Delaware’s Public Health Department. Automatic tracking of patients and staff met criteria for funding in that it enhanced emergency preparedness by providing a rapid view of room availability, the location of patients and the overall acuity of patients in the ED – information helpful when making decisions about the number and severity of patients that can be accepted in a multi-casualty incident. The system also allowed us to track the interactions of patients with staff. This information allows us to notify staff who have been in contact with a potentially infected or contaminated patient so that appropriate prophylaxis and follow-up can be initiated.

Once the grant was secured, the project was presented to the Information Management Planning Committee of our health system and then achieved final executive approval and IT resource allocation. A formal project plan was devised and a steering committee of high-level decision makers appointed. The current state and future state business process planning sessions as well as the conference room pilot required two months to accomplish.

After the hardware and software installations were completed, hands-on system training using computers in an on-site education center began. The training ran over a full month to accommodate the various schedule needs of the interdisciplinary personnel and was deemed “mandatory” for all ED staff by both physician and nurse leaders in the department. Automatic tracking “super users” were identified and educated first. They assisted in providing the training to all 205 nurse, clerical and technical staff as well as approximately 120 attending physicians, emergency
medicine residents and physician assistants. Following the ED training, ancillary departments such as Admitting, Bed Board, Radiology and Patient Escort were educated on aspects of the system pertinent to their needs. It is important to note that the training did not simply involve how to use the tracking software; it also thoroughly detailed the myriad of ED operational and system changes that would go-live the moment the tracking system was activated. Staff had opportunity to voice their concerns and have their questions answered in detail. In this regard, these training sessions also served the purpose of resolving potential conflicts, defusing emotions about the changes that would occur, and assuring that the business process design addressed all of the issues generated by these discussions.

The system went live as planned on November 9, 2004, the date set at the project’s inception. Both vendor representatives as well as our IT project team members were available to support staff around the clock for the first week. The system performed as expected, but on the third day, it had to be taken down for about an hour for work on a hardware problem. Interestingly, though staff had only used the system for 3 days, going back to the old way of doing things was no longer acceptable to them. The automatic tracking system was then deemed a “critical system” to ED operations. From the moment of go-live, staff fully embraced the operational changes without backsliding into previous work flows. This success stemmed not only from the ease of use of the tracking system, but also from the commitment to training of all staff prior to implementation.

One month after go-live, a “lessons learned” session was held between the ED staff and the IT project management staff. This effort was especially helpful to planning the subsequent installation of the system in the Wilmington ED in 2006. One important lesson was the realization that any adjustments to the tracking system that would involve changes in the defined business process had to be accomplished in a safe “testing mode”, much like the conference room pilot. Then, when these adjustments were found to be safe and did not cause any unanticipated consequences, staff could be formally educated about the resulting process change in staff meetings, department meetings, and by e-mail if the change was minor.

**Key Outcome Measures**

Implementing an automatic ED tracking system requires a substantial investment in both financial and human resources. The natural question is what kind of return on investment (ROI) can be anticipated?

When we contemplated the key outcome measures we would employ to assess the impact of automatic tracking, we first considered the outcome data we already had available to us that would provide a measure of our baseline performance as a basis for comparison. These data constitute basic measures of ED operational efficiency as well as patient and staff satisfaction.

We expected ED length of stay (LOS) for both *treated and released* and *treated and admitted* patients to decrease. We also expected that the percentage of patients who left without treatment and the ED diversion rates would...
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With these improvements in ED operations, we anticipated that patient and staff satisfaction would increase as well.

Implementation Results

Data collection ensued between November 2004 and June 2005 to assess the impact of automatic tracking. Data continues to be collected on an ongoing basis, however data derived after June 2005 were excluded from this analysis because of two key system changes that significantly impacted ED performance metrics: the initiation of “team triage” in July, 2005, and the opening of 17 additional ED treatment rooms in October, 2005, following a major construction project. Team triage partners an EM physician with an ED RN and technician to rapidly evaluate and initiate treatment on ED patients who are in the waiting room, hallway or still in the triage area. It helps to reduce door-to-doctor time and reduces LOS during peak volume periods.

The initiation of automatic tracking has eliminated the operational risk of “lost” patients. Overall ED length of stay (LOS) decreased despite a continued census increase of greater than 7%. The most significant LOS reduction was for admitted patients due to improved communication with Bed Board personnel. Overall ED LOS for admitted patients, as measured from triage to exit ED, decreased by an average of 36 minutes. Overall ED LOS for treated & released patients, as measured from triage to exit ED, decreased by an average of 14 minutes. The other key outcome was the 24% decrease in patients who left without treatment – presumably due to shortened wait times and improved efficiency.

We also measured a statistically significant improvement in patient satisfaction scores related to overall ED patient satisfaction and key wait time intervals as well as patient perception of how well they were being kept informed. Equally important, staff satisfaction improved with respect to knowledge of patient location, diagnostic results.

Figure 5. Median Composite Visit, Admitted Patient, Pre-Implementation vs March and June 2005

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availability and ED room status. Staff safety is enhanced through the staff encounter summary for contamination and infectious agents. Overall, the implementation of automatic tracking has contributed to strong staff retention performance.

From a department management perspective, we have enhanced intra-department communications namely with Bed Board, Admitting, Patient Escort and Radiology departments. Our ability to know real-time acuity levels and resource demand increased our overall emergency preparedness.

**Lessons Learned**

The introduction of the automatic tracking requires a commitment from the staff to wear the tracking badge to be successful. Department management must establish human resource policies to reinforce this behavior. Involving frontline staff early in the planning process helped with acceptance and resulted in some positive internal marketing of the technology. It was important for staff to understand that management was not looking for automatic tracking to become a “Big Brother” tool to monitor the movement of staff. For this reason, we do not track staff outside of care giving areas such as break rooms and staff lounges. It is also important to include physicians in the education process by communicating the workflow benefits that the real-time communication of patient care milestones provides. Patient acceptance should be addressed from the perspectives of service quality (e.g., reduced LOS) and patient safety.

Department management and hospital administration must also be coached not to micro-manage their emergency department because of the granular, real-time data on department utilization that is now accessible through the tracking software. Any recommended system changes must be based on validated trends along with knowledge of the operational issues and barriers that personnel confront in real world of providing emergency care.

Badge loss can dilute the return on investment from an automatic tracking system and requires pre-planning strategies to minimize the number of badges that will be lost. In our system the most common causes of badge loss are clipping the badge to the bed linen instead of the patient and risking the badge being thrown down the linen chute, and allowing the patient to leave the ED with the badge still attached. With that said, some patients refuse to return their badge and believe that protected health information is somehow embedded there. Despite thorough explanations to the contrary, we have found that a small subset of patients will still refuse to give up the badge at the end of the visit. Strategies to minimize badge loss which have been effective include patient educational brochures describing the purpose of the tracking system, posting the monthly badge loss numbers to increase staff awareness, the activation of alarms by security sensors installed at designated ED entrances and exits, and the placement of a larger plastic backing behind the badge to make it clearly visible to both staff and patients. These methods have kept badge attrition levels down. Departments need to devise their own work flow strategies to remove badges from patients at discharge and admission.
Path Forward

It has now been over two years since we introduced automatic tracking to our emergency department. As our census is now approaching 100,000 patient visits, we have succeeded in orchestrating patient flow effectively. In the spring of 2006, we implemented the same system with an infrared sensory network at our Wilmington Hospital emergency department which treats 47,000 patient visits annually. Currently we are designing ED performance improvement initiatives and research using the data captured by the automatic tracking system. Functional enhancements to the system that we are pursuing include an interface to allow the viewing of laboratory and radiology results, not just the “results availability” status, as well as a discharge instructions component. We will interface the system with our bed management software to further expedite the process of admitting patients. We also plan to develop a real-time ED dashboard to help us make upstream adjustments in resource utilization to avoid significant downstream bottlenecks.

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Linda Laskowski-Jones is the Vice President of Emergency, Trauma & Aeromedical Services at Christiana Care Health System in Delaware. Ms Jones serves as a supplemental faculty member at the University of Delaware College of Nursing where she received her Bachelors and Masters degrees in nursing. Ms. Jones is a highly published author and frequent speaker on emergency departments and trauma systems. She completed an Executive Fellowship with the Advisory Board Company in Washington, D.C. She is on the editorial board for the Journal of Emergency Nursing, and is a clinical advisor to a provider of automatic tracking software.