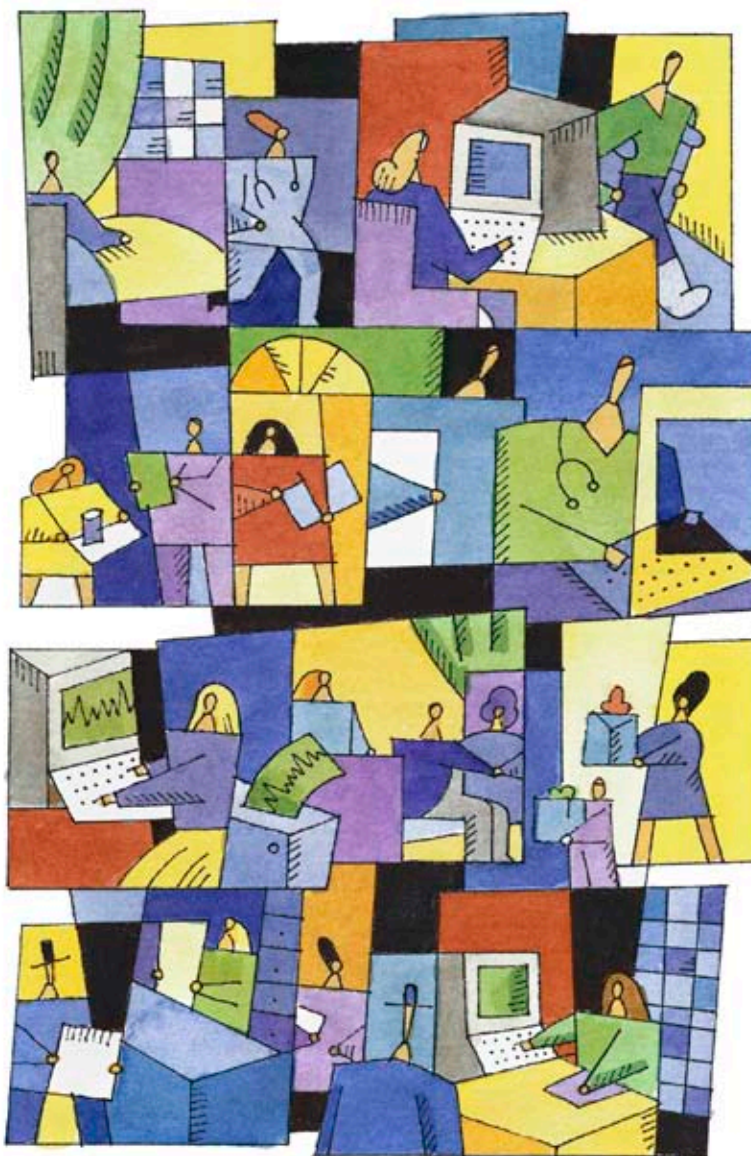




CALIFORNIA
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Equipped for Efficiency: Improving Nursing Care Through Technology

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by

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About the Foundation

The **California HealthCare Foundation** is an independent philanthropy committed to improving the way health care is delivered and financed in California. By promoting innovations in care and broader access to information, our goal is to ensure that all Californians can get the care they need, when they need it, at a price they can afford. For more information on CHCF, visit us online at www.chcf.org.

Contents

2	I. Introduction	
3	II. Overview	How Technology Can Help
5	III. Technologies That Enhance Nursing Care Delivery	Wireless Communications Real-Time Location Systems Delivery Robots Electronic Clinical Documentation Interactive Patient Technologies
24	IV. Summary	
25	Appendices:	A: Interviewees B: Vendors
28	Endnotes	

I. Introduction

NEW TECHNOLOGIES HAVE THE POTENTIAL TO CREATE a better work environment for inpatient nurses by improving the efficiency, safety, and quality of care. Advances include wireless communications, real-time location systems, delivery robots, workflow management systems, wireless patient monitoring, electronic medication administration with bar coding, electronic clinical documentation, and interactive patient systems. When linked with these technologies, alarm/event messaging and biomedical device integration add significant value to the way nurses coordinate and provide care. Because nurses work at the center of a complex web of care delivery, their use of proven technological solutions can have a dramatic impact on hospital operations.

This report, based on interviews with nurses and other professionals, describes the challenges that nurses face in everyday practice and how innovative hospitals around the country are applying eight leading-edge applications to overcome them. The results indicate that these systems have helped to create a better work environment for inpatient nurses and raise their job satisfaction, while also contributing to improvements in care. All of the hospitals that shared their experience are planning further enhancements or more widespread use of the technologies they have implemented to date.

II. Overview

NURSES PREFER TO WORK IN HOSPITALS WHERE PATIENT safety, quality of care, and nursing satisfaction are top priorities for hospital executives. Surveys over the years have cited common themes for high levels of job satisfaction among nurses: control and influence over their workday, workload, and workflows that enable them to be productive and efficient; an ability to deliver high-quality care and do their best for patients; and collaboration with fellow care providers in making decisions.^{1,2} Nurses' high job satisfaction also influences patient satisfaction. In one study, nursing care was the primary factor in how patients viewed their hospital stay. The more satisfied patients were with their nurses, the more satisfied they were with their stay.³

This report explores how technology can play a key role in creating such an environment. The focus is on emerging applications that are in early use, have demonstrated their value, and represent leading-edge technologies with great potential, as well as some already in the mainstream. For each technology, the authors interviewed nurses and others (see Appendix A) to learn how it enables them to do their work better and about the value it brings to them and patients.

Appendix B lists representative vendors and products, as well as contact information.

How Technology Can Help

Inpatient care is provided by a team of professionals and support staff that rarely meets as a group but is in constant communication. Each team member is dealing with multiple patients and care management tasks, with many information transfers and patient hand-offs that must be reliable and coordinated if care is to be effective, safe, and timely. Meanwhile, nurses and others are also responding to requests for information and assistance from patients, family members, physicians, and ancillary services. Indeed, the average nurse spends only about 31 percent of his or her time on direct patient care.⁴ The result is a web of workflow and communications prone to resource or decision bottlenecks, communication gaps, missed or delayed tasks, and inappropriate use of valuable resources. Nurses are at the center of this web and spend considerable time performing many different tasks.

Although difficult, unraveling the care process is necessary in order to identify specific workflow and efficiency issues. Hospitals that scrutinize this process can then incorporate technology to:

- Increase efficiency by removing nurses from the communication chain regarding tasks that do not require their attention, such as responding to a patient’s request for another blanket or walking to central supply to restock bandages;
- Improve patient safety and quality of care. Technology helps organize work and incorporate clinical knowledge and clinical decision support to provide guidance and feedback on medication administration, vital signs monitoring, and other patient care activities;
- Help deliver care by empowering patients and others to assume new delivery roles, thereby making nurses more efficient and effective. For example, patients at some hospitals use an interactive system to receive education about their medical condition or care received; and

- Improve collaboration and communication by routing and prioritizing messages and requests, as well as enabling immediate response to patients, caregivers, and staff. One example is wireless technology integrated with patient monitors that enable nurses to respond quickly to alarms.

Some of the eight technologies described in this report address multiple areas of improvement (Table 1).

The following sections also describe two additional solutions—alarm/event messaging and biomedical device integration—in greater detail, including the problems they help overcome and the benefits that particular hospitals have realized by implementing them.

Table 1. Selected Technologies and Improvement Areas

TECHNOLOGY	IMPROVEMENT AREAS			
	EFFICIENCY	SAFETY AND QUALITY	CARE DELIVERY ASSISTANCE	COLLABORATION/ COMMUNICATION
Wireless communication solutions (including alarm/event messaging)	✓	✓		✓
Real-time location systems	✓	✓		
Delivery robots	✓		✓	
Workflow management systems	✓	✓		✓
Wireless patient monitoring solutions		✓		
Electronic medication administration with bar coding		✓		
Electronic clinical documentation with clinical decision support (includes biomedical device integration)	✓	✓		
Interactive patient systems	✓	✓	✓	✓

III. Technologies That Enhance Nursing Care Delivery

Wireless Communications

The Problem

For nurses, even the seemingly simple task of contacting a pharmacy, laboratory, or other hospital department to ask about the status of an order involves an average of four to eight steps that consume nearly three minutes, according to one study.⁵ Another calculated that it takes 58 minutes each day for individual nurses to walk to the nurses' station to answer the telephone.⁶ A major reason for the disjointed and inefficient workflow is that nurses must use multiple modes of communication—a unit desk phone, pager, and overhead pager—to get the job done. Some of these devices are in fixed locations, whereas nurses are highly mobile. Effective solutions must not only abet mobility, but also route a communication to the right person or team based on its urgency.

The Solution

Voice over Internet protocol (VoIP) technologies address these needs by tapping into the hospital's wireless local area network. There are two such devices: telephone handsets and wearable, light-weight badges that can be clipped to a pocket or lapel, or worn on a lanyard. Telephone handsets and badges have different features and capabilities (Table 2).

Table 2. Features and Capabilities of Telephone Handsets vs. Badges*

TELEPHONE HANDSETS	BADGES
Voice and data display capabilities <ul style="list-style-type: none">• Listen and respond (talk)• View and respond (data entry)	Hands-free voice capabilities <ul style="list-style-type: none">• Listen and respond (talk)
Pre-programmed keys and buttons for specific requests and actions	Speech-recognition call features (by name, title, role)
Call transfers, forwarding, holds; conferencing; broadcasts	Call transfers, conferencing, broadcasts
Ability to call outside of the hospital via a PBX connection and accept incoming calls	Ability to accept incoming calls via a PBX connection and ask for outbound calls

*This report does not address cell phones or Blackberries because they do not offer the full range of communication functionality. In addition, they raise security, financial, and technology integration issues.

Wireless communication technologies can be used for point-to-point communication or, with additional capabilities, to connect with other technologies. These extra capabilities have many different names: messaging or event-management middleware application, messaging integration solution, workflow communication solution, and event management solution. They are the “glue” linking people, data, and patient events. In general, there are three main capabilities:

- **Connectivity.** Sending and receiving information to or from a wide range of information technology applications, sensor devices, communication systems, and medical equipment;
- **Rules.** Using logic to tie events to responsible parties. The rules identify a particular caregiver and the particular wireless communication device he or she is carrying. They also assign a clinician to a room, patient, or medical equipment, and govern escalation up the chain of responsibility and back-up; and
- **Reporting.** Keeping a full audit trail of all events. This includes tools to monitor events and resources.

The Benefits

Basic Wireless

At Beaumont Hospital, a 1,061-bed tertiary facility in Royal Oak, Michigan, a close call involving a telemetry patient prompted a rethinking of the communications approach. Trained technologists constantly watch telemetry monitors centralized in a “war room,” and when an alarm sounds, they determine what action needs to be taken. Previously, the technologist used a pager to notify the assigned nurse. If the nurse did not respond within three minutes, the technologist paged the nurse again. Frequent alarm pages began to desensitize nurses.

After a team analyzed the close call, which involved an arrhythmia, it identified the need for hands-free, two-way communications between the technologist and nurses, and decided to implement wireless

badges. Now, when the technologist calls, the assigned nurse can accept or refuse the call—if, for example, he or she is attending to another urgent situation. Refused calls are automatically routed to the next nurse in the area or, if necessary, escalated up the chain of responsibility to the charge nurse, nurse manager, and so on. Once the two parties are connected, the telemetry technologist and nurse can discuss the arrhythmia alarm and the patient’s current rhythm status.

The impact on nursing response time to alarms has been dramatic, dropping from 9.5 minutes on average to 39 seconds, well under the goal of no more than three minutes set by the hospital. The communication loop is also closed 100 percent of the time, compared with the previous 35 percent rate with pagers. This means that whenever there is a true alarm, the technologist can immediately hand off critical information to the patient’s nurse.^{7,8}

Integrated with Telemetry and Nurse Call Application

At Children’s National Medical Center, a 283-bed facility in Washington, D.C., the construction of a new inpatient tower presented an opportunity to investigate fresh communication solutions. The layout of nursing units in the tower, which has only single-bed rooms, is such that nurses must cover a much larger area. Instead of a central nursing station, there are alcoves with workstations throughout the unit. Senior leaders realized that the facility needed technology to help coordinate communications, prioritize requests for nursing assistance, and minimize unnecessary walking to and from patient rooms. Additional goals were to better manage group emergency communications (such as code blue alarms), to triage calls from the patient rooms via the nurse call application, to support one-on-one communications between care providers and ancillary support, and to augment patient-monitoring alarm notifications.

Initially, a multidisciplinary team spent months reviewing each process and then redesigning it to

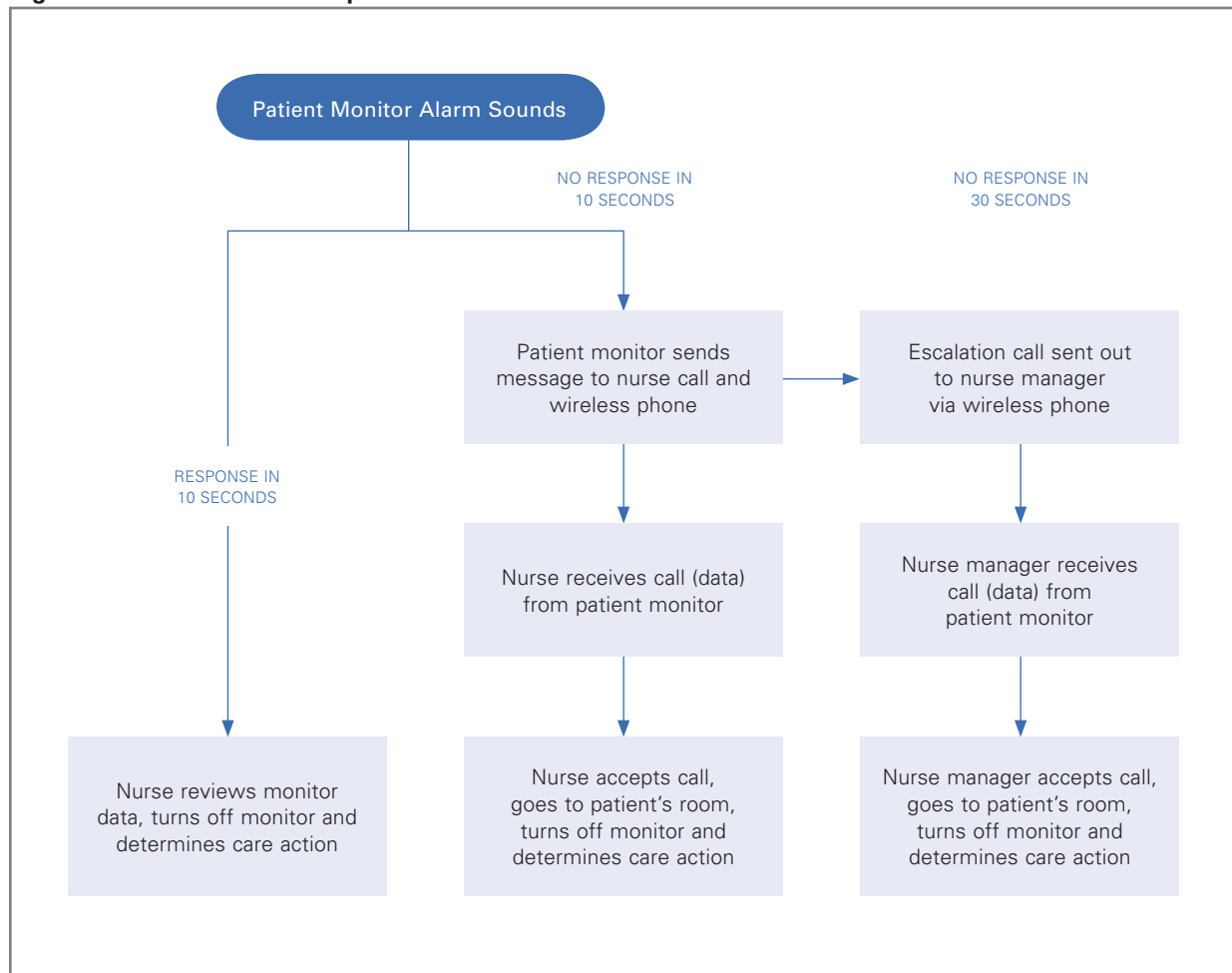
incorporate the new technology and modified work roles. Figure 1 illustrates the results for responses to a patient monitor alarm. For all processes, the team built in escalation and back-up resources to ensure that the communication loop would always be closed.

Improvements in response time were significant. The mean response time for alarms dropped from 3 minutes 10 seconds to 34 seconds. Responding to patient calls dropped from 4 minutes 45 seconds to 1 minute 22 seconds. In addition, nurses reported fewer interruptions, better continuity of care, and improved workflow.⁹

“This [wireless communication] solution is a decision-support tool. It gives us information to prioritize requests [which] allows us to be more efficient and more responsive to our patients.”

— LINDA TALLEY, R.N.
DIRECTOR OF NURSING SYSTEMS
CHILDREN’S NATIONAL MEDICAL CENTER

Figure 1. Patient Monitor Response Process at Children’s National Medical Center



Integrated with Multiple Alarm and Information Systems

One of the most comprehensive implementations of wireless communications is at Sampson Regional Medical Center, 146-bed facility in Clinton, N.C., where the wireless telephone handset solution is integrated with clinical applications, sensors, patient monitoring equipment, and the nurse call system. The project involved only wireless telephones when it started four years ago as part of a nursing unit renovation. However, the benefits quickly convinced management to integrate the telephones with other systems and technologies, and to make the set-up part of routine practice in many inpatient units.

Procedure for Responding to Panic Values in Lab Results

At Sampson, panic values in lab results—those that require immediate action—are sent to the hospitalist and the nurse assigned to the patient. Both must acknowledge receipt of the message. If they do not, the information is sent to the charge nurse, nurse supervisor, and then back to the lab. All notifications and escalations take place in less than five minutes.

In a number of studies, the hospital has identified benefits for nursing, ancillary services, support departments, the emergency department, and inpatient units. According to a management engineering analysis, 80 percent of nurses saved a minimum of 30 minutes each per shift. More surprising to the project team was the discovery, thanks to reports accumulated by the technology itself, that most requests did not require a nurse's attention. The ability to route those requests to unit secretaries has freed up nursing time even further and reduced interruptions.^{10,11}

Real-Time Location Systems

The Problem

As they deliver care, nurses need to coordinate patients' need with mobile equipment such as intravenous (IV) pumps and electrocardiogram monitors, as well as other care providers. In a busy inpatient setting, just locating the necessary equipment is a difficult task, especially when the facility is spread out or if the equipment is hidden or located on several floors. On average, nurses spend 30 minutes per shift tracking down equipment.¹² This inefficiency wastes hours of nursing time, ties up other resources, and delays the delivery of care.

Hoarding equipment and supplies is common. Stories abound of equipment stashed out of sight in linen closets and smaller items such as medical supplies hidden above suspended ceiling tiles. Hoarding is a short-term fix that exacerbates the problem, as fewer items are available from the proper channels when nurses request them. It also distorts inventory, impairing the efficient use of assets and leading to over-buying of frequently used supplies and equipment by as much as 50 percent.¹³

Equally frustrating for nurses is the time they spend locating a patient who might be in the lounge or in radiology for a procedure, or finding other staff members needed for patient care, patient transport, or support services.

The Solution

Hospitals can use a real-time location system (RTLS), also known as an indoor positioning system, to locate equipment, patients, and staff. Resources to be tracked are outfitted with small tags that communicate with transmitters and detectors located throughout the facility. Through the use of complex positioning algorithms and signal detection technologies, the system can locate a particular resource or type of resource and display the information online. For example, if a nurse needs an IV pump, he or she selects the pump from a list of tracked equipment and the system displays an online

map showing where the closest available pump is located. Some systems also have remotely activated flashing lights and buzzers—visual and audio cues that help find the resource. To restrict movement beyond a designated area, chokepoint devices at entryways and exits set off an alarm when the tagged resource crosses the boundary.

Several different types of technologies can provide real-time location tracking. The best-known is radio frequency identification (RFID). As the term suggests, RFID tags communicate with receivers through radio frequency signals. In hospital settings, the tags are usually powered by small onboard batteries that enable them to “announce” their presence to receivers and detectors installed throughout the facility. As long as a piece of equipment and its tag remain within range of the receivers, the RFID system can locate the item to within the level of accuracy of the specific technology, ranging from 1 foot (bed-level precision) to 150 feet (zone-level precision).

Other RTLS technologies include ultra-wideband radio frequency, infrared beams, and ultrasound acoustics. Ultra-wideband systems use short bursts of radio signals across a very broad frequency spectrum to achieve better precision than regular RFID. Infrared-based systems use tags that give off pulses of infrared light detected by sensors installed in the walls or ceiling, similar to the way a remote control device communicates with a television or stereo. Ultrasound systems use tags that produce a periodic “chirp” for identification. Detectors located in rooms and hallways pick up the chirps, which are inaudible to humans.

Each RTLS technology has advantages and disadvantages. For example, RFID tags can provide room-level accuracy, but their signals tend to permeate or “bleed” between rooms and floors. This can confuse the system as it tries to distinguish between information to use in the calculation and information to ignore.

Ultra-wideband systems, which operate on very low power output, are less likely to cause interference. However, the signals can still bleed, and the technology is newer to the market than others. Infrared signals do not bleed, but the tags must remain in the line of sight of sensors; they will not work if covered by a blanket, clothing, or any other opaque object.

Finally, ultrasound systems share many of the best capabilities of both radio frequency and infrared systems, but the short-range nature of sound compared to longer-range radio signals may require more detectors in a given area of coverage. To determine which technology is appropriate, the resources to be tracked and the necessary level of accuracy must be considered.

The Benefits

Equipment Location Tracking

Before the installation of RTLS at Brigham and Women’s Hospital in Boston, a 777-bed teaching affiliate of Harvard Medical School, nurses reported they spent a significant amount of time tracking down equipment and hoarding critical items, such as IV pumps, if they knew they would need them later. On some shifts, nurses could save time by sending a health care assistant to search for equipment, but this only passed the problem to another staff member. In addition, the hospital experienced inventory losses. To help prevent items from leaving the floor or hospital, staff were asked to send manual alarms to a generic alarm mailbox when they noticed that something was being removed. But because no one was responsible for tracking and monitoring equipment, oftentimes no one heeded the alarms.

To address these issues, managers decided to implement an RFID-based RTLS that targeted medical equipment for patient care—equipment that would be a pressure point for quality of care or patient flow. This definition encompassed cables, pacers, defibrillators, portable monitors, data acquisition modules, and IV pumps, but not beds or

wheelchairs. They also decided to install a separate wireless infrastructure to reduce the risk of signal interference.

Now, hospital staff can locate equipment automatically. Using a mobile telephone, nurses call either the unit secretary, who checks the RTLS system to find the nearest device of a particular type, or the biomedical department, which is now much more likely to have the device in stock and ready. Although the hospital has not completed a formal analysis of benefits, nurses anecdotally report better equipment availability and a significant improvement in quality of work life. Nurses are no longer hoarding equipment because they are more confident they can find what they need when they need it.

RTLS also helped the hospital reduce equipment losses by automating the alerts triggered when tagged items are moved outside of defined areas. Based on the results of an initial pilot project, the hospital expects to lose 50 percent fewer pacemakers per year and no transmitters, defibrillators, or monitors, for total annual savings of more than \$300,000.

This success resulted not only from implementing new technology, but also from redesigning roles and responsibilities for equipment tracking. Unit secretaries are responsible for locating and tracking equipment. They have the time for this task because, thanks to the implementation of advanced clinical systems, they no longer need to transcribe orders. And because they coordinate equipment transfers, they also know whether or not equipment should be leaving an area.

Patient and Staff Location Tracking

RFID tags worn by hospital staff and patients enable a facility to pinpoint their location and analyze workflows, make staff members more accessible, and improve staff and patient safety. At Hospital St. Louis, a 297-bed facility in Ettelbrück, Luxembourg, nurses as well as psychiatry and neurology patients suffering from dementia receive wristbands outfitted with RFID tags as a safety measure. Before, nurses had to walk the halls frequently to make sure patients did not leave the premises. Patients who were likely to wander required more attention and more frequent bed checks, which took away time that nurses could have spent on other care-giving tasks.

Hospital St. Louis started by successfully piloting the technology on the psychiatry unit. It then rolled out the technology more broadly and integrated it with the mobile phone system. When a patient tries to leave the unit, alert messages are sent directly to nurses' and security guards' telephones.

In addition to keeping patients safe, Hospital St. Louis uses RTLS to enhance workplace safety for nurses. Before, if a nurse was threatened by a patient, security guards had no way of knowing where to go in response; in some instances, nurses could not use a telephone. Now, nurses wear RFID tags with an emergency call button. They can request help very easily and security guards can pinpoint the exact location and respond more quickly.

The hospital needed to address staff concerns about tracking people before it could implement the technology. Through a variety of educational sessions and multiple communication avenues,

“There is a huge cultural component to the implementation of technology. You can install a lot of technologies, but if [a technology] doesn't fit into the existing workflows, it won't be adopted.”

— MICHAEL FRAAI, DIRECTOR OF BIOMEDICAL ENGINEERING
BRIGHAM AND WOMEN'S HOSPITAL

hospital leaders reinforced the message that the purpose of the RTLS system was not to monitor staff whereabouts at all times, but rather to improve safety. In addition, leaders educated patients about the RFID tags and asked them to sign a consent form.

“We are also planning to use the technology for evacuation and disaster plans so we can track and ensure the safety of every patient and nurse.”

— DANIEL SCHATZ
INFORMATION TECHNOLOGY PROJECT LEADER
HOSPITAL ST. LOUIS

Delivery Robots

The Problem

Numerous studies of how nurses spend their time have generated some staggering statistics about how much they devote to activities not directly related to patient care. For example, a study at Ascension Health, the nation’s largest Catholic, non-profit health system, found that caregivers spent 48 percent of their time on tasks such as managing supplies, looking for equipment, doing paperwork, reporting, making telephone calls, directing other staff, and handling admissions and discharges.¹⁴ Many of these tasks—finding linens and supplies, and tracking down medications, for example—not only take up valuable time, but do not need to be done by a nurse.

The Solution

Delivery robots can handle some fetch-and-deliver tasks that nurses do. They also perform tasks done by other skilled personnel, which frees these staff members to support nurses directly on care units. Robots can reliably deliver medications from the pharmacy to unit nurses on a scheduled or ad hoc basis, as well as meals, linens, supplies, and patient charts, and deliver laboratory specimens to the lab.

Robots are more flexible than older technologies, such as pneumatic tube systems, because they can deliver a wide variety of items. Furthermore, they do not require any structural changes to hospital interiors. Using laser sensors and pre-loaded electronic drawings of hospital floor plans, and guided by an onboard computer, robots detect beds, water fountains, people, and other obstacles, and adjust their route to avoid collisions. They can even call elevators. Newer versions automatically attach to and detach from carts and hampers.¹⁵

The Benefits

Robots have a long track record of success in pharmacies and laboratories, including a quantifiable return on investment. Even though their role as a delivery assistant for nurses is relatively new, early results are very promising. Providence Hospital, a 408-bed acute care facility in Washington, D.C., reports that a delivery robot can do the work of 4.2 full-time-equivalent staff for about \$2.85 per hour and haul loads of up to 500 pounds. Nurses now are confident that deliveries will arrive on time and can plan accordingly. In a University of Maryland study, nurse satisfaction with pharmacy services increased 23 percent and confidence that pharmacists would promptly fill and deliver new medication orders increased 50 percent after medication delivery robots were implemented.¹⁶

Care Process Redesign

Washington Hospital Center, a 926-bed non-profit facility in the District of Columbia, introduced robots as part of a hospital-wide campaign to make the facility one of the “best places for nurses to work.” Taking a holistic view of the nursing workflow and the tasks that make up a nurse’s day, a team of nurses, physicians, pharmacists, and administrative support staff redesigned workflows and recast roles and responsibilities to streamline nurses’ work.

Initially, the team focused on medication management and medical materials processing. Up to then, nurses were responsible for locating

medications (stored in several different areas on the unit) and searching for a pharmacist or pharmacy technician to answer questions and resolve problems. Pharmacy technicians working on the units, occupied with transporting medication carts and helping the pharmacist at the satellite pharmacy, often were not available to assist nurses. If nurses needed new or additional supplies, and supply staff were not available to make a delivery, they would typically retrieve the items themselves.

To minimize nursing time spent on tasks other than patient care, Washington Hospital Center redesigned the workflow, incorporating robots. Two robots now deliver routine medication carts to the units. The pharmacy technicians have been reassigned to the inpatient units as part of the care team, which makes them more visible on the floors and enables them to spend more time on new orders, one-time orders, answering medication questions, and locating missing doses. They also stock individual patient medication carts. In effect, the robots took over tasks assigned to pharmacy technicians, who thus were able to provide a higher level of service to nurses.

An internal survey of nurse satisfaction with pharmacy services after the introduction of robots and workflow redesign revealed gains in every measure. Forty-four percent of nurses indicated that, before these changes, medications were available when they needed them—a figure that increased to 58 percent after the redesign. Nurses also missed fewer doses and felt more comfortable that they had the tools and support they needed to do their jobs. Pharmacy technicians like their new job responsibilities because now they are more involved in patient care and not “just pushing a medication cart.”

To help with materials management, a third robot makes regular deliveries of medical materials and ad hoc deliveries of additional linens and supplies. In the four units that tested the robots, the hospital estimates that robot-delivered medications (new orders and those for urgent use) and supplies

has eliminated six to ten 45-minute trips to the pharmacy or materials management area per day.

Work has already started on expanded use of robots to transport medical devices and linens, and to deliver medical supplies routinely. Cabinets will still be clearly marked to distinguish clean from dirty linens and equipment, and, like the medication cabinets pulled by other robots, will be locked for security and safety.

Workflow Management Systems

The Problem

The increasing demand for inpatient services, combined with the many challenges of coordinating tasks and resources hospital-wide, often leads to disjointed processes for managing patient flow. This results in frequent delays and inefficiencies. Slowdowns in one area can create roadblocks in other areas, exacerbating the problem. For example, inefficient patient discharge procedures can force hospitals to divert new patients due to a lack of available beds.

One notable cause of this situation is the difficulty locating information. For example, to check the status of a bed, a nurse might have to refer to a paper chart, check online, call the unit clerk or last nurse assigned to the room, or physically walk to the room to see if it is occupied or has been cleaned. If the nurse is waiting for a laboratory result before starting a patient’s medication, he or she needs to call the laboratory or log in to the clinical information system to see if the result has been posted.

The Solution

Workflow management systems, sometimes referred to as workflow automation tools, collect information from multiple sources and integrate it into a single display that highlights key patient and bed management information. Such a display serves as a tracking board or “scoreboard,” providing caregivers with real-time information on which rooms are available, how long each patient has been waiting,

which patients are at risk for a fall, which ones have outstanding orders or new results, and other care metrics and alerts. All of the information is displayed using color-coded icons overlaid onto an image of the nursing unit's floor plan or a patient or room list. This "information at a glance" enables nurses and others to quickly determine when a room is ready, when a STAT order has been placed, or if a patient request is pending.

The displays can also show unit- and hospital-wide utilization metrics that give staff continuous feedback on performance. Desktop views of the system can drill down to identify specific situations that are causing bottlenecks and provide a review of trends. For pending admissions and discharges, a timer often displays the elapsed time since the request was entered into the admission, discharge, and transfer (ADT) system.

In addition, the system can program alarms to call attention to scenarios that do not meet performance standards set by the hospital or The Joint Commission—for example, delivering antibiotics for pneumonia within four hours of a patient's arrival. Status updates, such as whether or not a room has been cleaned, can be entered directly into the application or via interfaces from the hospital's clinical information, environmental services, and ADT systems.

Some vendors of workflow management systems are integrating RFID technology to track the location of patients and equipment. This combination of technologies enables nurses to know more than just the availability of a device.

The Benefits

A workflow management system helps optimize patient flow by providing a single view of relevant, real-time patient information using visual cues and indicators. By looking at the large screens placed throughout a unit, nurses and staff are better equipped to prioritize their tasks, respond to changes, and recognize and alleviate

bottlenecks. Quick access to this information can save considerable time for nurses. In one vendor study, nurses recouped up to one hour per shift by eliminating seven to ten telephone calls and three to four workstation log-ins.¹⁷ In addition, the combination of placing patients in the right bed more quickly and reducing discharge delays can release five to ten "hidden" beds per day.

More Time for Patients and a Safer Work Environment

Oakwood Hospital and Medical Center, a 632-bed tertiary-care hub of the four-hospital Oakwood Healthcare System in Detroit, implemented a workflow management system to replace its manual, color-coded card method. In addition to bed status, the electronic scoreboard shows detailed flags, values, and parameters regarding a patient's care. For instance, "FP" reminds staff to remain alert for fall prevention. "LANG" indicates that the patient has a language barrier. "C," "P," and "A" are reminders of core measures for chronic heart failure, pneumonia, or acute myocardial infarction, respectively. These indicators help nurses prioritize work and identify patients who have special needs.

Oakwood fully implemented and integrated the workflow management system in just a few months. The effort was led by the nursing team and championed by the chief nursing officer. Formal training was minimal because nurses found the system to be very intuitive. Within weeks, telephone calls regarding bed management had declined by 35 percent. The number of excessive four-hour waits in the emergency department fell by one-half. And after six months, the number of bed assignments available within 30 minutes jumped to 72 percent from 52 percent. The system eliminated the need for twice-daily "bed meetings," enabling each nurse who had attended the meetings to spend 30 more minutes per day on bedside care.

The work environment at Oakwood is now safer. Before, isolation signs on doors could accidentally be turned around, covered up, or taken down after the

patient had been discharged but before the room had been cleaned. Today, the signs are linked to the ADT system; nurses, environmental services staff, and physicians can view them on-screen in real time.

Quicker Patient Discharges

Monongalia General Hospital, a 189-bed facility in Morgantown, West Virginia, is known for its heart care and surgical services. In response to new Joint Commission requirements, the hospital's patient flow committee examined the safety and timeliness of patient movement through the facility. Based on feedback from staff, the committee knew that nurses were constantly exchanging information by telephone and voicemail regarding changes in the status of patients and resources. A previous solution—a red light above the patient room door signaling that the room needed to be cleaned—eliminated some calls to environmental services supervisors, but floating discharge cleaners still had to walk constantly from floor to floor looking for red lights.

Now, using large, flat-panel displays, nurses can instantly alert environmental services about rooms ready for cleaning, regardless of where the room or cleaning staff is located. This relatively simple change has reduced calls to the housekeeping supervisor by 50 percent and calls back to the bed manager nurse by 20 percent.

“The system is very intuitive to use—it doesn't require any complicated interaction. Learning how to read the display board was more like a show-and-tell than a training session.”

— JOHNA MOWREY
DIRECTOR OF PERFORMANCE IMPROVEMENT
MONONGALIA HEALTH SYSTEM

Workflow management has also speeded discharges. Before, there were often delays between the time the patient's chart was dropped off at the front desk and the discharge was entered online. When a chart is dropped off now, the nurse can stop at any nearby touch screen to indicate the change in patient status, setting environmental or transport services in motion. As a result, the hospital has trimmed 30 to 60 minutes off the time it takes to process a discharge.

Better Resource Utilization Across Hospitals

At Catholic Healthcare West in Nevada, a new workflow management system helped consolidate management of internal patient flow, staffing, and bed placement across three hospitals. Patient census had been very uneven among these facilities: St. Rose Siena often experienced many emergency department admissions and long waits for beds, while the other two hospitals occasionally had idle capacity. The new enterprise-wide system means nurses can offer on-the-spot transport to other facilities where patients will receive care immediately. Knowing when beds are, or will become, available helps staff increase the census and bed turns; it has reduced the number of back-and-forth telephone calls by 50 percent. Patients are now transported to open beds 260 times per month, up from 30 per month, and are better coordinated at both ends of the transfer.

Finally, improvements in utilization also mean more-balanced staffing. Instead of canceling nursing shifts at some locations while nurses elsewhere are overextended, Catholic Healthcare West now reassigns nurses as needed.

Wireless Patient Monitoring

The Problem

Failure-to-rescue cases, which account for 60,000 deaths annually among Medicare patients younger than 75, and patient falls, a leading cause of death among people 65 or older, are important safety indicators.^{18,19} Patient falls are one of the most common occurrences in hospitals. Of those who fall, up to half may suffer moderate to severe injuries that reduce mobility and independence, and increase the risk of premature death.²⁰ Equally important are inpatients who develop complications and consequently suffer morbidity and mortality.

The Joint Commission, the Institute for Healthcare Improvement (IHI), and other entities are paying greater attention to these issues. The Joint Commission's 2009 National Patient Safety Goals address falls and changes in patients' condition, and provide broad guidance on programs to institute hospital-wide.²¹ One of six recommended interventions in the IHI's 100,000 Lives Campaign is deployment of a rapid response team of skilled care providers when a patient's condition starts to deteriorate.²² Such patients must be connected to monitoring equipment or under the close supervision of nurses checking their vital signs, which may not be the case for general medical and surgical units.

Although there have been some improvements, problems remain. In addition, there are several complicating factors. First, as of October 1, 2008, the Centers for Medicare and Medicaid Services stopped reimbursing hospitals for costs related to falls and associated trauma, which makes this a financial as well as safety issue for hospitals.²³ Second, today's medical and surgical units provide more than just basic care; rather, the care is similar to that provided by intensive care units in earlier years. Third, due to the continuing nurse shortage, nursing staff must care for more patients than they did in the past.

The Solution

In response to these needs, a new generation of wireless patient monitors with sensor technology has emerged to enable continuous, bed-level vigilance. These technologies can be integrated into the bed or the mattress pad. Some feature electronic weight scales, blood pressure monitors, and sensors that measure heart rate, respiration, and body movement during sleep. If this technology is integrated with a nurse-call or other communication system, it alerts a caregiver when a patient who is at risk for falling tries to exit the bed or when a patient who should be lying flat has raised the bed's angle.

The mattress pad-sensing devices make it possible to outfit an existing bed with advanced monitoring capabilities. One high-tech bed pad consists of a zip-on mattress cover embedded with an array of high-tech sensors. The sensors in the pad, or "coverlet," collect continuous physiological data from the patient. Complex waveforms representing the patient's heart rate and respiratory rate are captured, decoded, and displayed on monitors at the bedside and central desk. Caregivers can view current values on the spot or review trends for the previous 12 hours. The coverlet also contains pressure switches that can detect when a patient attempts to leave the bed. All of these data can be monitored automatically for comparison to hospital-defined threshold values and be used to trigger alarms and pages, either as part of a self-contained network or one that works in conjunction with the hospital's nurse call system.

To reduce false negatives and "alarm fatigue," wireless monitoring systems enable hospitals to set up alarm templates and tolerances. For example, the system can be set to allow the bed head angle to exceed the recommended limit for up to 30 seconds before it sounds an alarm, enabling incidental adjustments and movement. Alternatively, alarms can be selectively activated or suppressed, depending on what is appropriate for a given patient.

The Benefits

Wireless patient monitors provide a technological safety net for busy caregivers who are caring for more and sicker patients. The ability to receive an alert indicating that a patient is trying to get out of bed, and to respond immediately through the nurse call system, improves productivity and workflow, and prevents falls. Fall rates at 636-bed St. Joseph's/Candler Hospital in Savannah, Georgia, decreased from five falls per 1,000 patient days to 1.4 after it integrated wireless patient monitoring with nurse communication technologies.²⁴

Continuous centralized monitoring also promotes patient safety by reliably enforcing safety protocols. Beds with built-in percussion and vibration therapy help prevent ventilator-associated pneumonia by alerting nurses when the therapy session is done so suction can be performed in a timely manner. Similarly, customizable timers can prevent skin complications by reminding caregivers to shift patients before bed sores develop. By incorporating accurate timers, reminders, and alerts, these technologies save nurses the administrative time they would otherwise spend tracking all such activities manually.

At the James A. Haley Veterans' Administration Hospital, a 327-bed tertiary care teaching facility in Tampa, Florida, a bed pad-based wireless monitoring solution enables continuous patient observation. In a pilot study, the hospital implemented this solution in a single-floor, 21-bed general medical unit that cares for patients with a wide variety of conditions, ranging from chronic obstructive pulmonary disease to pneumonia and other infectious diseases. The study concentrated on the impact that automated monitoring of respiratory and heart rates had on nurse workflow, workload, and satisfaction.

Results showed that patients received care more rapidly than they would have otherwise. Timely alerts prompted nurses to adjust care parameters about 10 percent of the time. In addition, about 2 percent of patients were transferred to a higher level

of care due to an alert, often several hours before they were scheduled to be re-evaluated. One study identified sizeable differences in ICU length of stay (nine days in cases of pre-event transfers versus 14 days post-event) and mortality rate (11 percent versus 41 percent).²⁵

Wireless patient monitoring improves nursing workflow. One pre- and post-implementation analysis concluded there were statistically significant increases in the time nurses spent on direct and indirect care. Eighty-six percent of nurses agreed that wireless patient monitoring helped them provide quality care, and 77 percent agreed that it helped prevent falls. In addition, they spent 4.4 percent less time on administrative activities, and there was a 24 percent drop in the need for bed sitters.²⁶ Nurses strongly supported the new technology as an "extra set of eyes" that improves vigilance and patient care.

Electronic Medication Administration with Bar Coding

The Problem

Medication errors occur frequently in hospitals. Numerous studies have analyzed the contributing factors and resulting harm to patients in different hospital environments and patient populations. National attention to the issue started with publication of a landmark Institute of Medicine report. Although the often-quoted statistic of 98,000 preventable deaths a year relates to all types of medical errors, medication errors that harm patients ("adverse drug events") are the most common, affect a substantial number of patients, and account for a sizeable increase in health care costs. Annually, about 400,000 preventable adverse drug events occur and medication errors cost an additional \$3.5 billion, according to the report.²⁷

Inpatient medication management is a complex process involving different departments, professionals from various disciplines (nurses, pharmacists, physicians, and pharmacy technicians), and multiple hand-offs. Errors and adverse events can

occur at every step, many of them while nurses are administering medications (Table 3).

Table 3. Adverse Drug Events During Medication Management

STAGE	ADVERSE DRUG EVENTS
Prescribing	49%
Transcribing physician order	11%
Dispensing	14%
Administering	26%

Source: *Physician Order Entry: Costs, Benefits, and Challenges. A Case Study Approach.* First Consulting; January 2003.

Medication administration is the last opportunity to catch an error created during the other three steps, so any changes at this stage to reduce errors will have an immediate impact on patient safety.

The Solution

Software called electronic medication administration (eMAR) with bar coding can help reduce many types of errors that occur during medication administration. When nurses have access to better information about the drug and the patient, they have a much better chance of preventing a mistake. eMAR presents legible information about the medication, which means the nurse need not transcribe it from the physician order; when it was last administered; and when it needs to be given.

A hand-held scanner tethered to the nurse’s laptop or connected to it wirelessly is part of the technology solution. The scanner quickly identifies and verifies the “five rights” checklist—patient, route, dose, time, and medication—by scanning barcodes on the medication package and patient identification band. The ability to verify the five rights as each medication is administered adds significant safety to the process.

Figure 2 illustrates how this process works. The nurse uses a mobile medication cart and performs the tasks at the bedside. Atop the medication cart is a laptop or personal computer and scanner. The computer runs eMAR and interacts with the clinical

Figure 2. The eMAR Medication Administration Process

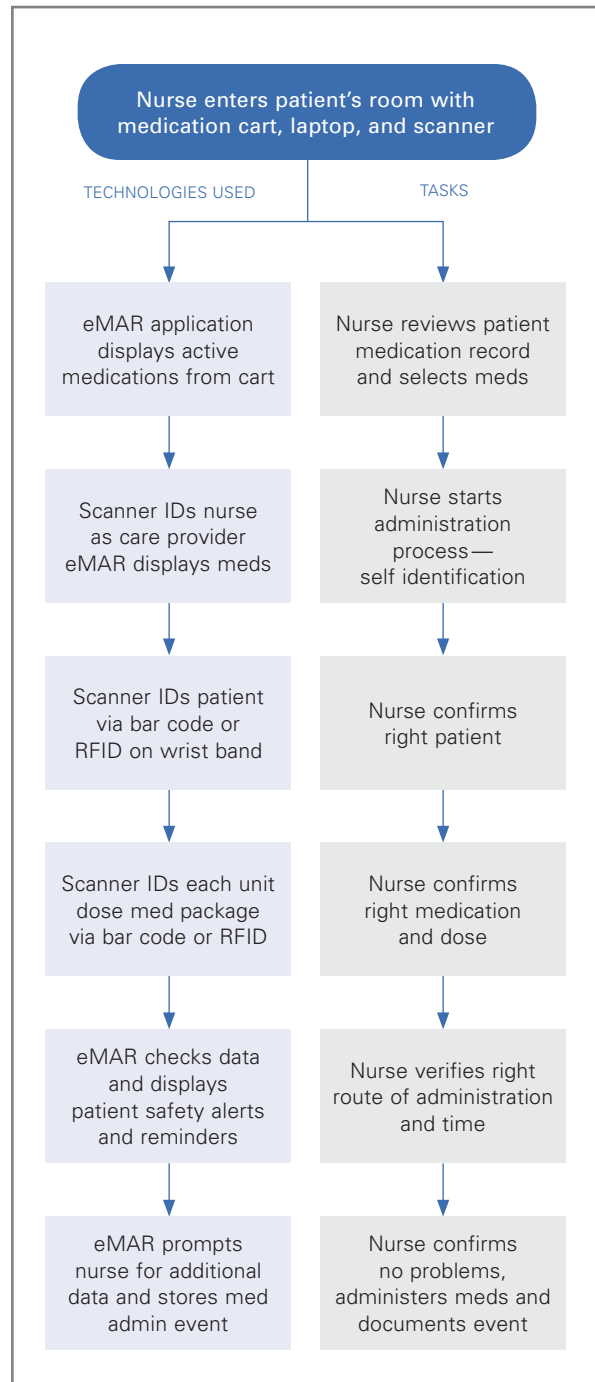


Table 4. Rationale at St. Clair Hospital for Using Bar Coding vs. RFID

COMPONENT	BAR CODING	RFID	REASONS TO USE
Patient wristband		✓	<ul style="list-style-type: none"> No line of sight requirement for scanning; no need to adjust patient if wristband is not visible. RFID tag does not wrinkle (wrinkles can cause incorrect scans).
Caregiver ID		✓	<ul style="list-style-type: none"> Safer—performs two-factor authentication more easily; RFID tag is more difficult to replicate.
IV bag		✓	<ul style="list-style-type: none"> Manufacturer’s bar coding is inadequate for IV identification. Flexibility of bag and fluid content wrinkle barcode labels, making correct scans difficult. Height of IV pole creates a difficult barcode scanning angle.
Unit dose medication	✓		<ul style="list-style-type: none"> 80% come pre-packaged with barcode. Easy to scan due to flat surface packaging

Source: Patient Safety at the Bedside: Prevent Errors with RFID and Bar Coding. Vendrome Group: May 2007.

information system (through a wireless connection to the hospital’s local area network) and the scanner.

As Figure 2 suggests, this set-up can accommodate two identification technologies: bar coding and radio frequency identification (RFID). Hospitals most commonly use bar coding, although newer scanners support both, which a growing number of hospitals have found to be more effective. St. Clair Hospital, a 329-bed facility in Pittsburgh, Pennsylvania, started with barcode identification only, then migrated to using RFID for IVs, patient wristbands, and caregiver badges (Table 4). The net result was a 10 percent increase in the use of eMAR.

Nationally, only 23 percent of hospitals have adopted eMAR, according to a survey. However, more than one-half of hospitals plan to implement it within the next three years. Continued emphasis on technological advances and improving patient safety are driving adoption.²⁸

“Barcode medication administration technology makes the environment not only safer for the patients, but for the staff taking care of them.”

— PATTI STOVER, R.N., DIRECTOR OF PATIENT SERVICES
DOYLESTOWN HOSPITAL

The Benefits

At Doylestown Hospital, a 208-bed facility near Philadelphia, barcode-assisted medication administration was part of a larger effort to revamp this task.

Because of the priority that Doylestown placed on improving safety, the eMAR project—from planning to full implementation—took just six months. The entire hospital has adopted the technology, resulting in an estimated reduction of nearly 40 percent in potential medication-related errors (Table 5).

Table 5. Medication Error Reduction at Doylestown Hospital Using eMAR and Bar Coding

	PATIENT SAFETY PARAMETERS	POTENTIAL ERRORS PREVENTED*
eMAR	<ul style="list-style-type: none"> Legible medication information Checks for duplicate orders Drug interactions and allergy checks Alerts to check latest lab values for specific medications Dosing alerts 	23%
Bar coding	<ul style="list-style-type: none"> Right patient Right medication 	16%

*Estimates based on an internal study at Doylestown Hospital, 2007.

Electronic Clinical Documentation

The Problem

Nurses spend a significant portion of their time completing forms and documenting care. One study found that for every hour of time spent on patient care per shift, a nurse spends 30 minutes to one hour on paperwork.²⁹ According to other studies, documentation—admissions and other nursing assessments, medication administration, progress notes, care plans, vital signs, and discharges—requires two to three hours per nurse per shift.³⁰ Manual documentation is time-consuming and often incomplete or illegible.

In addition to being the official record of care delivery, clinical documentation is the source of much of the information needed to monitor and improve patient care, as well as improve performance overall. Culling this information from paper charts is so time consuming and expensive that often it is only performed after the fact for external reporting purposes and does not contribute to the broader quality improvement agenda.

The Solution

Hospitals implement a suite of clinical applications to incrementally move paper documents with information about patient histories, assessments, orders, notes, and the care they have received into an inpatient electronic health record. Ultimately, clinicians from all departments and disciplines perform all care planning and documentation electronically, but the journey from a paper-based system takes place in stages over a period of years.

In the ideal electronic setting, caregivers capture information only once, in real time and often at the point of care. Each member of the care team builds upon information that is already available. Templates and other decision support tools guide the documentation process and ensure that hospital protocols and care standards are applied consistently in support of effective patient care and the hospital's quality improvement agenda.

Nurses are very mobile and do much of their work at the bedside. Electronic clinical documentation becomes part of that routine (sometimes in patient rooms), thanks to a combination of mobile and fixed workstations. Nurses who have electronic resources at their disposal are likely to use a mix of mobile devices, including wireless laptops on the medication cart during medication rounds, hand-held tablets, or subcompact notebooks for other tasks.

The Benefits

Hospitals adopt electronic documentation primarily to do a better overall job of providing care. However, today's applications and integration technologies can also save time for nurses, although the results vary depending on factors such as the portion of documentation that involves nursing, system design and configuration, and the implementation approach. An analysis of multiple studies concluded that electronic solutions can reduce the time spent on clinical documentation by up to 24 percent.³¹ Biomedical devices connected to an electronic documentation system also save time by transmitting data automatically for review and incorporation into the electronic record. Each such device can save a nurse one to two minutes per reading task.³²

There are workflow benefits, too. The latest generation of clinical documentation systems generates work lists and reminders as “an electronic helping hand” to nurses as they manage a plethora of patient care tasks. Alerts tell them which must be completed and when per the care plan, and include the specific electronic form that ties actions to documentation of the care delivered.

Florida Hospital, a seven-hospital system in Orlando, migrated from a combined paper and electronic patient chart to a totally electronic environment. Among the more than 250 electronic forms are all of the nursing and ancillary documents in medical and surgical units, the emergency department, and critical care units. They include flow sheets, which were particularly challenging in the transition to electronic format because staff had been used to

a tri-fold paper document that displayed vitals, physiological inputs/outputs, and drips on one sheet. Patient consent and signature documents are the few remaining paper forms.

A primary goal was to reduce documentation redundancies. For example, the emergency department nurse electronically records a patient’s medications, medical and surgical history, allergies, problems, and current interventions. Because the new system supports interdisciplinary documentation and adherence to data and care standards, it enables clinicians in all areas to work from the same information base. Now, when patients are admitted, nurses use what was documented online in the emergency department as the starting point.

Florida Hospital’s new system improves clinical documentation by:

- Providing standard templates for assessments, plans, and notes ensure complete data collection. Information already captured is displayed for review and update;
- Allowing users to perform documentation of an exception, pull data from prior stays, and select from menus rather than having to enter text, which minimizes typing and increases standardization;
- Enabling the integration of bedside devices on the critical care unit to automatically populate flow

sheets with pulse, respiration, and blood pressure data; and

- Coordinating tasks and reminders to manage work and ensure compliance with regulatory and patient-safety documentation requirements.

Implementation team leaders at Florida Hospital believe that the two most valuable gains are data-sharing among caregivers and task management support, including alerts for providers that “push” electronic forms. These features have improved both the efficiency of documentation and effectiveness of care delivery. An unexpected benefit is the “helping hand” that the task management functions give to novice nurses. Using the automated work list, nurses see all of the work that needs to be done and the electronic forms they must complete.

Interactive Patient Technologies

Most technologies profiled in this report address a single operational challenge, such as bridging communication gaps or improving patient monitoring or some other aspect of care delivery. Interactive patient technologies can lead to improvements in multiple areas, including nursing workflow, efficiency, and care delivery.

An interactive patient system is a digital platform for two-way communication and delivery of multimedia content at the bedside. The system enables communication with the nurse and support personnel, delivers patient education videos,

Table 6. Features and Functions of Interactive Patient Systems

PATIENT EDUCATION	HOSPITAL SERVICES	ENTERTAINMENT
<ul style="list-style-type: none"> • Educational content available on demand or at scheduled intervals. • Content can be customized based on patient-specific diagnosis and parameters. • Content can be purchased from vendors or generated by the hospital. • End-of-session quizzes confirm the patient’s understanding of the materials. 	<ul style="list-style-type: none"> • Service request routing to nursing, housekeeping, environmental services, and other departments • Electronic communication about, and submission of, complaints • Real-time satisfaction surveys • Pain assessment surveys • Information for family members and visitors • Patient-customized food menus and online ordering 	<ul style="list-style-type: none"> • Local and premium television options • Internet access, including email and Web browsing • Movies on demand • Music and audio books • AM/FM radio • Video games

handles patient requests, and provides a range of entertainment and Internet services, usually over a dedicated network. Table 6 (see previous page) lists the educational, hospital-services, and entertainment features and functions of such a system.

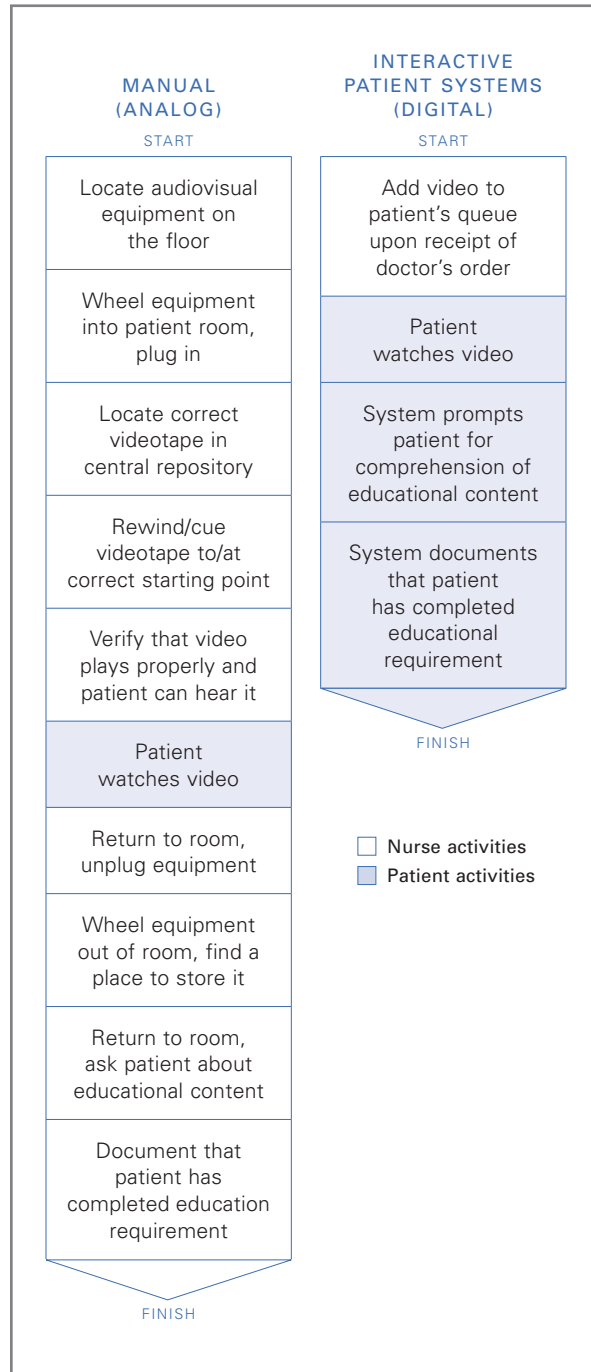
Patient Education

Patient education is often an inefficient, time-consuming task for nurses, who must coordinate video equipment, educational materials, and patient and family availability. The nurse sets up the system, either a freestanding cart with a television and video player or the hospital’s closed-circuit TV; comes back when the session is over; and asks questions to confirm the patient’s understanding of the materials. The nurse then notes in the chart that the patient has received the required education. If the patient is unavailable, gets interrupted, or does not feel well enough to watch the video at a convenient time for the nurse, the process is repeated at a later time.

Interactive patient systems make the delivery of patient education vastly more efficient because online videos, diagrams, and animations are delivered directly to the bed (Figure 3). In-room monitors can access videos from a central online resource at any time. As soon as a patient has finished watching an educational video (or, optionally, after the patient has answered a set of questions to test his or her understanding), the clinical application is automatically updated to reflect that the information was successfully delivered.

Interactive patient systems make education convenient for patients and their families, make it easy for nurses to deliver, and help hospitals comply with Joint Commission requirements. One study found that such systems reduced the time nurses needed to initiate an education session from 19.1 minutes to 5.2 minutes—a savings of nearly 14 minutes per session.³³

Figure 3. Patient Education Workflow: Manual vs. Interactive Systems



Hospital Services

Nurses are often the first point of contact for any type of patient request. Many requests—for a missed meal, a change in room temperature, or an additional blanket, for example—are unrelated to nursing care. The nurse either fulfills the request or finds someone who can. This is an inefficient use of nurses' time and adds to their already busy work schedule. Given the way nurses are used as middlemen for administrative requests, it is not surprising that more than half think support services are inadequate.³⁴

The instant request function in interactive patient systems removes nurses as middlemen. The patient enters a request online and the system routes it to the appropriate department or service. This function can include escalation notifications when responses are overdue. Some versions are more closely integrated with other hospital systems, enabling patients to order meals directly or adjust room temperature from the bedside.

Entertainment

Interactive patient systems can also help occupy patients during their stay by replicating many of the amenities and entertainment options they enjoy at home. The entertainment choices range from TV and movies to games and Internet access.

By offering such features and services, hospitals keep up with changing patient demographics and consumer expectations. Many patients, accustomed to the conveniences and personalized service they receive from other industries, now expect to have such capabilities at their fingertips. Interactive patient systems give them more information about their condition, more choices regarding how to spend their time, and a greater sense of control.

The Benefits

Winchester Medical Center, a 411-bed non-profit facility in Winchester, Virginia, initially installed an interactive patient system to give patients and families access to the Internet, and to enable patients

to conveniently look up information about their medical condition. Over time, however, the hospital found that the system freed nurses to focus more on providing direct care. In its orthopedic unit, for example, where rooms easily become cluttered with equipment and where trash cans fill quickly, patients may send room service requests directly to environmental services, which means they get a faster response.

In addition, Winchester has extensively used the system's instant feedback capabilities, implementing patient-compliment and patient-suggestion features. Via email, compliments go directly to the nursing director and suggestions to the patient service recovery team. Issues related to cold food or excessive noise during the night, for example, can be addressed during the patient's stay.

The system also has reduced the burden on staff to educate patients individually, and the related documentation and compliance are significantly easier. Winchester enforces "safety pathways" that prompt patients to view videos on topics such as hand-washing and fall prevention at pre-set intervals after admission. Other videos can be added or deleted from the queue based on their relevance to particular patients and their diagnosis. Within the first month of system implementation, patient use of educational videos increased 15 percent.

Baptist Medical Center South, a 62-bed hospital in Jacksonville, Florida, uses an interactive patient system to guide patients throughout their hospital stay—from the welcome message they receive upon admission to the education, entertainment, and communication technologies that allow them to customize their experience and request services. For example, every patient receives education about proper hand hygiene twice within 24 hours of admission, to increase retention and emphasize the topic's importance.

Bedside communication also means patients get answers to their questions more quickly and

consistently. And nurses find it easier to include family members in the care process because education is more accessible and videos can be repeated at relatives' convenience. Baptist is planning to expand the system, enabling patients to order food and participate in surveys.

Interactive patient systems can improve the patient experience and the way patients and family members view an organization. For example, leaders at Inova Fair Oaks Hospital, a 182-bed facility in Fairfax, Virginia, believe that their system contributed to improving patient satisfaction with specific aspects of care. Officials have reported a 9 percent improvement in such ratings regarding ease of communication with staff, and a near 10 percent increase regarding timely response to their needs.³⁵

IV. Summary

THE TECHNOLOGIES DESCRIBED IN THIS REPORT HELP create a better work environment for inpatient nurses and increase their job satisfaction by improving the efficiency, safety, and quality of care. Only when hospitals experiment with such technologies in combination and evaluate the impact will they understand the full potential for improving nurses' work, nursing care overall, and hospital operations. Early results suggest that the potential could be substantial.

Appendix A: Interviewees

Kim Bonzheim

Director, cardiac services
Beaumont Hospital
Royal Oak, Michigan

Susan Clark, R.N.

Clinical educator
Winchester Medical Center
Winchester, Virginia

Sonia Collazo, R.N.

Nurse manager
James A. Haley Veterans' Hospital
Tampa, Florida

Lori DeVore, R.N., Certified

Process architect for clinical documentation project
Florida Hospital
Orlando, Florida

Mary Diehl, R.N.

Central staffing critical care nurse
Florida Hospital
Orlando, Florida

Monica Donofrio, R.N.

Administrative director, care management and
patient access
Oakwood Hospital and Medical Center
Dearborn, Michigan

L. Michael Fraai

Director, biomedical engineering
Brigham and Women's Hospital
Boston, Massachusetts

Kimberly Krakowski, R.N., Certified

Clinical specialist, pharmacy liaison
Washington Hospital Center
Washington, D.C.

Johna Mowrey, M.B.A.

Director, performance improvement
Monongalia Health System
Morgantown, West Virginia

Daniel Schartz

IT project leader
Hospital St. Louis
Ettelbrück, Luxembourg

Patti Stover, R.N.

Director, patient services
Doylestown Hospital
Doylestown, Pennsylvania

Linda Talley, R.N.

Director, nursing systems
Children's National Medical Center
Washington, D.C.

Wendy Yontz, R.N.

Operations Center director, St. Rose Dominican
Hospitals
Catholic Healthcare West
Henderson, Nevada

David Ziolkowski

Senior vice president and chief information officer
Sampson Regional Medical Center
Clinton, North Carolina

Appendix B: Vendors

VENDOR/PRODUCT	CONTACT INFORMATION	TECHNOLOGY CATEGORY
AeroScout <i>Unified Asset Visibility</i>	1300 Island Drive, Suite 202 Redwood City, CA 94065 www.aeroscout.com (650) 596-2994	Real-time location systems
Aethon <i>TUG Robot</i>	100 Business Center Drive Pittsburgh, PA 15205 www.aethon.com (412) 322-2975	Delivery robots
Ascom <i>Wireless VolP Phones, MedUnite</i>	598 Airport Boulevard, Suite 300 Morrisville, NC 27560 www.ascom.us (877) 71ASCOM	Wireless communications, alarm/event messaging
Capsule Technologie <i>DataCaptor</i>	300 Brickstone Square, Suite 203 Andover, MA 01810 www.capsuletech.com (800) 260-9537	Biomedical device integration
Cerner <i>Cerner Clinical Documentation and Medications Administration</i>	2800 Rockcreek Parkway Kansas City, MO 64117 www.cerner.com (816) 201-1024	Clinical documentation, medication administration technologies
Eclipsys <i>Clinical Documentation and Medications Administration</i>	Three Ravinia Drive Atlanta, GA 30346 www.eclipsys.com (404) 847-5000	Clinical documentation, medication administration technologies
Emergin (Philips) <i>Integration Suite</i>	6400 Congress Avenue, Suite 1050 Boca Raton, FL 33487 www.emergin.com (866) 363-7446	Alarm/event messaging
Epic <i>Clinical Documentation and Medications Administration</i>	1979 Milky Way Verona, WI 53593 www.epicsystems.com (608) 271-9000	Clinical documentation, medication administration technologies
GetWellNetwork <i>PatientLife:)System</i>	7920 Norfolk Ave. 11th Floor Bethesda, MD 20814-2500 www.getwellnetwork.com (877) MEETGWN	Interactive patient systems
GlobeStar Systems <i>ConnexAll</i>	7 Kodiak Crescent, Suite 100 Toronto, Ontario, Canada M3J 3E5 www.globestarsystems.com (866) 556-3377	Alarm/event messaging
Hill-Rom <i>VersaCare Bed</i>	1069 State Route 46 East Batesville, IN 47006 www.hill-rom.com (812) 934-7777	Wireless patient monitoring
Hoana Medical <i>LifeBed</i>	828 Fort Street Mall, Suite 620 Honolulu, HI 96813 www.hoana.com (808) 523-5410	Wireless patient monitoring

VENDOR/PRODUCT	CONTACT INFORMATION	TECHNOLOGY CATEGORY
InnerWireless <i>PanGo</i>	1155 Kas Drive, Suite 200 Richardson, TX 75081 www.innerwireless.com (972) 479-9898	Real-time location systems
iSirona <i>SmartAdapter, DeviceConX</i>	2211 Hwy. 77, Suite 101 Panama City, FL 32444 www.isirona.com (866) 202-2124	Biomedical device integration
Magnet Health <i>Patient Experience Platform</i>	785 Bedford Street Whitman, MA 02382 www.magnethealth.com (781) 447-9500	Interactive patient systems
MEDITECH <i>HCIS, Closed Loop Medication Management</i>	MEDITECH Circle Westwood, MA 02090 www.meditech.com (781) 821-3000	Clinical documentation, medication administration technologies
McKesson <i>Horizon Enterprise Visibility, Clinical Documentation</i>	One Post Street San Francisco, CA 94104 www.mckesson.com (415) 983-8300	Workflow management, clinical documentation
Radianse <i>Radianse RFID, Radianse Reveal</i>	200 Brickstone Square, Suite 302 Andover, MA 01810 www.radianse.com (800) 974-9302	Real-time location systems, workflow management
Siemens Healthcare <i>Soarian</i>	51 Valley Stream Parkway Malvern, PA 19355 www.medical.siemens.com (888) 826-9702	Clinical documentation, medication administration technologies
Skylight Healthcare Systems <i>ACCESS Interactive Patient System</i>	12777 High Bluff Drive, Suite 150 San Diego, CA 92130 www.skylight.com (858) 523-3700	Interactive patient systems
Sonitor <i>Ultrasound Indoor Positioning System</i>	8250 Bryan Dairy Road, Suite 120 Largo, FL 33777 www.sonitor.com (877) 477-9767	Real-time location systems
Spectralink (Polycom) <i>Wireless Telephone Systems</i>	4750 Willow Road Pleasanton, CA 94588-2708 www.spectralink.com (800) 765-9266	Wireless communications
Versus Technology <i>VISion Enterprise Locating Solution</i>	2600 Miller Creek Road Traverse City, MI 49684 www.versustech.com (877) 9VERSUS	Real-time location systems
Vocera Communications <i>Vocera Communications Badge</i>	525 Race Street San Jose, CA 95126 www.vocera.com (800) 331-6356	Wireless communications

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