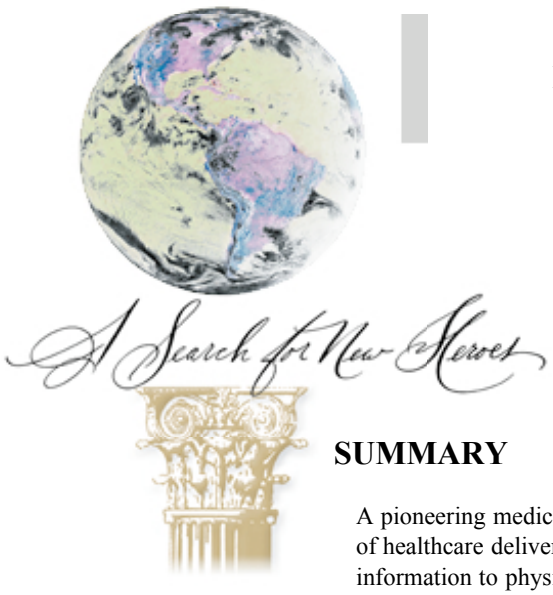

INNOVATIVE USE OF WIRELESS TECHNOLOGIES

2005 COMPUTERWORLD HONORS CASE STUDY

MEDICINE

A PIONEERING MEDICAL-GRADE, WIRELESS INFRASTRUCTURE SUPPORTS COMPLETE MOBILITY THROUGHOUT THE FULL CONTINUUM OF HEALTHCARE DELIVERY, FACILITATING ACCURATE COLLECTION AND THE IMMEDIATE DISSEMINATION OF PATIENT INFORMATION TO PHYSICIANS AND OTHER HEALTH CARE PROFESSIONALS AT THE TIME OF CRITICAL CLINICAL DECISION-MAKING. **[20055278]**

SUMMARY

A pioneering medical-grade, wireless infrastructure supports complete mobility throughout the full continuum of healthcare delivery. It facilitates the accurate collection and the immediate dissemination of patient information to physicians and other health care professionals at the time of clinical decision-making, thereby ensuring timely, safe, and effective patient care.

APPLICATION

Lifespan is a not-for-profit healthcare system, comprising five major hospitals and a Physician Services Organization of more than 700 physicians. Its hospital members are Rhode Island Hospital, which includes Hasbro Children's Hospital, The Miriam Hospital, Emma Pendleton Bradley Hospital and Newport Hospital. Demonstrating their mission to improve the health status of the people they serve, these hospitals are Rhode Island's leading providers of uncompensated care for the uninsured and underinsured, providing over $50 million in uncompensated care in FY 2004. Lifespan also has a strong commitment to medical education and research, empowered by its academic affiliations with Brown Medical School.

Over the past decade, wireless networks have changed people's lives, with cell phones now ubiquitous, Internet hot spots commonplace, and RFID product tracking a retail necessity. Lifespan has aggressively applied the innovations of the wireless era to healthcare--an arena typically slow to adopt technological change--with an emphasis on improving health care delivery.
Lifespan's wireless network is distinguished by longevity of strategy, and completeness of execution. In 1996, Lifespan initiated an Information Technology Strategic Plan to assure that its technology investments would further the operational, strategic, and quality initiatives of the Lifespan affiliates. Guided by the mission to improve the health status of the people it serves through a "high-value, widely accessible, comprehensive, integrated information network," the plan mandated provision of "all relevant information to those who need it, when they need it, wherever they are." The goal was to enhance efficiency, improve care, and form the basis for a Computerized Physician Order Entry (CPOE) system that would reduce errors and speed the delivery of care. Wireless networking was quickly selected as a necessary vehicle for meeting the IT goals. The wireless network would be:

• Medical grade and pervasive throughout all clinical areas of all affiliated hospitals—unique in healthcare. Other attempts with wireless implementations have been more peripheral in design, where Lifespan's would be both comprehensive and fully integrated into the workings of the hospital.
• A vehicle for increasing immediacy, efficiency, and therefore quality, in the healthcare process by moving the clinical evaluation and order-writing process to the patient's bedside, wherever in the hospital the patient might be at any time, and by enabling immediate transmission of orders to the delivering departments, whether pharmacy, laboratory, respiratory, or x-ray, and by enabling immediate on-line availability of results as soon as analysis is completed.
• A key enabler for reviewing patient test results through Lifespan's wireless-optimized web portal called LifeLinks. Wireless optimization means preparing and transmitting information in manageable sized packages, so there are no unacceptable delays over the inherently slower wireless network.
• An enabler for adoption of a Computerized Physician Order Entry (CPOE) system by the system's 2,300 physicians. This application, which Lifespan called Physician Order Management (POM), launches directly from within the LifeLinks portal. Nationally, adoption rates of CPOE systems are abysmally low, as numerous journal articles attest. Without a wireless network, Lifespan's designers did not believe success could be reached.
• A foundation for new projects, such as RFID, voice/video wireless networking, and patient wireless Internet service, seeking a competitive edge and pushing new avenues of care improvement.

• A vehicle for cost savings on cable and equipment. A wired network would have been extremely expensive, if not physically impossible in many situations, to install; and it not be possible to deliver the pervasive "anytime, anywhere" coverage mandated.

"Medical grade" quality (a new standard of network security, robustness, and availability) grew out of Lifespan's view of wireless as an extension of its Cisco wired network. The wired network required secure, user authentication, so did the wireless. The network required central management, performance monitoring, and resiliency; so did the wireless network. While applications were being developed and optimized for wireless transport, the technical group within Lifespan's Information Services department deployed and tested the technology, overcoming all the challenges inherent in this new way of working.

The result: Lifespan's wireless network gives caregivers a real-time picture of all relevant data needed to treat their patients anytime, anywhere, enterprise-wide throughout its five hospitals. Hundreds of devices are in use, including wireless laptops, tablets, and Personal Digital Assistants (PDAs). Most of these are hospital-owned and checked out to employees, although many are owned by physicians who have individual personal preferences. Enjoying one of the highest CPOE adoption rates nationally, Lifespan physicians order medications and treatments that are immediately transmitted to wireless-enabled clinicians, thus speeding patient care and eliminating transcription errors.

In a typical scenario at a Lifespan hospital today, a physician at a patient's bedside may enter a pharmacy and respiratory order on a laptop or tablet PC that the physician carries. The medication order is immediately interfaced to the pharmacy system and validated for safety by a pharmacist and within an average of 12 minutes a medication label prints on the patient's floor approving the administration of the drug. The wireless network enables Lifespan to reduce a process that typically can take two hours to just minutes. At the same time, a respiratory order reaches a technician via the tech's wireless tablet, and the technician arrives at the patient's room before the physician leaves. A nurse enters the patient's vital statistics on a wireless PDA, making the data immediately available to the physician and other clinicians. Workflow optimization formerly considered impossible is made possible through the medical-grade wireless network. As a result, patients are treated more quickly and safely, and their hospital stays are shortened. The immediacy built into this system could only be enacted through enterprise-wide wireless technology. It is this immediacy that people expect in their non-medical lives, and which they deserve in their hospital stays.

LifeLinks is Lifespan's secure, Web portal that provides a full spectrum of patient data and clinical testing results via a single clinical data repository fed in real time by ancillary systems. Text-rich reports are reviewed and edited online by the dictating physician, and then made available through LifeLinks immediately following electronic sign-off. A VPN provides secure access to LifeLinks from physician home- and -office-based Internet connections. Wireless downloads to PDAs provide rounds reports. Used by nearly 3,000 physicians, LifeLinks provides one-stop access to CPOE, Orders and Results, EKG graphs, diagnostic reports, diagnostic images, discharge summaries, medication lists, patient histories and allergies, and more. In all, LifeLinks serves as an electronic lifetime clinical repository that follows patients from hospital to hospital and can be electronically sent to medical facilities in other locations should the patient move. More than 100 applications are available wirelessly through LifeLinks.

In short, the wireless network provides the foundation for immediate access to clinical systems, speeding the delivery of care, standardizing care practices, reducing interface errors at all points they might otherwise be made, and saving on now-unnecessary transcription costs.

BENEFITS

Mobility brings a revolution in culture. The wireless network has changed processes, and spawned a revolution in attitudes and culture within Lifespan hospitals. Originally conceived to support availability of data for physician order entry (POM system) and clinical work, the wireless network has accomplished that and much more.

• Physicians have the ability to review wirelessly all patient results while at the bedside, in rounds, in consultation, or while teaching at any of Lifespan's five partner hospitals. They have the wireless ability to download up-to-minute patient "rounds" reports to PDAs anywhere in the Lifespan clinical space, across all five hospitals and in other wireless hotspots in the medical environment.
• Physicians can enter orders for medications and treatments and sign off electronically on transcription reports, as well as view diagnostic images anywhere.
• Instant electronic transmittal of orders to wireless-enabled support personnel results in immediate action, eliminating error-prone transcription steps and time-bound paging sequences, thus speeding the delivery of care.

• At Newport Hospital, nurses enter patient vital statistics on PDAs at the point of care. The stats are immediately available in clinical record anywhere they are needed.
• Nursing stations have been redesigned, no longer requiring a concentration of computer equipment and staff in a very constrained space. Wireless brings caregivers to the bedside, and to new "ad hoc" productivity spaces, enabling true point-of-care computing. Use of space on nursing floors is maximized, and traditional cable costs are reduced.
• Caregivers have a choice of device (laptop cart, tablet, PDA) and location where they want to work. This alone has boosted morale, leading to the enthusiastic adoption of the systems. Physicians create their own "computing spaces" where they can focus on analyzing data and entering orders. Groups of residents assemble in alcoves and conference rooms doing research on wireless laptops, while discussing treatment plans. (See Successes for details).
• Surgeons have the ability to view diagnostic images wirelessly within the operating room environment. Custom-designed, moveable wireless PC wall mounts enable the OR environment to be tailored to surgeon preferences or the requirements of specific procedures, without the hazard of cables on the floor.
• Electronic prescribing speeds care in ambulatory clinics. The physician can sit with the patient, while writing prescriptions directly to a pharmacy via wireless PDA or laptop. This results in faster, more accurate response than paper orders or telephone calls, and the pharmacist or technician is reached immediately.
• Clinicians can communicate and confer with each other discretely in front of patients. At Bradley Hospital, Lifespan's psychiatric treatment hospital for children, evaluators use wireless laptops for note taking while sitting in a relaxed atmosphere with the children. In addition, they can suggest lines of interaction to their colleagues through emails while the interview is actually under way.
• Lifespan leverages the wireless network for training. To train personnel during CPOE rollout, training tapes were placed on the Intranet, accessible to wireless devices anytime, anywhere, including off-unit quiet areas like lounges and cafeterias.
• A new project, wireless voice technology (Vocera) transformed nursing communication on the first unit where it was installed at Rhode Island Hospital. Nurses communicate through small devices on lanyards that provide hands-free communication nurse-to-nurse, nurse-to-physician, and nurse-to-ancillary department. With a simple command, "page Dr. Smith," the system finds the phone number and pages directly back to the nurse. Nurse-to-group communication, such as "call respiratory to Room 200 stat," shortens emergency response. Overhead paging has been dramatically reduced, resulting in a quieter environment for patients. Communication is faster and more professional because nurses are focused on the patient, instead of looking for the cell phone, intercom button, and phone numbers. Patients appreciate that the latest and greatest technology is being used in their care.
• The wireless network is an enabler of new projects largely unheard of in healthcare. RFID identification of patients via wristbands will ensure positive patient identification at all times. A positioning and tracking system for medical equipment, such as infusion units and portable x-ray machines, will improve hospital logistics. Equipment will be staged where it is most likely to be needed. When personnel need a device, they will be able to quickly locate the closest one.
• Wireless technology has become a key element in Lifespan's ability to react in disaster situations, where computing environments need to be set up quickly. This became evident in the aftermath of the 2003 nightclub fire, when over a hundred burn victims, their families, and the national media presented at Lifespan hospitals in the course of a few hours. A complete wireless "command center" was set up in under an hour to manage triage, treatment, and reporting from a single informed location.
• Finally, wireless technology has been a boon to the recruiting of resident physicians. The wireless network is part of the promotional tour, and numerous residents have cited strength of computer systems as a factor in their selection of Lifespan.

Beyond the specifics cited above, the most significant benefit of the wireless network is its acceptance and enthusiastic use by staff as a means of changing process and improving patient outcomes. A cultural transformation has occurred, and long-standing traditional practices have been willingly revisited and revised accordingly.

IMPORTANCE

The total process re-orientation at Lifespan could not have occurred as quickly as it did without the medical-grade wireless network. "Medical grade" implies 24x7 uptime, with failsafe, accessible availability of clinical systems anytime, anywhere. The Lifespan wireless network was conceived as an extension of the wired network in manageability using Cisco Wireless LAN Solution Engine performance standards, and security. Total wireless saturation of the clinical space provides consistency, and a platform for new projects. Over 300 Cisco access points, more than 500 laptop carts with Cisco wireless client cards, and pervasive use of wireless-enabled PDA's, and tablets provide immediate access to data.

Commitment to bringing mobility to the entire enterprise, Lifespan designs and optimizes all applications to

run wirelessly. A technology team constantly looks for new opportunities for wireless enhancement of hospital processes, most recently RFID patient identification and a global positioning and tracking system for equipment. Lifespan takes immediate advantage of every wireless opportunity, in accordance with its Information Services plan. Lifespan drives wireless opportunities by working with vendors on custom solutions. Some items, such as our custom nursing carts, have been productized by vendors for other customers hoping to capitalize on our successes.

ORIGINALITY

Lifespan is unique in the healthcare industry for its long-term consistent strategy and completeness of execution.

The medical-grade wireless network infrastructure was conceived as an integral element of the original Lifespan IS plan in 1996. Although wireless network deployment is not unique in healthcare, the design, development, and implementation of an enterprise wide, medical-grade wireless network infrastructure is. Today, Lifespan's wireless network infrastructure covers one million square feet of clinical space and over 100,000 square feet of administrative areas. All clinical systems developed from 1996 to 2000 were prepared for through the medical-grade wireless network. The wireless network was seen from the start as an extension of the wired network, with comparable performance standards and security. Every medical device is viewed as a potential wireless candidate, if patient care efficiencies and quality improvements can be achieved.

Lifespan has driven advances in applications of wireless technology to health care. There are many examples of innovation associated with this project.

• Design of modified nursing carts, co-developed with vendors to include auxiliary batteries, bar-code/RFID readers, and retractable power cord reels. The nursing staff was given free rein to suggest features and functions. Carts went through several design iterations until the final cart design was selected. The custom carts have become the favorite innovations among nurses.
• Extension of the medical grade wireless network to physician and clinician office practices off campus, which are connected to the Lifespan extranet wide area network.
• Pilot of hotel-style wireless Internet technology to offer free Internet to patients and their families at Hasbro Children's Hospital. The Hospinet system allows patients in long-term care to surf the Internet for fun and education, and parents to keep in touch with their offices so they don't have to take excessive vacation days to be with their children.
• Co-development project with two leading point-of-care glucometer companies to design and implement wireless-capable glucometers for use with the medical grade wireless network space. These devices dramatically enhance patient care. Analysis results are wirelessly uploaded automatically to the clinical record immediately when the blood sample is taken. This eliminates an extra data entry step, ensuring that accurate readings are immediately available.
• High-speed wireless connections between buildings. These save thousands of dollars in traditional connection costs, at the same time offering increased bandwidth. We need the maximum bandwidth because diagnostic imagery is very bandwidth-intensive and a large hospital network has many simultaneous demands.
• A model of technical sharing involving vendors, clinicians, and the healthcare community. Our approach of modeling wireless installation at one affiliate and then quickly rolling out to others is usable by other healthcare institutions.
• Recognition that wireless technology is the glue to tie together process improvement initiatives. Ability to access clinical information anytime, anywhere was critical to success of the project. No other vehicle so elegantly eliminates steps from the time-sensitive process of caring for patients.
• Specialized wireless PCs for operating rooms. Movable display units can be placed on any wall to accommodate surgeon preference and the requirements of the procedure.
• Use of the wireless network for pervasive tracking of patients, staff, and assets. Lifespan is developing and testing a hospital positional system, which will use the wireless medical-grade network as a positional grid. The grid will interpret the wireless nursing carts as location transmission buoys. Position data will be wirelessly collected from RFID codes on patients and medical devices. Medical equipment may be used only intermittently, but when it is needed, it must be found "stat"(immediately). The RFID positional system will track the location in the hospital of every device, enabling staff members to run it down without delay.

The hallmark of Lifespan's innovation in healthcare mobility is its long-term strategic view of wireless technology, consistency of plan, and completeness of implementation. The wireless applications present a consistent interface from hospital to hospital and from department to department. For example, Pharmacy orders are always located in the same quadrant on the screen.

SUCCESS

Lifespan is an early adopter of wireless technology and provides a model for the healthcare industry.

The success of the original project to enhance adoption of Computerized Physician Order Entry management was extraordinary. Nationally, only one-third of hospitals have CPOE systems, but for most of those fewer than 10 percent of orders are electronically processed. At Lifespan, during the third quarter of 2004, 91 percent of orders at Rhode Island and Hasbro Hospitals and 81 percent at Newport Hospital were entered electronically. At Miriam Hospital, the adoption rate was 36 percent because implementation was still in process. The wireless network figures prominently and is largely responsible for high compliance rates among physicians. On most patient floors, the ratio of wireless to wired equipment is 7 to 1. While the extraordinary adoption rate of the CPOE application is testimony to the success of the wireless network, there are other indicators as well.

The sights and sounds in Lifespan's hospitals have changed. On all units, mounds of paper order slips on the secretary's desk are gone. In the halls, clinicians wheel laptop carts and carry tablets, always in tune with up-to-minute patient data. In conference rooms, administrative personnel wirelessly connect to network presentations, email, and Internet access. On the nursing unit where the first Vocera implementation was recently completed, the silence is deafening, with overhead paging virtually gone. This has a very positive effect on patients' ability to sleep, and removes the constant reminder to patients that they are in a hospital.

A critical success factor was the consistent application of wireless technology across the wide area network connecting the Lifespan hospitals, and extending into the physician offices that are part of the Lifespan extranet. Consistent availability and usability engender high adoption and acceptance.

Lifespan's wireless network was built very early in the technology's evolution (planned in 1996, and built starting in 2000). Other hospitals just entering the wireless arena are looking to Lifespan as a model. Lifespan has developed a model for the deployment of wireless technology to other medical institutions. This model involves the following:

- Use standards-based processes
- Integrate with current work process across the enterprise
- Establish commonalities in procedures of physicians and nurses
- Gain "buy-in" of users
- Have physicians on the core IS team providing guidance
- Establish a liaison between nursing staff and the IS department
- Send IS people into the field to shadow staff and gain insight into how they actually work
- Create a feeling of partnership between the medical staff and the IS staff.

Lifespan doctors, nurses, and patients are the best people to explain the success of Lifespan's mobility initiatives.

Physician, director of residency programs and Associate Professor of Medicine, Brown Medical School: "The resident physicians are responsible for a very high volume of patients with high turnover who represent probably the sickest patients in the institution when you take into consideration the care in the critical care areas. The wireless networking enables the residents to translate their decisions into interventions directly at the point of care, at the bedside. If not for this technology, then we would have to interrupt rounds to write orders or to set a plan in motion, whereas now we can do that without leaving the patient's room."

Physician, president and CEO, Rhode Island Hospital: "The key element in delivering the best care to patients is to have the information you need to make decisions where you need it and when you need it. There is no doubt that wireless technology has made it possible to do this right at the bedside. This results in more efficient, higher quality care."

Physician, Pediatric Residency director: "The new wireless network has given our tech savvy residents the ability to perform rounds at the patient's bedside with a tablet PC, pull up critical laboratory and x-ray information, and write orders in real time. It permits the patient and their family a more intimate role in understanding their care, and participating in planning, which is goal that we have as a family centered hospital. It is only a matter of time until all the resident's work can be done as a one-stop experience. I can hardly wait for whatever the Lifespan IS department will bring us next!"

Physician, PhD, The Miriam Hospital: "How has wireless changed my practice? Let me recount the ways! Its presence in the hospital has made my daily tasks of patient care and administration easier and far simpler. I need not find an open computer to look up information on any number of tasks each day. Having the wireless capacity in the hospital has made it possible to discuss cases with colleagues at any time--but because of

HIPPA regulations--not in every place. The ability to access information quickly, reliably and in a very timely fashion is most helpful in seeing that the care of patients is effective and efficient. Decisions are made more quickly and the entire process of care is made not only faster but now based on reliable and in some cases verified and validated quality data. It is still too early to tell if there is a measurable direct impact on patients for the system should be transparent to them at this point."

Physician, vice president for Medical Affairs, Newport Hospital: “The ability to move freely throughout the facility and remain "connected" to the information network is invaluable now and will become indispensable in the future. We currently have most inpatient information available solely online. Mobile laptops on carts, portable notebooks, and PDAs allow input and access to this data anywhere on the unit. In addition, we can move forward with other advanced patient safety technology such as the barcoded technology involved with medication administration. As we continue to move toward the totally electronic medical record, the wireless technology will permit unimpeded, advanced care at the bedside.”

Registered nurse, Rhode Island Hospital: “We’ve been part of the pilot program, and I’ve certainly found the new technology to be both patient-friendly and nurse-friendly. Eliminating the overhead paging system has been a real plus for our sick patients who want as quiet an environment as possible. For the staff, in addition to the faster communication, I think we’re getting politer communication. Two-way messaging is a lot friendlier and more humane than one-way.”

Registered nurse, clinical manager, MICU, Rhode Island Hospital: “Wireless technology has changed my practice by bringing data in a timely manner directly to the bedside so that patients’ conditions can be assessed quickly and interventions can be started sooner. These changes in technology have improved the care delivered to patients and patient outcomes.”

Registered nurse, director of Nursing Clinical Systems, Newport Hospital: “Point-of-care’ documentation has long been a goal in maximizing patient care. Now, it has become a reality, thanks to wireless technology. Whether we use our laptop carts, or for even more portability, our handheld PDAs, we are able to bring the chart to the bedside and document as we go. Vital signs are entered into the database immediately, rather than being transcribed hours later, and physicians and other caregivers have immediate, important access to point-of-care patient information.”

Registered nurse, manager of Adolescent Services, Bradley Hospital: “Nurses and milieu therapists can be in the room with the kids doing their documentation and watching what’s going on. The more eyes you have on teen-agers, the better. The technology has helped us immensely. It makes the workflow easier and makes it safer. Staff can be more flexible and not be tied to a chart in the back room.”

Patient: “Having high-speed internet access from my bed was great, I was able to instant message and email my friends. Helped pass the time."
Patient’s parent: “During the course of our son's multi-year treatments, we had numerous overnights and several lengthy stays. Having direct high-speed wireless access to the Internet from my son's room was critical in supporting many aspect of his treatment program. In addition to my son's usage, I was able to spend quality time with him and, at the same time, keep up with my on-going work and email. This enabled me to limit the number of vacation days needed, given that I was still able to be productive. Without the wireless access, I would have been using extensive vacation time and/or had to leave my son alone at the hospital during working hours. Simply stated, it made the whole experience much easier for all of us. A must for all hospital stays.”

DIFFICULTY

Flaws in wireless security standards surfaced early on as the wireless network was under construction. However, Lifespan provided the security required for a medical-grade wireless network by adopting the Cisco security protocol and applying the best practices for security developed for wired networks, including a multi-layered security and authentication system.

Acceptable medical-grade, wireless point-of-care nursing carts did not exist when Lifespan began it mobility initiatives. Lifespan partnered with a nursing cart manufacturer to design an ergonomic, medical grade, wireless laptop-equipped, mobile cart. Lifespan also had to design a method of hanging access points from ceiling tiles so they could be repositioned easily. Wireless is very sensitive to radio signal blocking, and positioning of access points has to be continuously adjusted.

Reliance on human intervention to charge wireless equipment when not in use has been difficult. An auxiliary battery was added to the nursing cart to extend time between charging sessions. Processes have been designed

to make recharging as convenient as possible.

Operating rooms needed wireless access, but there were no off-the-shelf solutions. Lifespan had to design and develop its own, wireless, diagnostic image viewing workstation for use in all Lifespan operating rooms. The resulting unit is stainless steel enclosure, small-form, enclosed PC, with a high-speed wireless network card, optimized antenna, NEMA 4 keyboard, mouse, and two 2-Mpixel diagnostic display units. The unit is mounted to the operating room wall, anywhere in the room by flexible hinge system.

Wireless coverage analysis, interference, and channel overlap issues brought new challenges to the technical staff. Rogue wireless network interference was originally suspected to be creating connectivity issues between mobile devices and the wireless network. This problem was quickly eliminated by the use of proactive, rogue detection and management tools to be sure that non-network wireless signals cannot “ride along.”

Almost every department was affected in some way by the implementation and integrating of the wireless network into their day-to-day clinical process.

Finally, in planning new RFID initiatives, the relative immaturity of the equipment and the market makes progress difficult.