A Hospital Pharmacy's Experience with Automated Dispensing Technology

Background

In October 1999 installation of the RobotRx system was completed at Sunrise Hospital and Medical Center. The promise of the system meant the conversion from a labor-intensive, error-prone process to a highly accurate and efficient automated one. Sunrise was the first hospital in the HCA Healthcare company to implement the system, and Sunrise would be used as a proving ground for the value of the system. The return on investment (ROI) had to be achieved at Sunrise before many other facilities would have their RobotRx agreements approved. The system would cost $2.2 million over five years, but promised savings of $2.7 million.

One year later the facility decision-makers are evaluating performance of the system and reflecting back on the decision to implement the system, and its impact on the operation of the pharmacy. The system was operating at a level below initial projections. Staffing to operate the system far exceeded initial estimates. Inventory was lost and unaccounted for. Data system interface errors had resulted in the loss of $250,000 in potential revenue. Errors in medication picking by the robot had occurred. And the estimated return on investment and savings was in doubt. Reliability of the system was being questioned as the department had experienced four downtimes of extended duration that affected drug distribution. In what areas were expectations met and where were they not met? What have the decision-makers learned from this experience and what direction should the facility take from here?

System Description

RobotRx is a robotic drug distribution system that utilizes barcode technology to identify patient records and medications. It is a centralized system that automates the storage, dispensing, return, restocking and crediting of unit dose, inpatient medications. A robotic arm propelled by compressed air moves along horizontal and vertical rails to retrieve medications from storage rods and deposit them in patient-identified bins or envelopes. The system uses bar codes to verify; retrieve and track the movement and location of medications throughout the supply chain from drug wholesaler to the patient.

The robot software, Connect-Rx, receives patient-specific medication and location information transmitted from the hospital information system. Operation of the robot required minimum of six computers interconnected via a Windows NT local area network. Each computer had a specific function, a central database server, two support workstation PCs to operate the robot, robot motion controller PC to direct the movement of the robotic arm, an interface PC to process data transferred from the hospital system, and a packager PC to control packager operation and track offline inventory.

Information was transferred to the robot using a series of interfaces. Information transferred from the hospital information system consisted of patient admission,
discharge and transfer data, and new medication order data, batch filling data, and billing data. The format of the data crossing the interfaces needed to be customized to the hospital specific record definition, as industry standard does not exist.

RobotRx requires uniform packaging and bar coding of medications. Information provided in the packaging included generic/brand drug name, strength, size, and expiration date and lot number. McKesson would also provide this package service based on an up-charge per dose packaged agreement.

Although the robotic technology did offer significant benefit, it had limitations that needed to be considered. The robot did not have refrigeration capabilities, so refrigerated medications needed to be handled through a manual system. Also, the robot did not have the security to store and dispense controlled substances.

RobotRx is existing technology present in approximately 150 hospitals nationwide. This technology is primarily present in larger facilities (> 200 beds), but it is increasing being justified in smaller hospitals with limited staff and services.

System quality was considered to be excellent. RobotRx was considered to be state of the art technology. At the time of the feasibility evaluation no other commercially available hospital-based systems existed. The purported benefits of the system included reducing manual tasks, reducing labor and inventory costs, eliminating medication dispensing errors, improving inventory management, increasing medication charge/cost capture.

Firm Description

At the time of the initial evaluation for the robot, third quarter 1998, Sunrise Hospital and Medical Center had 688 beds with an average annual patient census of 532. The Department of Pharmacy Services provided medications for all areas in the hospital and dispensed approximately 8000 medication doses daily for inpatients. The department consisted of 77 full-time equivalents, including 26.5 FTE staff pharmacists and 30 FTE technicians. Unit dose distribution was a manual process whereby medication orders entered into the hospital computer system generated labels for new orders or a batch fill list for existing orders to be filled for the next 24 hours. Medications were then pulled from storage bins by pharmacy technicians, labeled, and then checked by a pharmacist prior to delivery.

Medication control and distribution is an important aspect of care at the hospital. The robotic dispensing technology offered the ability to create a more accurate and efficient cart fill and first-dose process. Safety of the medication use process is a priority for the organization; RobotRx had record of no picking errors, and based on the technology, a theoretical error rate of less than one in a million picks. The existing manual cart fill system had picking error rate of approximately 0.5 to 1%, based on internal quality assurance measurements. This would improve an important operational task critical the
organization's objectives. Further, RobotRx provided the foundation to build upon with other technologies to improve safety in the medication use process.

Project Timeline

- May 1998 McKessonHBOC Automated Healthcare (MAH) is awarded a sole source provider agreement with HCA Healthcare (HCA) for pharmacy automation. The duration of the agreement is five years.
- June 1998 MAH presents RobotRx to Sunrise Pharmacy administration.
- July 1998 MAH and Sunrise personnel collect data on-site to determine the feasibility of RobotRx at Sunrise.
- Aug. 1998 Feasibility study is completed and an estimated return-on-investment is determined.
- Sept. 1998 MAH presents the first contract proposal to Sunrise administration.
- Mar. 1999 HCA and MAH agree to a RobotRx contract. It will be a model contract for all HCA hospitals.
- May 1999 Sunrise signs the RobotRx contract. The duration of the agreement is five years.
- July 1999- Aug. 1999 Central Pharmacy is renovated to accommodate RobotRx.
- Aug. 1999 RobotRx hardware is installed.
- Sep. 1999 Medication utilization database is created and interface development begins.
- Oct. 1999 Interface is tested and reconfigured.
- Nov. 1999 RobotRx commences operation of 24-hour cart fill on selected nursing units.
- Dec. 1999 RobotRx 24-hour cart fill is expanded to all nursing units.
- July 2000 RobotRx commences first dose distribution during limited daily hours.
- Aug. 2000 ROI guarantee measurement performed.
- Oct. 2000 RobotRx first dose distribution is expanded to 24-hour coverage.

Operational/Strategic Considerations

Being part of the hospital industry, Sunrise offered standardized services like many other hospitals. The quality of care is a constant taken for granted by payors and patients. And because hospital care is largely a prepaid expense through insurance premiums, prices are set contractually by private insurers or government entities and similar among local hospitals. Thus, competition among hospitals is based on non-direct patients care types of services, those considered value-added. Value-added services in hospitals are
customer service oriented include valet parking, food services, transport services, aesthetics of the facility, and courtesy and helpfulness of the staff. These services help make hospital stays more pleasant and can make the difference in the hospital a patient or employer chooses, but they are easily duplicated. With fixed reimbursements and duplicable value-added services, the success of hospitals is mostly dependent on the ability of institutions to control costs. RobotRx offered a return on investment (net savings as % of costs) of 125%. RobotRx also had the potential to address a current political and regulatory issue, medication errors.

Errors in the prescribing, dispensing, and administration of medications was a major issue facing health care, one that growing in prominence due to media coverage and regulatory focus. McKesson claimed more than 45 million doses dispensed by its robotic systems with zero errors. Although dispensing was not a major stage at which errors occurred, accounting for 8% of all errors, the bar-coding of medications required by the robot set the stage for use of technology to reduce errors at other stages in the medication use process.

Although Sunrise was not as advanced in the use of automated systems, the implementation of RobotRx would be the first of its kind in the state. The public relations and image of Sunrise as a technologically advanced facility with a focus on safety could help differentiate the facility from others. All other local hospitals were using manual systems to perform 24-hour cart fill. The manual cart-fill and first-dose processes at Sunrise were labor intensive processes, requiring 8.25 and 2.8 technician full-time equivalents (FTEs), respectively, one-third of total technician staff. Further, pharmacist time to double-check technician unit dose picks accounted for approximately 3.0 FTEs. Through negotiation with the vendor, Sunrise agreed to eliminate 12 FTEs, ten technician and two pharmacist positions. These positions were eliminated through attrition and transfer of personnel to McKesson for RobotRx operation. McKesson indicated it would take approximately 3.3 FTEs to operate the robot and another 1.4 FTEs for packaging support.

The facility had a history of being slow to adopt new technologies, unsure of their value and hesitant to radically change processes as a result of IT. Part of this reluctance was also due to poor management and acceptance of the assimilation of new IT into its operations. History of failed and underutilized implementations had made decision-makers reluctant to embrace new IT. But Pharmacy Services is one department comfortable managing, using, and experimenting with IT. The department had volunteered to be a beta site for several new software updates and knew automated systems, some of which worked and others that did not.

RobotRx would be the largest IT project, in terms of scope and dollars, Pharmacy Services had ever undertaken. Because of its cost and potential operational impact, it would require executive approval at the corporate level of the company. Pharmacy management dedicated significant resources on developing a justification and educating hospital executives on the benefits of the system. RobotRx was seen as an opportunity to promote change and reengineer the way medications were processed in the facility. The
first of a three-part implementation of technology to automate the medication use process.

Pharmacy management was committed to the success of the project. It was viewed as an opportunity to further automate the drug distribution process and provide better service to patients. RobotRx improve efficiency and accuracy, and provide cost savings. The system would introduce the use of barcode technology into the medication use process. Bar coding of medications would enable the use of other technologies to improve safety and accountability in the medication use system. Pharmacy management supported the use of technology that could reduce manual technical tasks, allowing reallocation of additional pharmacist time to direct patient care activities. Although RobotRx and other enhancing technologies primarily replaced technician labor, this technician labor could be retrained and re-skilled to displace other pharmacist-performed tasks that did not require professional judgement. Expansion of the patient care role of pharmacists had multiple potential benefits. The medical literature had several examples of improvement in patient outcomes (e.g., reduction in preventable adverse drug events, reduction in medication errors, improved therapeutic results) and cost savings when pharmacists are focused on clinical activities. Further, pilot projects at Sunrise had demonstrated positive outcomes and cost reductions when pharmacists were dedicated full-time on patient units focused on preventing medication-related problems. A secondary benefit was improved job satisfaction and retention with this practice environment. Through direct feedback, needs assessment, and satisfaction surveys the pharmacist staff had indicated this practice environment was more professionally rewarding, and resulted in enhanced inter-professional relationships.

There existed some reluctance by the end-user staff (pharmacy technicians) to utilize the RobotRx; thus, their commitment to the success of the project was uncertain. There were concerns about the robot replacing jobs and the adequacy of training and needed skills for those involved in its operation. Further, there were concerns about the split in staff that would occur as a result of the outsourcing agreement. This required reassurance of the staff involved that the MAH employees would be important part of the department and included in all hospital and departmental activities (e.g. staff meetings, celebrations).

The goal of automating this process was aligned with the business goals of the organization. Use of this technology would help address two operational objectives. The institution had struggled, like many others, with providing adequate professional staffing. There is a nationwide shortage of nurses and pharmacists, and an opportunity to reduce their time involved in the medication use process, a significant portion of their daily work, could prove particularly valuable. RobotRx was projected to save some pharmacist labor, but primarily would replace manual labor performed by pharmacy technicians. Nursing labor savings could be achieved by add-on technologies enabled by RobotRx. It would be the job of the pharmacy managers to champion this project and clearly elucidate the costs and benefits of the system to the facility.
Pharmacy management saw strategic value, not in RobotRx itself, but in the ability to use RobotRx as a foundation to add other technologies and ultimately address issues that required immediate attention, namely patient safety and staffing shortages. Dispensing errors accounted for only 8% of the total errors. Most errors occurred at the prescribing/transcription and administration stages of the process. Implementation of hand-held barcode reading devices would address many of the errors at the administration stage. McKesson offered software that worked on PDA devices equipped with barcode readers that would allow scanning of patient bar-coded wrist bands, scanning of bar-coded nurse's badge, and scanning of the bar-coded medication. This sequence of steps provided the information to assess the five rights of medication administration (right drug, right dose, right route, right time, and right patient). RobotRx can also transmit information unidirectional manner to unit-based dispensing cabinets (AcuDose).

Availability of many medications on the nursing units in automated dispensing cabinets in combination with scanning technology at bedside has the potential to improve to critical issues in the process. Medication availability at the time needed for administration provided a significant advantage over the current system where most medication required dispensing from a central or satellite pharmacy. Medication turn-around-time (time from ordering to administration) could be significantly reduced with unit-based cabinets, but this increased access to medications needed to be complimented with bedside scanning, because experience had demonstrated increased access through automated dispensing devices without commensurate control did not reduce administration errors.

High buyer power and intense competition form rivals characterize the hospital industry. There was price competition, forcing prices downward or to remain unchanged. High quality and service orientation was demanded and expected. Customer loyalty was important to continued growth. IT projects were needed to differentiate services and improve price performance. Increasing the switching cost of buyers, such as large insurers and employers, would important to customer retention.

Return On Investment

The RobotRx agreement guaranteed an ROI of at least 25%, meaning for every dollar invested in RobotRx a minimum $1.25 in savings was expected, and the projection for Sunrise was even higher at 30%. The savings consisted primarily of labor reduction (73% of the total) with minor savings in supply costs, training costs, overtime reduction, expired medications and inventory reduction. On the investment side the costs included RobotRx labor fees (3.3 FTEs), equipment and software fees, one time installation fees, barcode packaging and labels. The 3.3 FTEs for RobotRx operation were to be offset by an equivalent reduction in technician labor from Sunrise. If the minimum ROI was not achieved, the contract indicated the monthly RobotRx fees would be adjusted downward until savings were 125% of total costs.

To achieve the needed savings, Sunrise needed to eliminate 12 FTEs, two pharmacist and 10 technician positions. There were no job losses anticipated as a result of RobotRx
implementation, as many unfilled positions existed within the department. Most of the position reductions were achieved through attrition with the remainder being hired by MAH to operate the robot.

**Outsourcing Issues**

Initial proposals for the robot involved purchase or leasing of the system. As negotiations progressed, the need for an operational and/or capital lease became the preferred method. To comply with the Medicare financing guidelines and to meet financial goals of the company, a service structure was created which involved not only leasing the equipment, but also required McKesson to provide personnel to operate the system. HCA facilities considering RobotRx would have to agree to outsource their unit dose distribution process. This arrangement would allow the costs of the robot to be treated as an operational lease, rather than a capital expense. Sunrise would be the first HCA facility to enter into such an arrangement.

McKesson had not previously been involved in such arrangements and had only leased or sold the equipment. The automated division of McKesson had no experience with outsourcing services and similarly, Sunrise's pharmacy management team had had limited experience with outsourcing. With this new agreement many details needed to be considered and implemented.

The contract only dictated that McKesson would provide personnel to operate the robot, but did not address specific tasks. Because unit dose distribution was such an integral part of the pharmacy operation, it would be difficult to segregate those activities from the rest of the drug distribution processes.

MAH provided necessary expertise in robotic technology that was not available internally, but the RobotRx onsite staff did not have this experience as most of them were former Sunrise employees and none had past robotic experience. All robot personnel required introductory training on the system, but would have to learn by doing to gain full functional competence.

From a facility management viewpoint drug distribution was not a core competency, and considered an ancillary service. And the pharmacy management viewpoint it was an important and essential function, but one that was operational rather than strategic, enabling focus on strategic services. From an HCA corporate perspective, as an operational expense, it meant cost savings that could be realized in less than six months and an increased return on equity. The contract was a risk-sharing type of agreement that encouraged both parties to work together to achieve the target savings. This was the most appropriate type of agreement as uncertainty existed in the benefits of the technology, and a loose degree of contractual definition was present.

**Outcomes**
Although MAH recommended a total implementation time line of six months, pharmacy management pressured MAH to try to get the system installed and functional within three months. A major quality accrediting organization would be evaluating the hospital in November 1999 and RobotRx would be an ideal technology to display to this group. Installation of the RobotRx took three days. Development of the interface between the RobotRx software and the hospital system took over three weeks. Sunrise was the first facility within HCA to install RobotRx so there was no existing operational interface with the HCA hospital system.

The system installation was completed within the financial budget allocated for system setup. The pharmacy required renovation, which involved installation of data lines, an uninterrupted power supply, and compressed air. Installation of robot hardware took three days. The software interface between the robot software and the hospital system took an additional three weeks to be completed. The robot transmitted information in HL7 compatible format, an emerging healthcare industry standard. Data crossing the interface would be bi-directional and included patient location, admission, transfer, and discharge status, billing, and medication information (type, dose, and quantity). Even with the robot using a standard format to transmit and receive information, the interface required significant revision to ensure accurate data transmission.

RobotRx had experienced data interface errors that affected quantities dispensed and amounts billed to patients. In December 1999 it was discovered that an alteration in the data transmission and software function of the robot had resulted in the erroneous crediting of over $300,000 in valid charges for medications. This crediting had gone on for 10 days before it was discovered. Some of this activity was rechargeable, but much was not and the hospital lost approximately $250,000 in potential revenue. Periodic robot software updates had resulted in dispensing excessive quantities and missing some orders altogether. The facility notified MAH that any future updates would require prior approval and pre- and post-installation monitoring.

In October 2000 RobotRx efficiency was averaging 86%, meaning 86% of unit dose medications were processed through the robot and the remaining 14% were manually picked. Efficiency was expected to be at least 90%. RobotRx efficiency is an important issue as it directly effected the labor involved in the unit dose process. Lower robot efficiency meant additional technician time to manually process orders and additional pharmacist time to check those doses. October 2000 was the start of full processing of all medication doses entered into the hospital system. Up to that point the robot only processed orders during certain hours of the day.

The agreement required an evaluation of the ROI at six months after implementation. This process was delayed and did not occur until ten months after go-live. Once the guarantee measurement was presented to hospital administration it was discovered that it was requiring 7.9 FTEs of labor to operate the robot instead of the 3.3 FTEs originally projected in the contract. Further, the facility was unaware of the labor component because MAH had not invoiced the facility for labor during the first 10 months of operation. All other aspects of the estimated savings had met or exceeded projections.
Because of the much larger robot labor needs the guaranteed 25% ROI was not being met, pharmacy management was asked by MAH to eliminate another 0.5 FTEs of pharmacist labor to achieve the needed savings. Investigation of the labor discrepancy revealed two primary causes. The facility's patient volume had increased 9% since the original feasibility study, and MAH had not taken into account all the needed aspects of staffing for the robot (e.g., coverage for nonproductive time, administrative responsibilities).

Because in many ways Sunrise was the initial site for RobotRx in HCA, there were not other firms to consult on the unresolved issues. HCA used a proprietary system, vendor-modified from commercial system, for its hospitals, so interface requirements were unique. Furthermore, its effect on other technology that interfaced with the hospital system was not known, and would be site specific. MAH had not previously had a service agreement that required segregation of the robot staffing and thus, did not have accurate volume-based estimates of robot labor required.

RobotRx had four extended downtimes during the first 12 months of operation. Each resulted in the implementation of a downtime contingency plan, a process of manual filling and verification. Each of these downtime occurrences was related to either mechanical or system issues (e.g., server, software, hardware). Several procedures were put in place to address outstanding issues. Information system policies and procedures and restriction of access and user functionality were implemented to address interface and software issues that were encountered. Industrial engineers were brought in to evaluate the work processes and make recommendations for improvement. This team discovered redundancies and inefficiencies, including the continuation of some manual tasks from the pre-robot distribution processes. The group also recommended changes to the physical work environment to facilitate efficient tasks. Poor performance in packaging and other areas were also identified, resulting in the redefinition of work performance criteria and changing of roles. Cooperation issues between Sunrise and MAH staff were also addressed to promote improved working relationships.

Recommendations

The facility learned many lessons from the RobotRx implementation. Project management was the weakest aspect of the initial planning process and was a factor in initial problems with implementation of the system. Better initial planning and closer monitoring of software manipulations will be essential elements of future technology projects. A realistic timeline and methodical implementation would have made for a smoother transition. Extensive monitoring of data transfer across the interface should have occurred. Software updates need to be pre-approved by the facility, tested before implementation, and monitored for performance. Contracting should be more explicit to prevent conflicts when outsourcing an inseparable element of a service. Clearly defined roles and goals in the contracting process can prevent ambiguities and misperceptions. With these caveats the facility management team is exploring future technology enhancements.
Enhancements

Several enhancing technologies are planned for the future. Implementation of a high-speed bulk packager that packages at a rate three times faster than the current one, and uses much less packaging is planned. This new packager can improve efficiency of the packaging process, and, because less packaging is used, the storage capacity of the robot will increase.

Development is underway by two pneumatic tube system manufacturers and MAH to develop a system interface between the two technologies. This would allow the two systems to work together so RobotRx could dispense by patient or location directly into a tube carrier device, and this device would delivery the robot dispensed medications directly to nursing units. This would reduce much of the manual delivery of medications with the potential to increase delivery accuracy and decrease medication turn-around-time.

MAH also produces unit-based medication dispensing cabinets (AcuDose). These cabinets are located on the nursing units within the hospital and operate similar to ATM machines. The cabinets are stocked with commonly used medications with par levels set based on volume history. Nurses are given PIN numbers for identification and enter this information along with a request for the needed medications. Software that interfaces with the hospital system and RobotRx software operate the cabinet. The medication is dispensed from the cabinet with an electronic record generated of the medication, the patient, and the nurse involved. RobotRx monitors inventory in each cabinet and, rather than filling by patient, it fills needed medications by location on a regular schedule. This system has the potential to increase access to medications, provides better tracking of medication use, and decreases medication turn-around-time.

Another technology, which is being evaluated, is the AcuScan system. Bar coding of medications with RobotRx allows the use of personal digital assistants equipped with barcode readers running from a radio frequency network to document medication administration. This process involves barcode identification of the medication, patient, and nurse. Before a medication is administered the nurse scans the patient armband, his/her employee badge, and the medication. This process activates several safety checks, including right drug, dose, route and time, creates an administration record, and transmits billing information.