

**A REVIEW OF RADIO FREQUENCY IDENTIFICATION TECHNOLOGIES AND
IMPACTS ON THE HOSPITAL SUPPLY CHAIN: 2002 - 2012**

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EXECUTIVE SUMMARY

Supply costs are the second largest expenditure in hospitals, accounting for more than one third of the average operating budget. RFID technology can reduce these costs, improve patient safety, and supply chain management by increasing the ability to track and locate equipment, as well as monitoring theft prevention, distribution management, and patient billing. Findings of this study have shown that the application of RFID on medical equipment and supplies have resulted in efficiency increase in healthcare with lower costs and increased quality services. Even though the cost of RFID implementation is decreasing, the total expenditures are still significant and the return on investment remains unclear.

Key Words: RFID, Hospital, Supply Chain, Assets, Costs.

INTRODUCTION

The National Health Expenditure is expected to reach \$4.5 trillion by 2019 and account for 19.3% of the United States GDP and \$760.6 billion in hospital expenses (The Kaiser Family Foundation 2010). This worldwide trend in expense increases is worsened in the United States (US) by the shortage of nurses, physicians and skilled ancillary personnel, ineffective communication mechanisms, and inaccessibility unavailability of already existing clinical information (Bendavid and Boeck 2011). Health Information Technology (HIT) systems are now being considered as a potential means to reduce hospital costs and improve clinical performance (Munachemi et al. 2006; Andre et al 2008), however, the healthcare industry does not have a history of investing in information technology (Vogel 2003). In the near future many HIT systems are expected to be implemented as result of the mandate of the Health Information Technology for Economic and Clinical Health (HITECH) Act , which is a part of the American Recovery and Reinvestment Act of 2009 (ARRA), HITECH directs \$20 billion towards the implementation of such technologies as the Electronic Medical Record (EMR), the Electronic Health Record (EHR), and Computerized Order Physician Entry (CPOE) by 2014, and also provides guidelines for “Meaningful Use” for reimbursement and quality measurement of how HIT is implemented and used (Blumenthal 2009; Hoffman and Podgursky 2011; U.S. DHHS 2011). Additionally, the Center for Medicare and Medicaid Services (CMS) has mandated the implementation of the International Classification of Diseases 10th version (ICD-10) codes for October 2013 (DHHS 2009). The resulting financial pressures from such mandates, coupled with the economic recession, have caused many healthcare facilities to seek ways to cut costs and increase productivity.

Because supply costs are the second largest expenditure in a hospital, accounting for about 30% - 40% of the average hospital operating budget, careful and efficient control of supply spending is critical for a hospital's success (Shumaker 2009; Rardin and Jayaraman 2011). In the healthcare industry the supply chain can be a complex system that requires the adequate flow of products and services in order to fulfill the needs of the providers (Callender and Grasman 2010). Although supply chain and supply chain management have been the subject of frequent scholarly and practice-oriented literature, understanding the supply chain and its management for healthcare stands out as a particular challenge.

The healthcare supply chain has been variously defined. According to the University of Maryland Medical System (2011), the healthcare supply chain is the life-cycle processes for supplies, including the transportation from manufacturers to the point of use and reimbursement processes, whose purpose is to satisfy end-user requirements with products and service from multiple, linked suppliers. A similar, but less recent description by Schneller and Smeltzer (2006) defined the healthcare supply chain as the finances, information, and supplies involved in acquiring and moving goods and services from the supplier to the end user in order to enhance clinical outcomes and controlling costs. On the other hand, the definition of supply chain management is the planning and management of all activities in sourcing and procurement, conversion and all logistic management activities, including coordination and collaboration with channel partners such as suppliers, intermediaries, third party service providers and customers (Darling and Wise 2010).

Several conditions and circumstances serve to increase healthcare supply chain costs. Large amounts of expensive inventory are used in operating rooms such as pacemakers, defibrillators, catheters or implants; however the lack of visibility in the supply chain can result

in lost, stolen, or misplaced equipment, driving up operational costs (Kumar et al. 2010). In 2004, lost and stolen equipment cost about \$ 4,000 per bed increasing to \$8,000 when expenses incurred from out-of-place equipment were added (Davis 2004). Assuming that the U.S has about one million staffed beds it was estimated a potential loss of \$3.9 billion annually (Yao, et al. 2011).

Another significant cost driver is the universal complexity of the healthcare supply chain. It is believed that healthcare logistics is an area in which cost can be reduced and efficiencies can be gained to provide healthcare service at a reasonable cost. According to Lewis, et al. (2010) examples of unique challenges of the supply chain in the healthcare system are: products and medical devices used in procedures can be extremely expensive; inventory tracking can be highly difficult due to urgency of medical procedures, and demand in terms of types and amount of products required for surgeries can be very unpredictable due to the diversity of patients' characteristics.

While the hospital supply chain lags behind in applying the latest technology to operations, its counterparts in the retail and manufacturing industries have adopted increased automation (Chowdhury et al. 2008). Companies, such as Wal-Mart, CVS, and Target have demonstrated the relevance of Radio Frequency Identification (RFID) technology in their supply chain management, resulting in easier tracking of inventory and an increase in sales due to better accessibility to their stock using RFID's, with Wal-Mart reporting a reduction of out-of-stocks by 30% on average at selected stores (Nagy, et al. 2006; Mahdin and Abawajy 2011). Along with the determination of a proper supply chain strategy, RFID technologies are emerging as the standard for hospitals and healthcare centers to track valuable and strategic mobile assets in medical facilities, to identify and locate patients, to control pharmaceutical inventories, and to

manage staff (Fisher and Monahan 2008; Bendavid & Boeck 2011). Furthermore, the American Hospital in 2010, in response to the ARRA, has recommended a set of alternative hospital Meaningful Use objectives for the period 2011-2017, which has also included the progressive implementation of bedside medication support using both barcodes and RFID (AHA 2010).

Despite much discussion of the potential benefits from the adoption of RFID technology by healthcare organizations in research-oriented and practitioner publications, there remains a significant gap in understanding the current and future state of its application. Therefore, the primary purpose of this study is to gauge the recent and potential impact and direction of the implementation of RFID in the hospital supply chain. Beyond the stated research goal, it was thought that both potential researchers and current practitioners will derive secondary benefits of the current investigation. These include an introduction to the hospital supply chain and its significance, an introduction to RFID technology, an understanding of the ways in which hospitals are trying to reduce their operational cost in the supply chain, and some guidance on the future state of adoption of RFID.

METHODOLOGY

The methodology for this study consisted of a literature review following the basic principles of a systematic search. Given that RFID can be applied to patient tracking, pharmaceutical tracking, and device and supply tracking, the study was focused only on device and supply tracking. When completing the online research, the following terms were used: "Radio Frequency Identification" "OR "RFID" OR "RFID standards," AND "supply chain", OR "hospitals", OR "hospital inventory", OR "inventory management." A mix of databases and online sources were used to compile a set of references covering both academic research and practitioner literature. It was

believed that this approach would help create the most comprehensive and up-to-date review. The following electronic databases and sources were used: ESBCOhost, Google scholar, Academic Search Premier, Pub Med, Consumer Health Complete, CINAHL, Healthsource-Consumer Edition, Healthsource-Nursing/Academic Edition, and RFID Journal. The literature review yielded to 66 academic sources which were assessed for information pertaining to this research project.

RESULTS

Currently the use of bar codes is widespread among hospitals, but limitations of this technology are causing those concerned with the healthcare and hospital supply chain to search for other IT alternatives. Barcodes must be scanned and results coupled with manual cycle counts to reconcile supply usage and on-hand inventory (Lin 2009; Business Wire 2010). In addition, bar codes must be scanned at close range, requiring personnel to take time for scanning and relying on human accuracy (Davis 2004). Barcode technology is also limited in the amount of the data that can be stored, approximately ten to twelve digits (Pandey 2010).

In the RFID environment, barcodes and associated technology are being replaced with RFID tags and readers. The tags are essentially smart labels and, in most cases, have a chip and an antenna as their main components. The radio waves generated during the reading process are able to penetrate many materials and therefore can be employed where tags are not readily visible (Schraag 2006). RFID enables tracking and monitoring of items through the application of invisible radio waves over distances that range from less than a centimeter to those that span hundreds of meters (Butters 2006). RFID can track inventories, equipment and people in real time as the tagged item travels around the hospital (Davis 2004; Lin 2009). Information storage

capacity is much less limited, permitting as much as two kilobytes (KB) of data to be stored by a microchip in a RFID tag (Pandey 2010).

There are two types of RFID. One type of RFID, referred as “active”, can transmit information. The "passive" device can be read by a nearby RFID scanner when the tag is within three meters of it. The costs of the passive tags range between \$0.10 and \$0.50 depending on the requirements of the tags and amount of information to store (Barcoding Corporation 2011).

Active tags have an internal power source, usually a battery, and can continuously transmit and receive signals from long distances, and can store relatively massive amounts of information. The prices of the active tags vary also depending on the requirement of the tags and ranged in 2009 between \$0.50 to \$50 (Barcoding Corporation 2011). In addition to the tags, the system consists of a RFID reader, antenna, the software (middleware) and hardware necessary for communication (Ngaia et al. 2008). This RFID infrastructure can run from \$200,000 to \$1 million or more for a facility-wide RFID tracking system in a medium-size hospital (Fischer and Monoham 2008).

With the continued and evolving adoption of the RFID technology by the healthcare sector, the expected and reported benefits of adopting the latest technology are difficult to ignore, as extant statistics and findings show. Sixty-nine percent of hospital executives that responded to a survey stated that supply chain automation is an area of strategic importance for their organizations (Carpenter & Hoppszallern 2007; Kumar, Livermont, and Kumar 2010). In another study Nachtmann and Pohl (2009) surveyed 1,381 healthcare supply chain professionals and found that the average healthcare provider organization participating in this study was spending more than \$100 million each year on supply chain functions, equaling about one-third of their annual operating budget. Also, half of these professionals indicated their supply chain was

immature and loosely defined with 42% of respondents thinking that the lack of data standards was the main challenge (Nachtmann and Pohl 2009). Additionally, Callender and Grasman (2010) described the relevance of mismanagement of traditional hospital purchasing, including lack of inventory control, missed contract compliance, frequent stock-outs with costly emergency deliveries, excess inventory levels, workflow interruptions, and expensive rework.

RFID has been widely used in tracking items such as pallets or cartons within a supply chain or warehouse, resulting in overall cost reduction, improved business processes and workflow, decreased equipment cost, improved inventory management and decreased operating cost (Sade 2007; Kumar et al. 2009). In 2008 it was reported by Pleasant (2009) that healthcare incurred in more than \$11 billion in unnecessary costs as a result of inefficiency in supply management. It was suggested that the use of RFID technology can reduce these expenditures by improving patient safety and supply chain management by increasing the ability to track and locate equipment, as well as controlling theft prevention, distribution management, and patient billing (Pleasant 2009).

One area where most hospitals have spent HIT dollars is on Wi-Fi infrastructures, which may be leveraged for RFID-based applications. Technology vendors claim that by adding RFID components to existing wireless networks with little interference, hospitals could reduce the cost of building an instantaneous tracking system. For about \$100,000, a hospital could track its most critical assets by adding RFID to its wireless system (Scott 2006). In addition, it has been estimated that a 200-bed hospital could save \$600,000 each year using RFID from less shrinkage, fewer rentals, deferral of new purchases, improved staff productivity, and enhanced quality improvement (Buyurgan et al 2009). For example, Advocate Good Shepherd Hospital in

Illinois applied RFID to help manage inventory and the annual inventory losses were decreased by about ten percent (Glabman 2004).

With retail giants such as Wal-Mart and the Department of Defense requiring and mandating suppliers to begin tagging items, and the push from the FDA to tag pharmaceuticals to prevent counterfeiting, the use of RFID technology is slowly making its way into the healthcare market (Young 2005; Coustasse et al. 2010; Reyes, et al. 2012). The FDA issued a recommendation that all pharmaceutical industries implement RFID tagging of all drugs by 2007 and recently the FDA has approved RFID utilization in the blood supply chain (Wicks et al. 2006; Hohberger et al. 2011). Wicks, et al. (2006) also indicated that the leading supplier of products and services supporting the healthcare industry, Cardinal Health Inc., has been attaching RFID tags on surgical medical products to guarantee nothing would be left inside the patient during surgery.

Since RFID is expected to help reduce costs for hospitals, sales of RFID technology for supply chain applications were expected to grow about 38%, increasing from \$89 million in sales in 2002 to \$448.4 million by 2007 (Hickey 2003), with some predictions estimating growth up to \$2.6 billion in 2009 (Raths 2008; McGrady et al 2010). The growth rate for RFID hardware has decreased from over 20% in 2005 through 2008 to roughly 10% in 2009 due to the economic recession, with growth expected to continue at between 10% and 15% per year in the following three years (Nathanson et al 2009; McGrady, et al. 2010).

Several interesting examples serve to demonstrate the benefits of the application of RFID technology. The Memorial Sloan Kettering Cancer Center in New York has been using this technology since 2007 to assess inventory. They have also expanded its utilization for both asset

tracking and workflow by using active RFID to locate wheelchairs and stretchers as well infusion pumps to determine if they are in use or not (Degaspari 2011).

The Heart Center at Columbus Children's Hospital successfully implemented RFID in 2007 to enable their inventory management system to store, track, and manage the utilization of its high cost devices and supplies supporting congenital heart care, including STENTS, closure devices, specialized catheters and guide wires (Health Data Management 2007). The system used was called iRISupply, developed by Mobile Aspects, Inc., and used an RFID tracking architecture to automate charge capture, inventory management, device expiration management, and other key operational processes within the patient care setting. By implementing the RFID-based technology, the organization attempted to efficiently and accurately automate devices and supply utilization processes without using manual approaches such as paper documentation, stickers, bar coding, or button pushing. This solution was expected to create an atmosphere of cost efficiency that would directly benefit patients, as well as the hospitals (Health Data Management 2007).

In a study in 2010 in the radiology department of Massachusetts General Hospital, 13 RFID units were installed within two Interventional Radiology (IR) rooms to store and track on-hand inventory assets such as catheters, coils, STENTS and other implantable devices. The hospital was able to confirm the need and cost effectiveness of purchasing RFID technology for supply management within IR and other surgical or interventional departments. As the RFID system has the ability to remove the human factor from clinician work flow as well as eliminate manual cycle counts needed to reconcile usage against actual on-hand inventory, IR at Massachusetts General was able to achieve exemplary results. Main findings consisted of an

increase in charge capture of \$2.1 Million, 70% Reduction in stock outs, and \$ 1 million increase in cash collection (Byers et al. 2011).

Kaiser Permanente San Jose Medical Center was also a successful case in which RFID was implemented to enhance their supply chain management of a 242-bed facility handling 35,000 outpatient visits and delivering 2,225 new borns annually (Swedberg 2010). Kaiser selected Awarepoint's ZigBee-based system with access points that plugged directly into power outlets to locate assets and nurses in an area of 660,000 square feet with 35 floors of coverage. This \$500,000-value project was considered to be a holistic approach to healthcare that would benefit its patients, healthcare professionals and management by providing both managers and caregivers with better data concerning equipment availability, location, and usage. The new system was expected to save the organization \$257,000 annually by reducing theft and increasing utilization of existing equipment (Swedberg 2010).

Not only has RFID technology assisted in tracking inventory, patients, and nurses, but has also been utilized in the garment and laundry operations of hospitals. Saint Olav University Hospital in Trondheim, Norway, saved several millions of dollars by replacing its existing labor intensive system with an advanced RFID garment logistics system to track its 130,000 staff garments, such as operating robes, gowns, and trousers (Texas Instruments 2007). The hospital management authority expected savings of over six million in costs of space alone. It was projected that further savings of several million dollars in operational costs can be realized due to more efficient data collection for improved logistics management, automated ordering, and time-saving for staff because garments are much easier and quicker to find (Texas Instruments 2007).

Another case of unusual RFID implementation is in Children's Hospital Colorado where the RFID system was implemented to monitor the temperature of refrigerators, blood coolers, blanket warmers and other heating or cooling appliances, as temperature fluctuation can damage supplies such as blood, medications and food. According to the hospital reports the system has already paid for itself at least a couple of times over by reducing the labor required to track the temperatures of this supplies (Svedberg 2012).

Finally, Veteran Affairs announced in December 2011 a request for proposal for a \$550 million RFID project to equip all 21 of its Veteran Integrated Service Networks which consists of about 152 medical centers. The system may include a mix of active (mostly Wi-Fi based) and passive tags to be used in asset management, supply management, temperature tracking and surgical instrument sterilization flow management (Svedberg 2011).

DISCUSSION

Utilization of RFID in the hospital supply chain can be beneficial for hospitals that want to lower costs and provide quality services. Different studies have shown that the application of RFID tags on medical equipment and supplies have resulted in using time more efficiently. With RFID technology, hospital staff can find the equipment they need whenever they need it. RFID can also create a safer hospital environment for patients and enhance overall patient satisfaction. The safety of operating room procedures can be improved with RFID by making the count of the items on the surgical tray more reliable. Patient scheduling can be more precise with the utilization of RFID because hospital employees know where the patient is and what the waiting time is for needed services. Communication throughout the organization also can be more efficient and can result in fewer medical errors. Healthcare managers expect that this technology

solution can help their organizations by creating an atmosphere of cost efficiency that will directly benefit both patients and the hospitals.

Hospitals are looking for ways to reduce expenses due to higher healthcare costs and expensive mandates by CMS and the DHHS. Consequently, applying RFID can be the best option because it can lower the direct and indirect costs in patient care. Agility Healthcare Solutions CEO Fran Dirksmeier stated that a 500 bed hospital could save one million annually after the utilization of RFID (Wicks et al. 2006). In addition, Glabman (2004) also pointed out that after the application of RFID, annual inventory losses could be cut by about 10%. However, currently in HIT there are several expensive technologies that hospitals will need to implement very soon, like the EMR/EHR, CPOE, in addition to the mandated change of the ICD9 codes to ICD10 codes by the DHHS by October 1, 2013 (CMS 2010).

Despite the promise and potential of RFID implementation, RFID adoption has not proceeded as some have predicted only a few years ago. Even though cost of RFID implementation is decreasing, the total costs are still significant and unclear return on investment also has been a barrier to the adoption of RFID (Yao et al. 2011). Degaspari (2011) reported that RFID implementation has been slow as hospitals have dealt with budgetary constraints as well as those of complexity as the integration with the EMR or the hospital Wi-Fi environment. On the other hand, in a report provided in Healthcare Purchasing News in April 2011, the Healthcare Supply Chain Research Consortium at the W.P. Carey School, Arizona State University, identified eleven trends for 2011. Among them was an ongoing focus on improvement of the healthcare system supply chain information technology. Supply chain IT within the healthcare sector is considered as necessary to enhance performance and facilitate transparency. Additionally, there is a desire to connect the hospital supply chain to financial

systems and clinical systems, to support electronic transactions, maintain data standards, and increase the linkage of supply chain-financial-clinical outcomes. Unfortunately, cost has been acknowledged as barriers.

Despite the benefits from RFID implementation, hospitals have been concerned with buying a technology with no definite standards in place as most of RFID technologies have been mostly proprietary (Grey 2007). Adoption of RFID is currently tied to the development of identification standards. Expected benefits of applying data standards in the supply chain include reduction in supply costs, elimination of ordering and procurement errors, improvement in patient care and safety, and help in ensuring critical supplies and resources are available at the point of care. Hampering the healthcare industry's ability to improve supply chain efficiency and accuracy is the lack of industry-wide product identification standards. Inconsistent data can lead to challenges ranging from supply outages to needless duplicate supply orders. As a product moves through the supply chain, it may be given multiple identifiers, which can lead to confusion and an increased chance of errors. Use of standardized product identification codes by healthcare organizations can promote more accurate location and identification of supplies as they are ordered, received, distributed and utilized organization-wide. The advent of 'Sunrise' dates of 2010 and 2012 for adoption of the Global Location Number and Global Trade Item Number respectively, will create the need for many healthcare organizations to move quickly toward full adoption of standards (Healthcare Purchasing News 2010).

Two noteworthy gaps that will have to be bridged in the potential adoption of RFID is the ability of other hospital systems to deal with the volume of data generated through RFID use and the redundant data and duplicate readings from RFID data streams. A report from the HDMA Research and Education Foundation (2006) posits that the volume of data generated by item

level tracking of all prescription products would be ‘...astounding....’ This would of course be data generated along with additional data potentially created in device and supply tracking, a not-insignificant set of data in itself. Concerning the data redundancy several technical approaches are under development which may offer significant improvements to the RFID system (Mahdin and Abawajy 2011).

CONCLUSION

RFID has great impacts on the hospital supply chain. It will be a widely-used technology to help hospitals reduce costs by tracking equipment and increasing patient safety. Although there is some concern with this technology, particularly in the issue of patient privacy and price of its implementation, there is a general conviction that hospitals, by deploying RFID in its supply chain, can significantly reduce cost.

Healthcare system and hospitals in particular, currently are facing implementation of other mandated technologies which have been given more priority than RFID. Given the significance of cost reduction by the implementation of RFID technology in hospitals’ supply chain, it is key to understand the cost, challenges of its implementation and benefits of RFID so useful guidance can be provided to healthcare organizations.

The findings contained in this study may help inform healthcare managers of the promise and progress of the implementation of RFID technology. While definite steps have been taken by some, there remains much to be done. Government mandates, progress on standards and standards adoption, and a better vision of the benefits of efficiencies gained through the use of advanced information technology and RFID will help complete the transition to a more successful management of the hospital supply chain.

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