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MANAGEMENT OF RFID SYSTEMS IN HOSPITAL TRANSFUSION SERVICES

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ABSTRACT

Radio Frequency Identification Devices (RFID) technology is used by hospital supply chains to track various medical products and monitor inventories. To improve overall operations, hospitals have implemented RFID as part of their supply chain processes. Hospitals have also have begun incorporating RFID technology as part of their transfusion services processes. The purpose of this review was to analyze how healthcare organization supply chains can benefit from the utilization of RFID systems in transfusion services departments. The methodology for this study was a literature review following the steps of a systematic review with a total of 51 sources referenced.

RFID technology is being used to manage and track blood products from the initial donor phlebotomy to final disposition or product transfusion. Through RFID, transfusion departments and hospital supply chains have been able to manage blood samples and components to facilitate identification and transfusion of blood products to the correct patient. RFID-enabled transfusion practices have successfully increased provider productivity and product quality through work-reduction times and error reduction. A pilot study in one Iowa hospital system yielded a 3%-10% reduction in misidentification of patients and/or blood products during transfusion. A cost-benefit assessment reported showed a 5-year ROI of 2%, with an approximate pay-back period of four years. Cost of RFID tags can be 10-15 times more expensive than barcode systems. There are also risks of this technology involving privacy and the security of patient information.

Findings of this research study suggest that RFID has provided improvements in quality of care and efficiency, while initial costs, security and privacy appeared as principal barriers of adoption.

Key Words*: Supply Chain, Blood Bank, Transfusion Services, Radio Frequency Identification Devices, Benefits, & Barriers*

INTRODUCTION

Supply Chain Management (SCM) in the healthcare setting is the practice of actively managing the material and information flow within an organization in order to provide the highest level of customer service to end-users, while also maintaining a competitive advantage in overall business processes (Handfield, 2011). SCM within healthcare organizations entails the procurement of organizational products, data management, and logistics operations (Roark, 2005). Additionally, SCM involves the accurate, day-to-day operations, and efficient movement of goods throughout an organization (Handfield, 2011).

In maintaining and improving the SCM's operation processes, hospitals have begun to incorporate Radio Frequency Identification Device (RFID) technology to control, monitor, and evaluate products and goods throughout the organization. RFID technology systems utilize radio frequency electromagnetic fields to obtain data for tracking and identifying medical products and goods (RFID Journal, 2012a). RFIDs contain identification tags that enable a scanning a device (reader) so contents, location, manufactured date, order numbers, batch numbers, dosage information and shipping data can be transmitted to a corresponding data terminal (HDMA, 2004). In healthcare organizations, tags have been placed on patients, pharmaceuticals, mobile assets, and blood products. These items can be scanned with RFID reader software and tracked by potential end-users (Yao, Chu, & Li, 2012). RFID technology has allowed for increased efficiency of employees and management of product volumes stored within the healthcare facility (The Institution of Engineering and Technology, 2009).

RFID technology has slowly integrated into healthcare settings due to a lack of immediate payback in savings, and with continuous advancement, many providers do not want to invest in implementing and managing the technology (The United Postal Service, 2005). Even though there has been slow integration, several areas within health care organizations have started utilizing RFID technology. An example of RFID implementation is the process of identifying, tracking, and monitoring the status of blood products from the point of collection to the final disposition, or transfusion, of the product to patients (Kozma, Speletz, Reiter, Lanzer, & Wagner, 2011). Through RFID, transfusion departments and supply chains are able to manage blood components to facilitate the delivery of correct blood products to the correct patient (Sandler, Langeberg, Carty, & Dognalek, 2006). According to these authors, RFID enabled transfusion processes can become more efficient by simplifying verification processes.

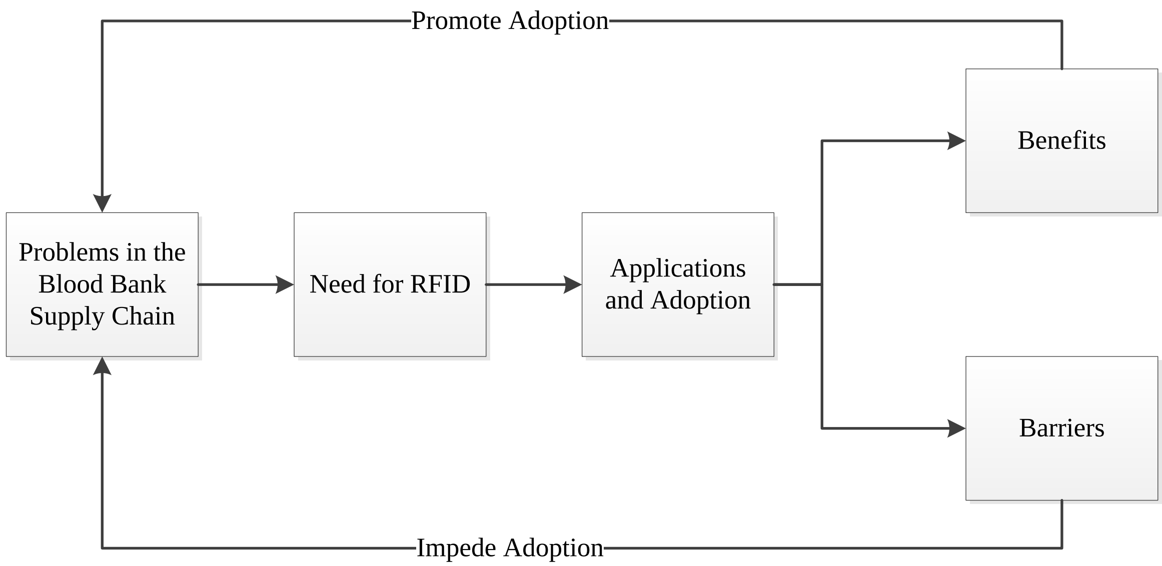
As RFID technology has been implemented in patient care areas, safety concerns exist due to emission of low radiation levels from the devices. While there have not been reports of patient injury, there is a possibility these devices can have adverse reactions for patients with pacemakers or implantable cardiovascular defibrillators (FDA, 2012). As a measure of maintaining patient safety standards, continuous testing has assessed how these devices affect patients (FDA, 2012). Conversely, studies have shown that blood products exposed to the 13.56 MHz radio waves an RFID emits has not shown significant adverse effects to red blood cells up to the 25th day of holding blood products (Kozma et al, 2011). These authors concluded that RFID enabled processes in transfusion services is a feasible option for future blood bank inventory management.

Research Purpose

The purpose of this research was to analyze how healthcare organization supply chains can benefit from the utilization of RFID systems in transfusion medicine.

METHODOLOGY

The approach for this research review followed an organized search pattern adapted from the conceptual framework of Yao, Chao-Hsien and Li (2010). The use of this conceptual framework in the current study is appropriate because the focus of both studies is to show how new technologies (RFID) can be applied to healthcare settings (Blood banks) to enhance the care of patients, as well as this approach has been successfully replicated in previous studies, increasing its internal validity (Coustasse, Tomblin, Slack 2013; Deslich, Coustasse 2014). This framework was utilized to allow clear identification of the benefits of RFID and barriers to implementation of RFID in transfusion medicine. To research problems involving the current processes in transfusion medicine, it was first necessary to recognize the existing problems and issues that drive and impede adoption of RFID with regards to blood component processing and transfusion. Figure 1 illustrates the progression to implementation of RFID in transfusion services and identifies the recognition of both benefits and barriers to adoption.



Figure

1. Conceptual Framework, Yao, Chu & Li (2010)

The methodology utilized in this literature review conformed to the principles of a systematic search. For the intent of this research query, a comprehensive and exhaustive review was not feasible due to the abundance of studies of heterogeneous quality. The literature review was conducted in three distinct stages including the following: 1) determining the search strategy and literature Identification and collection, 2) establishing inclusion criteria, scrutinizing text for relevancy, and literature analysis of the data, and 3) identification of appropriate categories.

Step 1: Literature Identification and Collection

The electronic databases of PubMed, Science Direct, EBSCOhost, ProQuest, Science Direct, Academic Search Premier and Google Scholar were searched for the terms 'RFID' AND 'supply chain' AND 'blood bank' OR 'transfusion services' OR 'benefits' OR 'barriers'. The

International Journal of Blood Transfusion Medicine, The International Journal of Medical Informatics, The Journal of Health Information Management, and other reliable healthcare websites, including those of the College of American Pathologists, Food and Drug Administration, Red Cross and the American Association of Blood Banks, were also used. Citations and abstracts identified by the search were also assessed in order to identify relevant articles.

Step 2: Establishing inclusion criteria and Literature Analysis

Given the technology- and enterprise-oriented nature of the current study, literature was selected following technological and organizational impacts of use of RFID. The search was limited to sources published in the last 11 years (since 2003) to attempt to stay current in the research study. The search was also limited to sources attainable as full texts, and those written in the English language. The methodology and results of the identified texts were analyzed and key papers were identified and included within the research query. References were reviewed and determined to have satisfied the inclusion criteria if the material provided accurate information about RFID in blood banks with a particular focus on benefits and barriers to its implementation. From a total of 94 references found a total of 51 references were selected for this research study. The literature search was conducted by BC, PM, and SD and validated by AC, who acted as second reader and also double checked if references met the research study inclusion criteria.

Step 3: Literature Categorization

The results were structured following the conceptual framework and employed the use of sub-headings including: *Background of RFID in Healthcare Organizations, Use of RFID in Transfusion Medicine, Benefits of RFID in Transfusion Medicine, and Barriers of RFID Adoption in Transfusion Medicine.*

RESULTS

Background of RFID in Health Care Organizations

Efficient SCM systems within healthcare organizations are an important aspect when providing the best patient care, while containing operating costs. RFID technology has become a $2.1 billion industry so assessing which inventory management system to use is imperative for a particular healthcare organization's effectiveness (Tu, Zhou, & Piramuthu, 2009). Through RFID systems, medical product data entry is fast, automated, and contactless via radio waves (Singh, Kumar, Kaur, & Aboul-Enein, 2008). As a result, goods can be moved faster and cheaper while being tracked in a more accurate and timely fashion (Lapide, 2004). Implementing RFIDs in hospital supply chains has allowed healthcare organizations to operate more efficiently, improve organizational quality, and increase patient-level accessibility (Revere, Black, & Zalila, 2010).

The two key components of RFID systems include tags and readers (Schwaitzberg, 2006). Tags consist of silicon microchips and antennas that receive or emit radio frequencies depending on whether the tag is active or passive (Schwaitzberg, 2006). Passive tags, costing between $0.10 and $.50 per tag, lack a power source, generally store less than *2 kilobytes* of data, and are primarily used in short-range situations where tag reading is not important (Kumar, Livermont, & McKewan, 2010). Active tags possess an internal power source and continuously transmit and receive signals further than 3 meters. Active tags, which cost between $.50 and $50 per tag, are able to store between *2 kilobytes* and *128 kilobytes* of data and are used in medium-distance and expensive situations where fast reading is needed. (Kumar et al, 2010).

As RFIDs have become more prevalent in United States (U.S.) industries, the processes to utilize these systems have also grown. In June 2003, Wal-Mart required that their top 100 suppliers to place RFID tags on each of their pallets and item cases by January 2005 (Lapide, 2004). As a result, more than 300 suppliers currently feed RFID-tagged goods to 500 Wal-Mart facilities (Songini, 2006). Additionally, The U.S. Department of Defense (DoD) began enforcing new policies in which all government vendors would be required to use RFID passive tag technology when shipping pallets and cases to the DoD's inventories throughout the country by January 2005 (Brewin, 2003). The required policy allowed for the DoD to track over 45 million line items from each of their 43,000 different suppliers (Erickson & Kelly, 2007). Policies such as these have provided other industries throughout the U.S. a foundation on which to base their RFID utilization practices.

Using RFID-enabled medical assets in inventory management and product tracking throughout hospitals has become an important part of providing patient care in a timely and effective manner (Tu, Zhou, & Piramutho, 2009). It has been estimated that a typical hospital is unable to locate about 15%-20% of its assets, which can lead to increased purchasing, increased expenditures, and lack of control throughout the network (Tu et al., 2009). In placing RFIDs on medical assets, employees can use RFID software to locate devices needed for patient care throughout the hospital by searching their location, the RFID can transmit to the user its specific information about location and product, and use can be monitored accurately (Oztekin, Pajouh, Delen, & Swin, 2010).

Use of RFID in Transfusion Medicine

In providing transfusion services to patients, there is a multi-step process of transferring blood products from donation or supply centers to medical facilities. Over 15.7 million blood donations are collected each year and approximately 30 million transfusions are performed yearly in the United States (ARC, 2014). The primary steps involved in the transfer of blood products are identification, screening, and labeling (Goodnough et al, 2009). According to Dzik (2006), the root causes of transfusion errors occur in the stages of correct identification of the blood drawn at the time of donation, the correct identification of the intended recipient at the bedside, errors in laboratory testing and screening, and error in labeling of blood samples. Goodnough et al (2009) claimed that human error is accountable for these errors and suggested that electronic technologies, such as RFID, can reduce the errors associated with blood ordering and patient/specimen identification. In a study of RFID implementation in multiple blood centers, Davis, Geiger, Gutierrez, Heaser, & Veeramani (2009) concluded that RFID-enabled transfusion practices were successfully performed and increased provider productivity and product quality.

Transfusion medicine is in the beginning stages of adopting RFID technology to support blood collection, as well as the processing, labeling, inventory, and distribution of blood products (Ralf et al, 2010). According to these authors, RFID has been used to regulate and monitor smaller samples of red cells, plasma, platelets, and other blood-related products. In the process of tracking blood samples, the blood bag and the containers used for product transport are enabled with an RFID tag to monitor the precise location of the blood product and to account for missing and unused samples (Briggs et al., 2009). A packing slip is included in the transport container and contents are verified by the receiving blood center or healthcare facility (Hohberger, Davis, Briggs, Gutierrez, & Veeraman, 2012). Once the tagged products arrive, are received in by an RFID enabled database at the receiving facility (Hohberger et al, 2012). In the event of medical emergencies, such as trauma patients with severe blood loss, blood donation and processing centers and hospital transfusion services departments are able to utilize RFID to locate and track the closest available compatible blood products to treat these patients (Boulos & Berry, 2012).

As medical error-related deaths continue to rise, it has been made a priority by the Institute of Medicine to find ways to reduce the number of these deaths (Ralf et al, 2010). In 2013, preventable medical errors accounted for an estimated 210,000 to 400,000 deaths per year (James, 2013). Throughout transfusion-related services, human errors are bound to occur due high patient volumes and other external factors (Davis et al, 2009). Integrating RFID systems into transfusion supply chains allows for the opportunity to provide safer transfusions and improve the quality of blood products (Ralf et al, 2010). According to Briggs et al (2009), RFID has been able to reduce prevalence of morbidity and mortality of patients receiving transfusions. RFID utilization in transfusion services will be able to improve transfusion medicine workflow processes through increased productivity, positive patient outcomes, and significant cost savings (Ralf et al, 2010).

Progress has been made toward the adoption of RFID in recent years. The Transfusion Medicine RFID Consortium was formed to research the use of RFID methods and devices to identify and track blood products from the point of collection and distribution to final disposition or transfusion. The consortium included representation from blood collection and processing facilities, hospitals, RFID industry consultation from middleware and information system companies (Transfusion Medicine RFID Consortium, 2012). In May 2013, the Food and Drug Administration approved the use of iTrace, a RFID device, to store and track the manufacturing data of blood products including the collection, processing, and labeling of components (FDA, 2013).

Benefits of RFID in Transfusion Medicine

As part of implementing RFID technology in transfusion services, the Massachusetts General Hospital has taken the opportunity to utilize this technology in order to prevent blood transfusion errors (Vasu, 2012). First, the patient is assigned an identification number in the form of an RFID-enabled wristband, which is used to track all patient information throughout the entire transfusion process. The patient is then taken to the treatment area where an RFID enabled mobile point-of-care trolley initially verifies the patient's identity and procedure to be performed. Staff members then scan the patient's wristband into the RFID blood data system and once the transfusion is complete, the staff member scans the tagged blood bag into data system once again to complete the process (Vasu, 2012). A similar RFID transfusion system implemented in four Italian hospitals during a 2008 pilot study has shown significant improvement in work-reduction times and error reduction by 100% (RFID Journal, 2012b). The goal of this study was to record data in order to improve upon future systems and processes to achieve perfection (RFID Journal, 2012b).

The use of RFID technology in hospital supply chains can provide multiple benefits to a healthcare organization's business operations. RFIDs can increase patient safety, speed critical treatments, reduce supply chain costs, and provide better tracking of patient drug-treatment compliance, which leads to better follow-up treatment. Benefits of using RFIDs in hospitals not only include improved supply chain efficiency, but also translate into saving lives or improving patient outcomes (Wicks, Visich, & Li, 2006).

As outlined in Table 1, the benefits of utilizing RFID systems in Transfusion Medicine have ranged from improved identification of patients and blood components to long-term savings and increased productivity. A cost-benefit assessment examined by Davis et al. (2009), showed a 5-year ROI of 2%, with an approximate pay-back period of 4 years. (Table 1) From a patient safety standpoint, RFID implementation has also been proven as a valid and logical method of increasing positive patient outcomes. Lou et al. (2011) reported that passive RFID allows for increased positive identification of recipients, and thereby a decrease in fatal transfusion reactions. As shown in Table 1, Porcella and Walker (2005) described that a pilot study in one Iowa hospital system yielded a 3%-10% reduction in misidentification of patients and/or blood products during transfusion. In addition, the Transfusion Medicine RFID Consortium (2012) noted a 33% reduction in misidentification in addition to total elimination of delivery errors and an 87% reduction in product loss. (Table 1)

Barriers of RFID Adoption in Transfusion Medicine

Although RFIDs offer healthcare facilities an opportunity to increase productivity, efficiency, and produce higher quality care and safety standards, there are risks involving privacy and the security of patient information. In utilizing lower quality tags, there is an increased probability that patient information can be accessed by unauthorized sources (Lockton & Rosenberg, 2005). Through such uses of low-quality RFID technology, the privacy and anonymity of patients is susceptible to violations regarding the Health Insurance Portability and Accountability Act (HIPAA) (Rieback, Gaydadjiev, Crispo, Hofman, & Tanenbaum, 2006). Tags do not possess the ability to verify if readers have permission to access the chosen information, which in turn, jeopardizes the tag's programmed ID, Protected Health Information (PHI), including patient preferences and behaviors, as well as, confidential health records (Rieback et al, 2006). This information can fall victim to eavesdropping if not properly protected through proper high-quality RFID tag systems.

While the benefits of RFID implementation in transfusion service management are numerous, there are barriers that hinder adoption as denoted in Table 2. Yao et al. (2010) examined the startup costs of RFID implementation in an 800 bed hospital found that initial investment can range from $20,000 to $1 million, depending on the magnitude of implementation and desired usage. Also according to the College of American Pathology, in 2005 the cost of RFID tags was 10-15 times more expensive than barcode systems (Table 2). Perhaps one of the most significant barriers to RFID utilization is the issue of patient confidentiality as identified by Jules (2006) and Lahtela (2009). In a session conducted at the 2011 Annual Meeting of the American Association of Blood Banks, concerns of RFID safety and morphological and biochemical effects on blood components were discussed. (Table 2)

Solutions to security and privacy issues in RFID technology involve de-activating or killing a tag after a patient is discharged from a facility, which prevents the tag from being interoperable with any systems after that point (Ngai, Moon, Riggins, & Yi, 2008). A Hash-Lock approach can be used so that PHI can only be accessed when a password or key is entered to verify that the reader has access to the designated tag information (Weis, 2003). Silent tree walking can also be utilized, which prevents eavesdropping from unauthorized readers to hear a signal sent to a tag from a designated reader, blocks the unauthorized reader from hearing the signal that is sent from the tag back to the designated reader (Weis, 2003). Security of RFID-enabled medical products is a potentially serious matter when PHI is involved and must be approached cautiously.

DISCUSSION

RFID technology is not considered to be a new technology, but it is new in terms of integrating this technology into health-related practices. The skepticism leaders in U.S. healthcare feel towards RFID has reflected upon the low adoption levels. As RFID technology has continued to develop and emerge as a practical way to efficiently manage goods, organizations and government agencies, such as Wal-Mart and the DoD, have required their top suppliers to utilize RFID. Wal-Mart’s and the DoD’s mandates have lead the way in developing SCM RFID system models for other industries. Wal-Mart’s and the DoD’s efforts in mandating RFID technology as part of their SCM operations has led to other industries following in their tracks, but healthcare organizations are still lagging behind (Songini, 2006). It appears that the majority of healthcare organizations have been hesitant to adopt RFID technology as part of their SCM operations due to high start-up and maintenance costs, interoperability issues, and data security standards.

RFID possesses several positive qualities in terms of patient care and employee efficiency. RFID has allowed healthcare organizations to gain access to accurate and timely PHI in order to treat patients efficiently and effectively. RFID has permitted transfusion service professionals to accurately draw blood from a donor, perform tests on blood samples, and quickly return lab results to treating physicians. RFID can aid in the reduction of clerical errors involving pre-transfusion testing and positive patient identification. The more efficient tracking mechanisms provided by RFID systems, allows for ease of inventory management and reduces product out-dating, as processing centers can monitor hospital inventories and transfer short-date products to a facility where the products are more likely to be utilized prior to expiration. The ability to readily track component availability can increase positive patient outcomes in situations requiring emergency release of blood products by streamlining inventories and transfer of products between facilities. RFID systems also make it easier to perform “lookbacks” when the final disposition information for a blood product is required due to component, processing, or donation issues that arise either prior to or after transfusion. Additionally, the chances of blood being lost within or between organizations are significantly reduced. As a result, patients are treated quickly, accurately, and effectively to reduce the amount of wasted, or unnecessary, treatment.

In the past decade, healthcare organizations have begun to implement RFID technology as part of improving their overall transfusion service processes. In utilizing RFID systems, the tags are placed on blood products after going through the identification verification processes beginning at the initial phlebotomy or donation, and ending with the transfusion of that product to a compatible recipient. The primary purpose of implementing RFID as part of providing transfusion services was to increase the provider's work efficiency, and most importantly, improve patient outcomes. The majority of research regarding RFID implementation in transfusion medicine has suggested that the positive implications outweigh the negative implications, and therefore, should be adopted by healthcare organizations.

One of the most significant benefits of utilizing RFID in transfusion services is the impact on positive patient identification by aiding in the elimination of human error. By utilizing RFID to identify recipients, the risk of misidentification of blood products and patients is significantly decreased. It is possible that many incidents of misidentification go undetected during transfusions, if the products transfused are inadvertently compatible with the recipient. RFID would make it possible to better track product and patient information and to ensure such incidents do not occur.

The two major negative implications of RFID systems account for in healthcare organizations are the privacy of PHI and system implementation. Once medical products encrypted with patient data become RFID-enabled, the data associated with that product is susceptible to privacy and accessibility issues. Though RFID tags are capable of being secured with passwords and access codes to protect encrypted data, the cost of doing so comes at the organization's expense. The expense of ensuring that patient privacy is maintained at the highest level is a major concern for healthcare organizations attempting to control costs.

In addition to the cost of maintaining PHI privacy, the costs of implementing, operating, and maintaining RFID systems can be significant. RFID systems in healthcare organization supply chains can become extremely complex to the point that healthcare organizations believe that it would not be considered a feasible technology to adopt within their organization. In order for a healthcare organization to realize the positive effects of a fully implemented RFID system, healthcare organizations must be willing to invest a significant amount of resources towards the implementation and maintenance of the RFID system.

This study was limited due to the restrictions in the search strategy used, such as the key terms searched, while researcher and publication bias may have limited the availability and quality of the research identified for review.

RFID technology in the U.S. healthcare industry could potentially change the way health services are delivered for years to come. The lack of control of healthcare costs in the U.S. continues to be a growing concern and this reviews suggest that utilizing RFID systems in the U.S. healthcare system may be a way to control health care expenditures. The adoption of RFID systems in transfusion services may only appear to be a small solution to a major problem, but one that could change the way health care is delivered. There is still much more research that needs to be done in order to evaluate whether the implementation of RFID technology in transfusion medicine is a feasible option for health care organizations supply chains to explore.

CONCLUSION

The implementation of RFID in transfusion medicine offers many benefits over current procedures utilized in the tracking of blood products from the time of donation to transfusion or final disposition. RFID technology is not without risks, with specific concern noted regarding security and patient confidentiality, as well as high implementation costs involved with RFID systems. Further research, the benefits of RFID are anticipated to lead to wide-spread utilization in transfusion medicine. As RFID gains acceptance in the field of blood banking, significant impact is expected with regards to patient safety and cost savings.

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Table 1: Benefits of Implementation and Utilization of RFID Systems in Transfusion Medicine

SOURCE	BENEFITS
College of American Pathologists, 2005	• RFID allows for accurate identification of blood products and recipients. • RFID tags eliminate transfusion error due to patient misidentification.
Porcella & Walker, 2005	• Pre and posttest of RFID in transfusion medicine, first in a pilot of 5 units in an Iowa hospital system, then in a system wide implementation. • In pilot, rate of detection of misidentified patients or blood products increased between 3% and 10%, and in the system wide implementation, the rate increased 30%.
Chang & Huang, 2008	• Pre and posttest of RFID implementation in a blood center. • Detection of misidentified blood products improved 19%.
Davis et al., 2009	• Literature review of comprehensive assessment with a cost-benefit model. • Found a 2% ROI over a 5-year planning horizon with an approximate 4-year pay-back period.
Kumar, 2009	• Pilot Study of RFID implementation and utilization. • Found an inventory savings of $150,000 through the pilot program.
Revere et al., 2010	• Overview of hospitals that have instituted RFID within their organization. • North Carolina hospital Wayne Memorial reported a savings of more than $300,000 due to RFID initiatives.
Lou et al., 2011	• Passive RFID tags decrease fatal blood transfusions by linking all specimens and procedures during hospitalization. • Higher data storage than barcodes. • Temperature sensing potential important in component storage.
Pustkova et al., 2011	• Examination of implementation of RFID to assist with visual examination and identification of blood specimens in a single hospital setting. • Increased job performance in transfusion medicine processes.
Poshywak, 2012	• Examination of implementation and realization from facilities who have already implemented new technology. • Return on investment showed the annual impact, on a 5 year projection, of more than $10 million.
Transfusion Medicine RFID Consortium, 2012	• Pilot study of RFID implementation and utilization in a blood donation center and hospital setting. • Reduced donation site misidentification and lost products by 33%, reduced final destination loss of product by 87%, increased efficiency by 63%, had zero delivery errors.
Hohberger et al., 2013	• Pre and posttest of RFID implementation in a large 700 bed academic hospital emergency room and blood and marrow transplant units. • Found the system payback period to be 2-5 years, and an increase in employee performance of 10% with the implementation and utilization of RFID.
Kotzen, 2013	• Review of Virtua Health Systems implementation of RTLS, saving an estimated $1.2 million through error prevention and employee job performance.

Table 2: Barriers of Implementation and Utilization of RFID Systems in Transfusion Medicine

SOURCE	BARRIERS
College of American Pathologists, 2005	• Cost of RFID tags can be 10-15 times more expensive than barcode systems
Juels, 2006	• Literature review that identified threats to security as rogue scanning, “eavesdropping” on either tag to scanner or scanner to tag communications.
Chao et al., 2007	• Literature review that identified barriers to RFID use as cost to implement and security concerns.
Lahtela, 2009	• Review of the structure and infrastructure of several RFID systems. • Threat to patient level data security was identified as a risk.
Yao et al., 2010	• Examine of cost to implement RFID in an 800 bed hospital. • Found the startup contribution to be from $20 k to $1 million with $1,050 per day in medication tagging.
American Association of Blood Banks, 2011	• Safety issues of using RFID. • Studies required to test RFID tag ability to survive centrifugation, freezing and gamma radiation procedures involved in processing and storage of blood components. • Possible morphological and biochemical effects of RFID tags on blood components.
Lou et al., 2011	• Additional costs involved with RFID system implementation include readers, middleware and software applications. • RFID readers can cost between $50-$3,000 each. • Software applications can range in cost from $25,000 to over $100,000 for facility-wide implementation.

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