RFID Use in Hospitals: A Business Perspective

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Abstract. RFID technology is experiencing wide adoption in a number of industries while providing numerous unique benefits to each. However, the healthcare industry has been slow to adopt this promising technology, with some claiming cost constraints, satisfaction with barcodes or lack of universal standards as reasons. This paper provides an overview of RFID technology, and discusses the facilitating and inhibiting factors for its adoption within hospital environments. It further provides an analysis of the needs and concerns of the main hospital stakeholders impacted by this technology with the goal of maximizing the potential for realizing its full promise to improve and optimize healthcare delivery.

1 Introduction

Radio Frequency Identification (RFID) is a technology that allows for wirelessly storing and retrieving data about objects using devices called RFID tags that are attached to such objects [1, 2]. RFID technology is rapidly gaining popularity in many industries as a cost-saving and information gathering tool. Some companies such as Wal-Mart have even mandated that all of their suppliers adopt RFID technology to improve their supply chain logistics.

The two main components of an RFID system are the tag and the reader: electronic tags contain memory and an antenna and readers read the data stored on the tag [3, 4]. The size of RFID tags can range from barely smaller than the size of a postage stamp to the size of a postcard [5]. A complete RFID system consists of other components such as computers, networks, databases and software applications that sort and interpret incoming data [1].

There are a number of read/write options available for RFID tags [6]. They can be Read-Write, Read-Only or WORM (Write-Once, Read Many). The data on Read-Write tags can be changed or totally overwritten by any reader. Read-Only tags are written with a code by the tag manufacturer that can never be changed. WORM tags can be rewritten once by a reader. Read-Write tags are more expensive than WORM tags and are better applied in reusable packaging systems, while WORM tags are better suited to disposable packaging systems. RFID tags can be active, passive or semi-passive [7]. Active tags have a battery that can last several years and have a

larger range and data capacity than passive tags [3]. Passive tags do not have a battery and use electromagnetic emissions from the reader to power a brief response, usually just an ID number [2, 4]. Semi-passive tags use both the battery and the waves sent out by the reader. Active and semi-passive tags are typically used for higher-value goods that are scanned over longer distances [7].

In concept, RFID technology is similar to that of barcodes, yet it is quite different. While barcodes use light and lasers to exchange data, RFIDs use radio frequency [8]. A line of sight is not necessary to read an RFID tag, as automated wireless scanning is possible at a range of 30 feet [1, 8]. Theoretically, one could read many tags simultaneously, at any orientation and in most environments [3]. RFIDs can hold much more information than a typical barcode, ranging from 96 bits to over 125 kilobytes. Other advantages of RFIDs over barcodes include its superior data reading speed and the ability to change information in read-write tags if required [8] (see Table 1 for a full comparison between RFIDs and barcode technology, including cost). These advantages for RFIDs over barcodes translate to making the capture, storage and to a certain extent the utilization of captured information less disruptive to personnel in environments utilizing RFIDs.

Table 1. Comparison of barcode and RFID technologies [6, 8, 9].

	Barcodes	**RFIDs**
Line of sight	Required	Not required
Number of items scanned simultaneously	1	Depends on technology used, potential of several hundred
Orientation-sensitivity	Yes	Low-frequency tags are less orientation-sensitive compared to high-frequency ones
Rewriteablity	No	Read-Write RFID tags are rewriteable
Security	Data can be encrypted, but no protection from being copied	Allows more sophisticated forms of data protection
Effects of outside variables	Simply needs to be physically visible to be read; Degrades with handling over time	Read rates affected by variables such as radio interference, nearby metals or liquids; More durable
Storage space	~ 25 bytes	96 bits to > 125 kilobytes
Cost	As low as 1¢ or less per unit (in large quantities)	As low as 5¢ per unit (in large quantities), to as high as $20 per unit for sophisticated active tags

Universal standards are being developed to identify particular products or assets with RFID tags through what is known as an Electronic Product Code (EPC). Based on its EPC, an item can be linked with one or more networks either on the Internet or a virtual private network where information about it exists. An Object Name Service

(ONS) sits on a local server and matches tag EPC information with other information about the item, including location. Lastly, physical markup language (PML) is the standard being used to describe product items [5].

Healthcare as a whole is currently in the exploratory phase of adopting RFIDs, and has yet to fully embrace the technology. Despite a slew of clear benefits for RFIDs in effective healthcare delivery, adoption rates have been slow so far [10]. As hospitals are a major component of the healthcare sector and as they stand to gain the most out of applying such a technology due to the complexity of their operations, it becomes important to examine factors that influence the adoption of RFIDs within hospitals in particular. It is only when such factors are fully understood and that understanding incorporated into plans for deploying this technology in hospitals that we will start seeing an improvement in the adoption rates of RFIDs within the healthcare sector.

In Section 2, we examine the motivating factors for adopting RFID technology as well barriers to its wide spread use within hospital environments. Section 3 provides a discussion of the needs and concerns of the main stakeholders that are impacted by implementing RFIDs in hospitals and ends the paper with some conclusions.

2 RFID Adoption in Hospitals

The healthcare system in many countries is facing one or more of the following problems with varying degrees of severity [11]:

   i.   Excessive waiting times for patients due to an increased load on the system as a result of an increasingly aging population in most developed countries, and limited resources (staff, equipment and facilities)

   ii. High incidence of preventable medical errors due to poor workflow management, heavy reliance on paper records, fatigued staff and insufficient or wrong information. According to the Institute of Medicine, the cost of such adverse events is approximately $17 billion in the US alone [12]

   iii. High costs of delivery resulting from inefficient utilization of resources (staff, equipment and facilities) due to poor workflow management; inability of administrators and staff to access accurate up to date information regarding operations; suboptimal supply chain management and increasing legal and liability insurance costs

Many of the above problems could be effectively addressed through using modern information technologies such as the Internet, decision support systems, and RFIDs which can all contribute to the delivery of higher quality healthcare while realizing operational efficiencies [11]. However, in general, the healthcare sector has been slow to adopt IT advances in the past, due to internal bureaucracies, resistance from key personnel and budgetary issues [1, 11]. With budgets and policies usually being developed through the ruling government, political and economic forces can also have significant impacts on healthcare budgets and consequently on IT adoption. However, this slow adoption trend is changing; as hospitals and healthcare organizations are currently investing more in technology to help reduce costs, improve patient safety and decrease wait times [1]. Below we explore the motivations and barriers for adopting RFID technology within a hospital environment.

2.1 Motivations for Adoption

As explained earlier, the main promise of RFID technology lies in its ability to wirelessly collect and transmit real time information about tagged persons or items (e.g. identity, specifications, location, etc.) which could be used to optimize operations and improve the quality of immediate, short, medium as well as long range decisions. Fig. 1 shows the value network for the healthcare industry depicting the its various parties and their interactions [11]. RFID technology has the potential to optimize many of the interactions within a hospital environment (shown within the dashed line in the figure). Such interactions are labelled with an "R" symbol in the figure. Within a hospital environment RFIDs' added value can come in measurable forms like personnel savings. However, it is also the intangible factors, such as gains in efficiency and improvements in safety that can bring about value to hospitals [1].
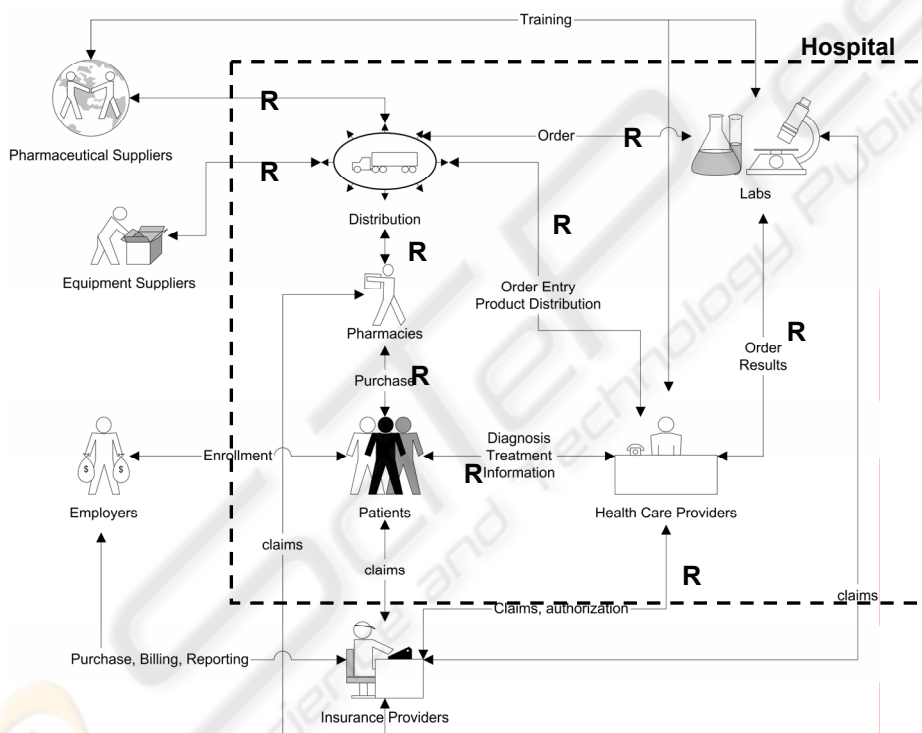

Fig. 1. Healthcare value network (adapted from [11]) (interactions where RFID technology could add value are labeled with "R").

The potential benefits of using RFID technology within hospitals stems from its ability to support the tracking and better management of patients, staff, equipment/asset, drugs and other supplies. Table 2 outlines a summary of the various hospital applications that become possible by tagging people or items and the resulting potential benefits of such applications. It should be noted that the benefits listed in each row of Table 2 do not have a one-to-one correspondence with the

applications listed in that row. Although implementing some of the applications will result in realizing some of the listed benefits, it is when all of the listed applications are implemented that the full potential of RFID technology is realized.

Table 2. RFID applications and benefits in hospitals.

Who/What is Tagged	Applications	Potential Benefits
Patients	Identify patient Locate patient Match patient to procedure Match patient to drug/blood Track patient history Control access to secure locations	Reduced wait times Less medial errors Lower delivery costs Lower legal costs Increased safety Increased security Increased patient satisfaction
Staff	Identify staff Match staff to patient/procedure Locate staff Track staff history Control access to secure locations	Reduced wait times Reduced medical errors Lower delivery costs Lower legal costs Increased security Increased staff satisfaction
Equipment/ Asset	Locate equipment Track use history Ensure quality Optimize maintenance schedule	Reduced theft Reduced hoarding Reduced wait times Reduced wasted time of staff Reduced equipment operating costs Lower delivery costs Lower legal costs Increased patient satisfaction Increased staff satisfaction
Drugs	Verify authenticity Locate drugs Check expiry date Verify patient compliance Track use	Optimized supply chain Decreased adverse effects Secured drug stock Lower drug costs Lower legal costs Increased patient safety Increased staff satisfaction
Supplies	Track inventory Coordinate orders Check expiry date	Optimized supply chain Lower product costs Lower legal costs Increased patient satisfaction Increased staff satisfaction

Below we explore the above potential benefits of using RFIDs within hospitals in more detail grouping them where applicable and outlining various examples for each:

(i) Patient and Staff Management: RFIDs are being used to track the positions of patients, staff and equipment to help better manage resources. This is especially useful during mass casualty events, when RFIDs can collect information and communicate it to personnel quickly and accurately [13].

A hospital in Bologna, Italy is currently using RFID tags for patients in need of blood transfusions. If the tags on the patient's wristband and on the blood unit are a match, then the blood is automatically released through a wireless electronic seal. This greatly reduces any chance of human error in such procedures [14].

A hospital in Taipei, Taiwan has installed field generators throughout its facility and equipped its staff, patients and instruments with RFID tags. When tagged people or equipment passes through the different field generators, their positions are logged and tracked using a separate software program. The technology also has a security component, restricting access of people and equipment to certain areas, and sounding an alarm if an unauthorized person enters a restricted area [1].

The location tracking capabilities of RFIDs could also be of great advantage in controlling the spread of infections in pandemic situations by tracking which patients and healthcare providers were in close proximity to infected patients [15].

(ii) Equipment/Asset Management: RFIDs can facilitate the tracking of equipment location and use history. This reduces the time spent by personnel searching for equipment as well as discouraging hoarding practices by staff trying to ensure the availability of equipment for their own use. RFID tagging also provides for reducing the incidence of under utilization, theft and loss of equipment [16]. Other benefits in this area include ensuring that equipment has been properly sterilized as well as making sure that all surgical instruments is accounted for following surgeries which greatly reduces the incidence of leaving such instruments in patients during operations [17]. For example, a medical center in Virginia, USA has used RFID tags on 12,000 pieces of equipment at its three facilities and documented benefits such as capital avoidance, and higher utilization efficiencies. Additionally, nursing staff are reported to have saved 30 minutes per nurse per shift due to not having to spend as much time searching for equipment [18].

(iii) Drugs Management: Healthcare organizations are increasingly concerned about drug counterfeiting due to its adverse effects on patient safety. Pharmaceutical companies are also concerned with this problem due to their severe financial losses to counterfeit drugs. RFID technology is being utilized to address this problem through its tracking and tracing functions [19]. Similar to the retail industry, currently tagging drugs is mostly at the pallet and case level, but plans are in place to have item-level tracking in the very near future. Starting 2007, any drug company that wishes to export to the US must be RFID-compliant [19]. Pfizer has has already begun shipping RFID tagged pallets, cases and bottles of frequently copied and stolen drugs like Lipitor and Viagra [20].

Within a hospital environment RFID tagging could be used to locate, authenticate and ensure that drugs are within their expiry dates. It could also be used to scan prescriptions and send them to hospital pharmacies to reduce the incidence of prescription errors due to poor hand writing [21]. In the US, hospitals are impacted by pharmaceutical Pedigree laws to ensure the authenticity of drugs. These laws vary by state and can be very labour intensive to comply with [22]. RFIDs can automatically

build an electronic pedigree (e-Pedigree) that documents a drug entire life cycle from manufacturer to end-user [23].

(iv) Supplies Management: Hospitals could benefit significantly from using RFID technology to improve their supply chain management operations. Within a hospital environment, lack of visibility in the supply chain and decentralized ordering practices results in erratic inventory shortages or surpluses with obvious implications to patient experience and financial bottom lines. Such problems could be greatly reduced through RFID tagging which would allow each item to be tracked regardless of location [5]. This opens the way for real-time inventory management which leads to improved replenishment, shorter order-cycle times, in-transit tracking of items, more accurate forecasts, and increased flexibility in responding to sudden surges in demand for particular items [5]. It also allows hospitals to better manage suppliers' relations including allowing suppliers to manage hospital product ordering and inventory levels [24].

The benefits within each of the above categories can also be classified in terms of hard and soft returns. For example, in terms of asset tracking, "Allowing nurses to find equipment more easily" leads to "soft returns" of "labour savings" and "increased patient and staff satisfaction". In terms of patient tracking, "Reduced risk of lost patient" leads to the "hard return" of "cost avoidance" [25]. Classifying RFID benefits in this way can be beneficial for creating the business case for it. For example, showing that being able to find equipment more easily makes nurses jobs less stressful and that reducing the risk of lost patients results in less resource spending and lower legal costs, can make the argument for RFID technology clearer and easier to grasp.

2.2 Barriers to Adoption

Despite the aforementioned benefits and applications of RFIDs in hospitals, the technology has been experiencing a sluggish rate of adoption [10]. Several reasons have been given for this slow adoption rate. Some studies indicate that healthcare providers are happy with bar coding and see RFIDs as something that will be further off in the future. Others say that organizations may not have invested in barcodes yet and feel that RFIDs are beyond their reach or feel that the Internet will preclude the need for either technology [10].

Below we summarize the main impediments of adopting this technology within a hospital environment:

(i) Cost: Similar to other industries, cost is cited as a chief barrier to adoption, with surveys showing 57% of large healthcare organizations saying that a lack of available funding is a major hurdle and 46% saying that the cost and return on investment of RFID tags and readers are a major issue [26]. It is important to note that the costs associated with implementing RFID technology exceed the simple costs of tags and readers and include the costs of applying tags to objects, implementing new applications, system integration, as well as training and reorganization [5].

(ii) Lack of universal standards: The same survey above also found 60% of respondents had delayed some RFID activities while they wait for industry or government guidance on standards. Some organizations are likely to wait until healthcare-specific standards have been evaluated and implemented elsewhere [26].

(iii) Integration issues: Another challenge relates to effective integration of this technology within organizations. With many hospitals still using the barcode system for tracking, moving to RFID tagging will require changes in business processes to integrate the new technology successfully. This will result in conversion costs (including consultants), reallocation of staff, additional hiring, and maintenance contracts [9]. Aside from the substantial associated costs, there are the obstacles of obtaining buy in from various user groups as well as the cost of training them on the new technology and processes.

(iv) Physical/hardware issues: Significant physical issues are involved, such as the details of antenna configuration, environmental conditions and interaction of product materials with tag materials. Other operational decisions include deciding the best location to place the tag on a case or pallet, the best locations for placing antennas, and locations within the value chain where data should be captured automatically [27]. One must also ensure that RFID devices are not interfering with other medical equipment in the hospital [2].

(v) Data/software issues: The volume, cleansing and analysis of RFID-generated data other major concerns when implementing RFID solutions within hospitals [21]. Such data would have to also be integrated with legacy data bases and applications. Extensive testing would have to be undertaken to ensure the reliability and security of new and existing applications utilizing this data.

(vi) Privacy and security issues: Finally, the privacy and security impacts of RFIDs are still unclear at present, which may be acting as a deterrent for some organizations [5]. There has been some outcry from civil libertarians and human rights activists regarding personal data being held in RFID tags, which theoretically could be gathered by 'snoopers' [3]. The introduction of any new, unfamiliar technology naturally leads to the perception of risk. However, until the true risks of RFIDs are discovered (whether privacy- or security-related), it is likely the perception of risk will continue to act as a barrier to RFID adoption [5].

3 Discussion and Conclusions

In addition to addressing the above barriers to implementations, the success of RFIDs within a hospital environment will depend on the extent to which it satisfies the needs and addresses the concerns of its main stakeholders. The main stakeholders who will be impacted with RFIDs within a hospital environment are outlined in Table 3 along with their potential benefits, and concerns in using this technology. The understanding derived from this stakeholders' analysis is key for the successful deployment of this technology within hospitals. It is important to note that members

of the same stakeholder's group might have varying needs/concerns based on where they are assigned within the hospital as well as the needs/concerns of other stakeholders that interact with them.

Table 3. RFID stakeholders at Hospitals: Benefits and concerns.

Stakeholder	Benefits	Concerns
Patients	Lower Wait times Increased convenience Increased Safety Increased Security	Potential loss of privacy
Nurses	Less time searching for patients, doctors and equipment Access to better patient information Optimized schedules Less paper work Lower incidence of medical errors Lower liability exposure	Learning new applications Coping with new processes Potential loss of privacy
Doctors	Better patient information Increased efficiency Optimized schedules Less paper work Lower incidence of medical errors Lower liability exposure	Learning new applications Coping with new processes Potential loss of privacy
Administrators	Workflow improvements Increased patient throughput Improved staff scheduling Better inventory management Better Asset/equipment management Lower legal costs Access to real-time up to date information Optimized Supply chain	Implementation costs Risks and costs of Implementing new processes Lack of universal standards Cost of training staff Managing privacy concerns Coping with regulations

RFID technology use is growing, as current users find more applications for it and new organizations and industries begin to adopt it. Its development in the healthcare industry may be slower than in other others, but with falling prices and more data becoming available from various health pilot studies, the barriers to adoption are continuing to fall. By recognizing the needs/concerns of the various stakeholders in a hospital environment and adopting best practices in implementing and rolling out this technology [28] hospitals can better realize the full suite of advantages it affords.

Acknowledgments

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