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Using RFID to Improve Hospital Supply Chain Management for High Value and Consignment Items

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Abstract

This paper presents a radio-frequency identification (RFID)-enabled traceability system for the management of consignment and high value products requiring item level traceability in a hospital environment.

The solution can be considered (i) as an alternative to RFID-enabled cabinets used in the replenishment of consignment and high value supplies in certain operating rooms, cardiac catheterization laboratories and interventional radiology departments, or (ii) as a complementary solution facilitating the tracking of medical devices removed from RFID-enabled cabinets. In short, the end-to-end traceability of medical products in the healthcare supply chain can be significantly enhanced.

Keywords: RFID; Hospital; Health care; Supply Chain Management; Business Process Reengineering; Traceability; consignpment; high value

1. Introduction

1.1. Health care's current challenges

> *"The [province's] health care system's expenses rose from 31% of total program expenses in 1980 to 45% in 2010. At that rate, the province's health care budget will account for two thirds of program expenses in 2030 [1]."*

This quote is taken from the budget speech delivered by Québec's Minister of Finance before the National Assembly. Although it is taken from a local Canadian context, it represents a global trend for health care services where the health system's share of program expenses is constantly rising.

As is the case in several other developed societies, Québec's population is rapidly aging. In 2008, its population included 7.6 million people (23% of the Canadian population). Since the early 1980s, Québec has been in a favorable period in terms of its ability to support individuals deemed to be dependent such as those under 15 years of age and those aged 65 and older. However, the baby boomer generation is now reaching retirement age, consequently increasing the dependent population [2]. The 2010-2020 period will see an acceleration in the aging of Québec's population, with the proportion of elderly increasing from less than 16% in 2011 to nearly 27% in 2031. The government already allocates almost half of its provincial budget (44.7% or $29.97 billion) towards providing health services and adapting them to the new realities and new needs of "the market" [3]. Specifically, in 2007 hospital expenses accounted for the most important category at 28% of the

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total expenses; other medical institutions 15%; physician expenses 11%; other professionals 9%; prescription drugs 20%; long term assets 5%; public health 4%; and administration 3%; [4].

The increase in health care expenses is not a local phenomenon and is also present elsewhere as illustrated with American data. According to the 2009 US national health expenditures, projections were expected to reach $2.5 trillion and grow 5.7% [5]. In terms of GDP share, it is expected to have reached 17.3% in 2009 and by 2019, national health expenses are expected to reach $4.5 trillion and represent 19.3% of GDP. Hospital expenses are expected to reach $760.6 billion; physician and clinical services expenses will account for $527.6 billion; prescription drugs $246.3 billion; nursing home care expenditures $144.1 billion; and home health care expenditures $72.2 billion. Again, hospital expenses account for the most important category.

This worldwide trend in expense increases is worsened by an increasing shortage of doctors, nurses and skilled ancillary personnel, undue work pressure, ineffective communication mechanisms and already existing but unreadily available clinical information [6]. The conclusion we can draw from health care's current challenges is that the system will increasingly be burdened by additional structural costs while its limited resources cannot be expected to keep up with demand. New methods must be encouraged to utilize existing resources more efficiently, especially in hospitals because they represent the most important national health care expense category therefore where the biggest potential savings can be found.

1.2. Supply chain management in health care

Reducing waste in health care system and improving its efficiency is therefore a global challenge, highlighting the need to identify any source of potential improvement and leverage on any tool, technique, methods and technologies to improve health care delivery and services around the world. With most of the expenses of hospitals tied to patient care activities, hospitals can certainly improve their clinical practices while controlling their costs by better managing their labor, supplies, equipment and facilities.

The nature of health care presents some unique challenges for adopting and using IT to improve work practices and the delivery of key services. (i) Products and medical devices used procedures can be extremely expensive. (ii) Demand in terms of types and amount of product required for procedures can be highly unpredictable due to the diversity in patient characteristics (iii). Inventory tracking can be difficult due to the urgency of medical procedures. (iv) Product expiration and tracking issues caused by a lack of accountability for products managed under a consignment process [7].

The objective of this paper aims at addressing this specific issue by presenting an RFID-enabled system for the management of consignment and high value products that require item level traceability in a hospital environment.

2. Literature Review

2.1. Reducing "waste" in health care: a leaner perspective

"Lean thinking", initially introduced in the automobile manufacturing sector [8] consists in eliminating "waste". It has now crossed various sectors and diffused into the health care sector – suggesting that "the Toyota way" could lead to health care excellence in terms of increased efficiency and quality improvement [9,10]. In fact, interest in the application of this improvement approach within the health care sector has grown significantly in the last few years [11] where activities that do not add value to patient care are now scrutinized. For instance, the Virginia Mason Medical Center in Seattle, Washington, may be one of the most cited examples of a health care organization that has reviewed its processes according to lean thinking, and witnessed a dramatic improvement in their operations. Among the researchers that have been studying the adoption of lean concepts (i.e. Kanban, 5S, Jidoka, visual control and Poka yoke) on the optimization of processes related to the delivery of care, [12] suggest that RFID technology can enhance actual replenishment methods and lead to lean health care by combining the two-bin kanban replenishment system with RFID technology – i.e. increase the efficiency of hospital processes and reduce various types of waste such as surplus inventory, expired products, and unnecessary staff movements. Although not formally linked to lean health care, similar findings were discussed by Bendavid et al. [13] in a case study of a hospital nursing unit that had evaluated an RFID-enabled two-bin e-kanban replenishment system. The authors explain how important benefits can be derived from time savings that

can be transferred to patient care activities combined with a significant reduction of on-hand inventory at distributed storage locations. In fact, among the technological solutions available to increase health care efficiency, recent improvements to RFID technology and supporting applications offer a great potential for hospitals who wish to improve their processes.

2.2. Reducing "waste" in health care: an SCM perspective

In terms of logistics activities, Chow and Heaver [14] suggest that approximately 46% of an average hospital's operational budget is related to logistics activities. Breaking down these cost proportions more precisely logistics expenses can be distributed as follows: 27% for the cost of supplies, 4% for time spent by clinical staff on logistics tasks, and 15% for employees assigned to logistics duties, including material management, nutrition and laundry staff. Although more conservative, a more recent report from the Ontario Buys & Health care Supply Network [15] indicates that the logistics function (purchase and supply of goods and services) represents more than 20% of a hospital's total operational budget, accounting for hundreds of millions of dollars per year. The fact that hospitals have not yet taken advantage of supply chain opportunities [16] suggests that financial priorities and project portfolio management should be re-evaluated. Given the relative impact of these costs on the overall operating budget, the constantly growing expenses due to the increasing cost and use of supplies, and the limited automation solutions normally in place, a potential exists for significant cost savings. Therefore, one untapped way to reduce operating expenses is for hospitals to address supply chain management inefficiencies by leveraging automatic data capture technologies and supply chain automation solutions. More specifically, when looking at specific product categories, consignment and high value products may represent an interesting niche for improvement.

2.3. RFID applications in health care

The health care sector is positioned as a fruitful emerging market for RFID. This market for RFID tags and systems is expected to rise rapidly from $94.6 million in 2009 to $1.43 billion in 2019 [17]. This increase is primarily due to maturing of applications such as the Real Time Locating System (RTLS) for asset, medical staff and patient tracking. In the pharmaceutical sector, RFID initiatives targeting item level tagging of RX drugs and other medical disposables are also driving the adoption. Of note, the tagging of blister packs and plastic bottles used by patients is primarily a U.S. phenomenon, driven by the need for improved anti-counterfeiting, but also for theft deterrence, improved stock control and enhanced product recalls.

RFID is still a relatively young market with good growth potential; still, the overall picture of RFID in health care is nuanced as health care providers "do not care about the technology, but about costs and functionalities" – that is the applications that can be improved with RFID technologies [18 p13]. The authors also suggest that RFID applications found in hospitals mainly focus on logistics and operational management, with different adoption perspectives from the US (driving cost reductions) and Europe (focusing on quality of care). Although conflicting, as presented in this study, we do think that these two views are not necessarily incompatible. More specifically six areas of RFID applications are clearly emerging in the health care sector to enable a safe and secure health care supply chain [19], namely: (i) IT and Medical Asset Management, (ii) security and access control, (iii) patient safety and management, (iv) employee management, (v) supply chain management & condition monitoring, and (vi) toxic waste management. Although RFID shows tremendous potential to enhance the efficiency of the health care medical supply chain [20], in this industry, it is an often neglected activity which deserves much more attention [16].

2.4. RFID-enabled cabinets & smart shelves

As per their requirements, traceable consignment and high value products need to be uniquely identified to allow traceability and as such lend themselves to perpetual inventory mode. In order to allow end-to-end traceability, each product transaction (e.g. receiving, storage, consumption, and disposal) needs to be captured and associated to its unique ID. By leveraging its wireless automatic identification and data capture (AIDC) features, RFID technology can facilitate product tracking of the products and conciliation with suppliers through a notice of consumption.

In order to manage high-value products, several hospitals are adopting RFID-enabled real-time inventory management systems such as RFID cabinets or "smart" shelves. Companies like Wavemark, Mobile Aspects,

Stanley InnerSpace, Terso Solutions, CareFusion and Omnicell offer such products to help organizations control inventories and keep products in continuous stock [21]. Basically, each cabinet is equipped with a reader and accompanying software that records each transaction and such information as what was removed, who removed it and (eventually) for which patient the product is intended. Some solutions also include an application for collecting data from RFID personnel identity cards before providing access to the storage cabinet. When integrated with the Hospital Information System (HIS), real-time data captured can feed the clinical documentation system, improve expiration date and recall management and eliminate the need to maintain excess inventory because staff know exactly how many high value products are available in the hospital. An alternative traceability approach with lighter technology requirements would be to capture the product data at the point of entry and consumption presuming of the availability of the supplies in between.

The next section presents a passive HF RFID-enabled traceability system for consignment and high value products with lighter technology requirements than RFID-enabled cabinets and smart shelves. While the following system is presented in a closed-loop context (within one room of one hospital), suppliers can be included in the replenishment process when the HIS is linked to an inter-organizational system (IOS) in order to automate electronic data interchange (EDI), i.e. to support electronic document interchange between health care supply chain members.

3. The RFID-enabled Traceability System for consignment and high value items

This section initially describes the RFID-enabled system designed for the management of consignment and high value products that require item level traceability. Then the optimal replenishment process that ensues from the system is presented.

3.1. RFID-enabled receptacle for the management of traceability items

The RFID-enabled system is shown in Figure 1 and is composed of:

- Mobile hybrid RFID/bar code reader
- RFID printer
- Tags affixed to consignment/high value item packages
- RFID boards
- A reader and its antenna embedded inside a receptacle to automatically initiate data collection as a package is disposed of during a surgical procedure
- A middleware system that analyzes the data and, based on defined business rules, transmits the replenishment order to the hospital's ERP.

The RFID-enabled process for consignment and high value items functions as follows (Figure 1):
(a) Once a product is received, the store employees scan the manufacturer's barcode on the package to capture related information on the delivered product (e.g. manufacturer's product number, serial or lot number, expiry date). The captured data is transferred to the middleware in real time to retrieve specific information such as the internal product number, internal product description, requesting department/specialty, and the specific storage location where the product needs to be put away. (b) An RFID printer automatically prints a removable self-adhesive label that contains a unique RFID transponder. Relevant product information is also printed on the label, including its storage location. (c) The RFID label is then affixed to the product packaging. (d) When delivered to the user department, the product is swiped in front of the RFID board (antenna) to update the application database. This action records the time that the product was delivered to the user department and confirms that it is ready for use. (e) The product is then put away in a specific storage location - for instance, storage location W, shelf X, level Y, bin Z. (f) When the product is required for a specific procedure, the product is picked and (g) given to the doctor to be used. (h) The empty RFID-enabled package is then disposed of in the RFID-enabled receptacle directly located in the procedure room, with the product ID recorded in the RFID label

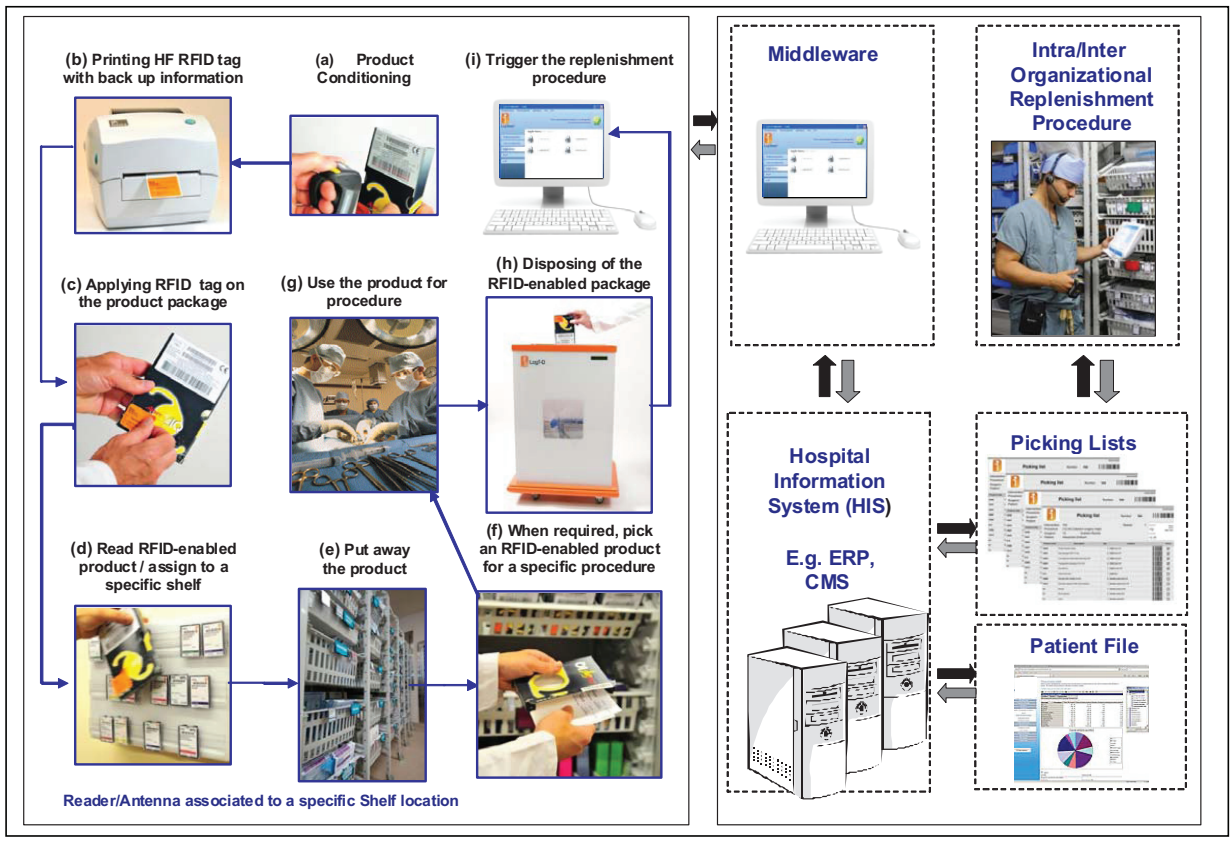

Fig. 1: RFID-enabled solution for the management of traceability items

automatically captured and transmitted to the middleware hosted by the HIS. (i) This registration automatically creates a replenishment request transaction. In order to ensure tracking and matching between the product, the patient, and the surgical procedure, the information captured by the receptacle can be transferred to the clinical management software (CMS) application and provide clinicians (and administrative staff) with all of the required information for updating the patient file or for charge capture (i.e. billing application). When an empty package is subsequently disposed of in the RFID-enabled receptacle, the process is repeated and consistently provides real time management of consumption of supplies related to specific procedures.

3.2. Optimal Replenishment/Traceability Process

Figure 2 presents the optimal replenishment process for traceability items in an operating room. Any time an item is used for a specific procedure and its empty RFID-enabled package is disposed of in the RFID-enabled receptacle in the procedure room, the replenishment process will be triggered by automatically transferring the captured information to the inventory management application hosted on the HIS (see Figure 1). The automation of this process has a direct impact on the administrative clerks, who are no longer involved in the process. The electronic requisition order is now completely automated, freeing the purchasing department of non-value-added activities such as data gathering, filling in order requests, completing, faxing and filing paper requisitions, etc.

Once the purchasing process is triggered, the products are delivered by the suppliers on a regular basis, according to the type of products involved. Upon receipt of the supplies, traceability items are subject to a verification by the storekeeper, as the packages are not tagged yet with RFID labels. Within the redesigned process, a conditioning step is added before items are put away in their corresponding locations, self-adhesive (smart) labels containing RFID transponders are affixed to the product packaging, initiating the traceability process.

4. Conclusion

This paper describes an RFID-enabled system designed for the management of consignment and high value products that require item level traceability and its resulting redesign of the replenishment process. The solution can be considered (i) as an alternative to RFID-enabled cabinets used in the replenishment of consignment and high value supplies in certain operating rooms, cardiac catheterization laboratories and interventional radiology departments by enabling the tracking of items from reception to consumption, or (ii) as a complementary solution facilitating the tracking of medical devices removed from RFID-enabled cabinets by adding the level of consumption traceability and associating it with a specific medical procedure and patient. In short, the end-to-end traceability of medical products in the health care supply chain can be significantly enhanced.

Three main categories of potential savings could be derived from the redesign of the replenishment process, namely: (i) productivity gains for logistics processes, (ii) inventory shrinkage, and (iii) non-recurring inventory-related savings. Potential productivity gains can be measured in term of time savings related to material management tasks performed by nursing staff and ancillary personnel. This category of saving could have a direct impact on patient care. Inventory shrinkage is another potential savings category that seems particularly relevant for the types of products within the scope of this paper, as a small discrepancy can rapidly become very costly (e.g. expired products, unused products in the operating room, products no longer used, etc.). A third potential category of savings is related to the reduction in inventory levels which are based on the improved visibility of consumption offered by the RFID-enabled replenishment system.

When the health care supply chain members are included in the replenishment process through the use of EDI, many other benefits can be derived such as (i) rapid, efficient and accurate automatic electronic transmission of business data between health care supply chain members, (ii) improved data accuracy in a number of supply chain processes from production to point of care, and (iii) reduced time spent on administrative and clerical duties, allowing more time to be dedicated to the main priority - patient care.

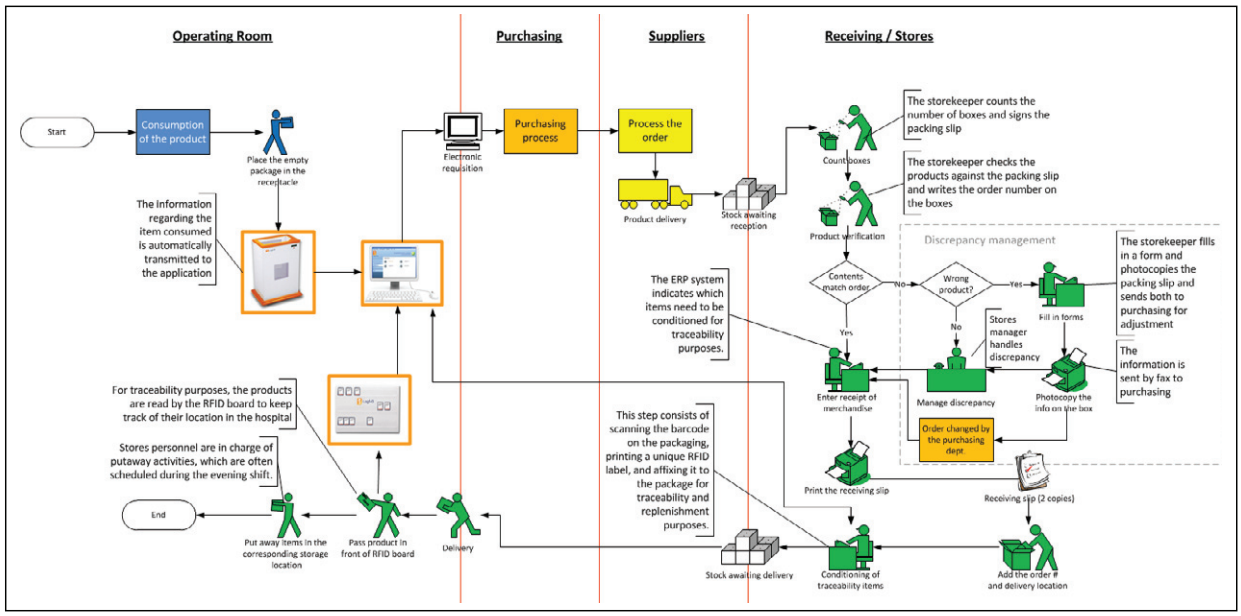

Fig. 2: Redesigned replenishment process for consignment and high value items with RFID-enabled system

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