

## Gaining Deeper Insights into RFID Adoption in Hospital Pharmacies

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*RFID holds the potential to fulfill more completely what is known as the five rights of medication management (right medication, right dose, right time, right route and right patient) and strengthens the security of patients. By automatically tracking and tracing in real-time medicines and doses, RFID also improves the pharmacy efficiency and accuracy, increases inventory visibility, reduces inventory costs, ameliorates the readiness of purchase orders, decreases supply cycle times and reduces manual labour. Moreover, it supports reverse logistics activities. Despite these alleged benefits, RFID adoption in hospital pharmacies is slow and remains under investigated in previous research. The purpose of this paper is twofold: first, to seek further explanations in the rate of RFID adoption in the specific context of the hospital pharmacy; second, to identify and analyze the critical factors that foster or hamper such adoption. The empirical evidence gathered from a field research conducted in six hospitals, shows that nine factors emerge as most critical. The paper adds elements of explanation for the slow rate of RFID adoption and underlines the overriding issues related such adoption.*

**Jel Codes :** I19, R41, O33 and O32

### 1. Introduction

The health care sector attempts to maintain care accessibility and quality while respecting economic restrictions and regulations. Medicines are an essential component of patients care but represent high cost assets that are rather difficult to manage. Hospital pharmacies must handle between 2 000 to 4 000 medicines per day and medication errors are common (Burton, 2007). In fact, the Institute of Medicine (IOM) has estimated that 44 000 to 98 000 persons die in USA hospitals per year due to an improper administration of medicines (Kohn et al., 2000). If we turn to the cost of preventable medication errors in the U.S., it reaches annually \$21 billion and this is a rather conservative estimate (NPP, 2012).

In order to decrease medication errors and their related costs, hospitals have favored the adoption of innovative ICTs (information and communication technologies) for indentifying medicines and doses throughout the pharmacy processes (HPP). More specifically, RFID technology holds a strong potential for improving hospital pharmacy processes. Despite a strong predicted growth of RFID applications in the health care sector (Wigand and Wood, 2011), the reality is that the sector lags behind far other industries (Chao et al., 2007). In particular, RFID

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adoption seems to raise some difficulties in hospitals around the world. The predominance of the “old” and “mature” barcode technology partly explains this slow RFID adoption rate (Matta and Moberg, 2006; Yao et al., 2011).

The main objectives of this paper are 1) to seek further explanations in the rate of RFID adoption in the specific context of the hospital pharmacy and 2) to identify and analyze the critical factors that foster or hamper such adoption. The remainder of the paper is structured as follows. The next section outlines the potential of RFID technology in hospital pharmacies and presents a literature review on RFID adoption factors. The third section exposes the main characteristics of the research design. The fourth section discusses the preliminary results while the last section offers some concluding comments and remarks.

## **2. Background**

### **2.1 RFID for Healthcare and Hospital Pharmacies**

RFID technology uses radio frequency waves to identify, automatically and without a line of sight, objects, humans, livestock or assets. An RFID system typically consists of 1) labels or RFID tags, 2) antennas, 3) readers or scanners and 4) a middleware. Data is stored on the tags. While passive tags can transmit data only when a reader transmits its own energy, active tags are powered by batteries and can transmit at any time. The middleware filters and analyses the data captured by the readers while it facilitates the communication of required or specified information with various information systems, triggering automatically various business processes. The future seems to point in the direction of full incorporation of RFID tagging with nearly all products, equipment, supplies, and people simply because of the wide range of use of these tags (Chopra and Sodhi, 2007; Riggins and Hardgrave, 2007; Fish and Forrest, 2007). Even though the distanced future for RFID technology seems very promising, its implementation and uses in the near future are uncertain.

RFID is considered as a promising and vital technology for improving healthcare services (Fosso Wamba, 2012). FDA (Food and Drug Administration) conducted in 2010-2011 a survey in American hospitals. Results from the survey indicate that RFID is mostly used for tracking portable or mobile assets. Infusion pumps, wheelchairs, beds, portable monitors, wheelchairs and ventilators are tracked the most, followed by other medical devices such as pacemakers or defibrillators. RFID applications for tracking medicines or pharmaceutical products, inventory control of medicines, medications administration, or management of expiration dates are not planned or deployed in the vast majority of hospitals.

For the hospital pharmacy, RFID holds the potential to fulfill more completely what is known as the five rights of medication management (right medication, right dose, right time, right route and right patient) and strengthens the security of patients (Thuemmler et al., 2007, Romero et al., 2011). By automatically tracking and tracing in real-time medicines and doses, RFID also improves the pharmacy

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efficiency and accuracy (Romero et al., 2012), increases inventory visibility, reduces inventory costs, ameliorates the readiness of purchase orders, decreases supply cycle times and reduces manual labour. Moreover, it supports reverse logistics activities (Bardaki et al. 2007; Schuster et al. 2007; Wang et al., 2010).

### 2.2 RFID Adoption Factors

Many factors may influence the adoption of a technology. Past research offers considerable insights into the adoption process and the diffusion of technological innovations, from the theory of technology acceptance (Davis et al., 1992; Venkatesh et al., 2003), to the diffusion theory (Rogers 1995, 2003) or to the institutional theory (Chwelos et al., 2001; Boeck and Fosso Wamba, 2008; Boeck et al., 2008). Previous work remains far less focused on the adoption of ICTs in health care despite their crucial role in this sector (Kolodner et al., 2008) and is considered as 'under-investigated' (Fichman et al., 2011, p.419). This is even more striking for RFID.

The following paragraphs will therefore examine the restricted number of articles with a focus on RFID adoption factors in healthcare. Perceived benefits derived from RFID adoption emerges as one of the most important determinant (see for instance, Chen et al., 2008; Fisher and Monahan, 2008; Yao et al., 2010; Fakhr, 2010; Vanany, 2011). This is aligned with the potential of RFID to improve drastically health care services, as discussed in the previous section. RFID complexity (Vanany and Saharoun, 2008; Chen et al., 2008; Vanany, op.cit) and compatibility (Chen et al., op.cit; Car et al., 2010; Vanany, op.cit) are also considered as two significant factors. RFID performance (Yao et al., op.cit; Vanany and Saharoun, op.cit), in particular reading rates reliability, its costs (Vanavy et al., op.cit; Yao et al., op.cit) and the technological risks it may entail (Fisher and Monahan, op.cit; Vanany and Saharoun, op.cit) are related negatively to adoption.

Healthcare institutions fall under one of the five generic organisation structures proposed by Mintzberg (1989), namely professional bureaucracies. The very characteristics of professional bureaucracies, such as those found in hospitals, may play a significant role in the adoption of information technologies. Size (Lee and Shim, 2007), financial resources (Lee and Shim, op.cit; Vanavy and Saharoun, op.cit; Yao et al., op.cit; Fakhr, op.cit; Car et al., op.cit), as well as organizational readiness (Chen et al., op.cit; Fisher and Monahan, op.cit; Car et al., op.cit; Vanany, op.cit) are retained as RFID adoption factors.

According to the literature, RFID adoption in healthcare is also influenced by external pressures (Lee and Shim, op.cit) In fact, Mintzberg (op.cit) noticed that healthcare decision-making depends deeply on policies and incentives coming from external actors such as government, regulatory national or international institutions, lobbying or pressure groups, among others. Cooperation and support factors are the most discussed determinants for RFID adoption in healthcare while market uncertainty and external pressures are also considered in some studies. It seems that healthcare institutions could opt for RFID technology if they gain the

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recognition, acknowledgement and support from their external environment (Vanavy and Saharoun, op.cit; Fakhr, op.cit; Car et al., op.cit).

### 3. Research Design

The paper presents partial results of an on-going field study in six Canadian hospitals. The number of hospital beds in these hospitals ranges from 320 to 630. Five hospitals use neither barcode nor RFID technology for medicines and doses identification. Instead, they read the label with characters and numbers displayed on the medicine package or the hospital-made label. One hospital has implemented a two-bin system supported with RFID technology and barcode in order to manage their medicine inventory. We extended the field research to include three additional organizations, namely one international health association and two technology providers, in order to validate and triangulate some of the information obtained from the hospitals.

A total of nine organizations and 44 persons participated in the study (Table 1). The key participants are pharmacists, other health professionals, caregivers, technicians, managers, IT specialists, administrators and clerks. Table 1 displays more information on the profile of participants to the field research.

**Table 1 : Key participants**

Organizations	Participants	Number
Six hospitals	Chief pharmacist	11
	Pharmacist	8
	Pharmacy clerk	6
	Physician and nurse	6
	Material manager	3
	IT project manager	6
	Quality and patient security director	1
One international health association	Association president	1
Two technology providers	Project managers	2
<b>Total</b>		<b>44</b>

The field research was carried out during a two-year period and relied on different data collection methods, namely observations, process mapping, face to face semi-structured interviews and focus groups. Some data collection methods did not require any direct interaction with the key participants while others built on direct intervention on a one-to-one basis and on a group basis.

Repetitive **observations** allowed analysing how participants really carry their tasks in the reception docks, the hospital pharmacies, the warehouse pharmacies, the hospital pharmacies, and the wards or the hospital units (e.g. the emergency unit). Basically, we observed the movements of medicines, the related activities and the personnel involved from their reception to their administration to the patients. These observations serve as an input for the mapping of current processes.

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Subsequent observations were relied upon to verify, validate and appraise the information provided in face-to-face interviews and in focus groups.

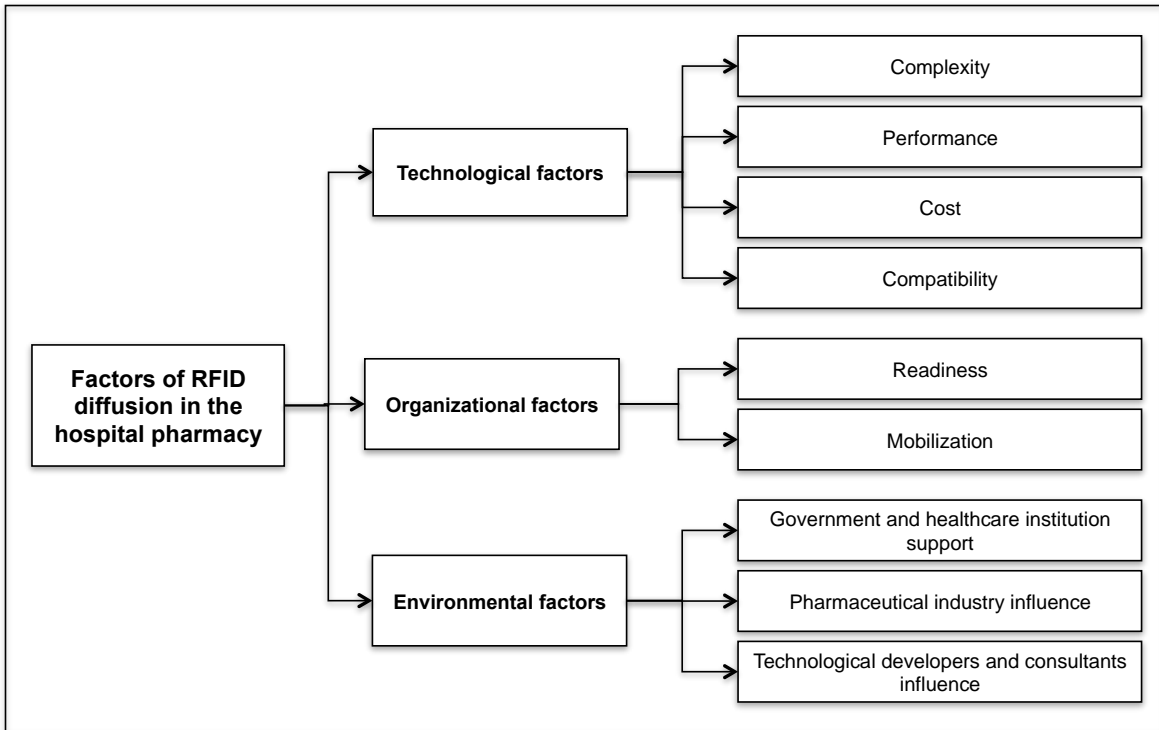
**Process mapping** of medication management throughout the hospitals proved to be valuable for three main reasons. First, researchers gain a better understanding of complex and even chaotic phenomenon. In fact, process mapping is aligned with the exploratory nature of the field study (Langley, 1999; Miles and Huberman, 2002). Second, it serves as a powerful and visual tool for the participants who can validate, react, discuss, or even deny the current situation. Third, it allows participants and researchers to suggest improvements to the current processes and simulate the impacts of different technological scenarios for tracking and tracing medicines and doses within the hospital.

Direct interventions with participants took place in the form of one-to-one face to face **semi-structured interviews** and several **focus groups**. Retrospectively, both data collection methods complement each other. Semi-structured interviews allowed participants to express their own points of views that were in some instances limited to the specific nature of their own profession. Focus groups confronted opinions, provided exchanges between different types of professionals and offer a realistic overview of the constraints, inefficiencies and strengths of the current management of medicines and doses.

The four data collection methods were used iteratively, mutually reinforcing the previous findings to gain deeper insights into the investigated phenomenon. Within the scope of this article, we will focus on the content analysis of the empirical data specifically related to the most critical RFID adoption factors for improving the hospital pharmacy processes. More detailed information on both the methodology and additional results can be obtained from the first author (contact e-mail address: [romeroto@uqtr.ca](mailto:romeroto@uqtr.ca)). The results discussed in the next section arise from the content analysis of the multiple data gathered from the four data collections. They reflect the usual levels of content analysis, namely manifest and latent levels, in an effort to make health research findings 'more usable' (Sandelowski and Leeman, 2012).

## 4. Results and Discussion

Based the empirical data gathered from the on-site observations, the semi-structured interviews and the focus groups, three sets of factors have an influence on the adoption of RFID technology for tracking and tracing medicines and doses in the hospital pharmacy, namely technological, organizational and environmental factors (Figure 1). This is congruent with previous research (Tang and Tsai, 2009; Alqahtani and Fosso Wamba, 2012).



**Figure1: Most Critical RFID Adoption Factors for Tracking and Tracing Medicines and Doses in the Hospital Pharmacy**

*Several technological factors* are found to be significant.

**RFID complexity** raises some deep concerns. As pointed by IT project managers and government advisers, using RFID for identifying medicines and doses requires an infrastructure with many components such as RFID tags, antennas, readers, middleware and IT links with other hospital information systems like pharmacy information system PIS, computerized physician order entry CPOE, among others. The staff and professionals from the hospital pharmacy must develop new competencies in order to implement this infrastructure and ensure its maintenance. According to the participants, RFID collisions would also raise the complexity of such an infrastructure. One pharmacist explains that collisions could arise when multiple medicines and doses are identified with RFID tags: *“since several medicines and doses are stored and handled in a small cabinet, the pharmacist can easily get the information of an incorrect medicine when he is preparing the medication doses. This can result in several errors”*. He concludes that *“pharmacists and existing information systems are not able to manage all the information generated by multiple readings”*. The hospital pharmacy must invest in anti-collision schemes resulting in a more complex RFID system.

**RFID performance** is also identified as a critical factor. RFID performance is considered as inappropriate because of its low tag reading accuracy due for instance to certain conditions or to the presence of liquids, moistures or metals. Several pharmacists agree on the following: *“in order to rely on RFID for medicines identification, the read rates must entail correct lectures during all the medication”*

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*activities*". Although RFID reading reliability has steadily increased over the last years, the overall perception in the hospital remains that current RFID systems still experience problems with reading accuracy.

The adoption of RFID for improving hospital pharmacy processes represents a substantial **cost**. In order to yield an appropriate return of investment ROI, hospitals tend to retain high cost or high value assets such as expensive medical equipment for RFID applications. Tagging medicines and doses with RFID technology seems not to yield an appropriate ROI even if it's critical to the quality of healthcare services. Several participants consider that "the *hospital pharmacy is inclined to postpone RFID applications when the ROI is uncertain*". However, they stress that "the *clinical utility of RFID is not fully demonstrated*". They also add that the frequency of medication errors and their resulting costs (financial and non-financial, i.e. human harm) have to be thoroughly documented and evaluated. They consider that it is the only way the ROI for RFID infrastructure can be better appraised.

Finally, **compatibility** hampers RFID adoption. For all the hospital pharmacy processes, health caregivers and support staff use different types of equipment such as electronic prescribers, robots to dispense medication, smart pumps, or automated distributors, among others. One IT project manager concludes, "if *RFID is not compatible with existing equipment, the cost of implementing the new infrastructure will increase drastically and the hospital will postpone RFID adoption*".

Two **organizational characteristics** stand out as the most critical factors for adopting RFID technology in the hospital pharmacy.

**The organization readiness** emerges as an important determinant; the more the hospital pharmacy has acquired competencies for supporting the new RFID system, the more it will tend to accelerate its adoption. Readiness also begins with awareness. First, the healthcare organization must identify and analyze the sources of errors and inefficiencies throughout all pharmacy activities including logistics and medication processes. Several pharmacists agree that "government advisors and hospital managers do not spend time in analyzing deeply the source of problem and they sometimes invest in a technology which is not totally appropriate for all the pharmacy processes". Second, awareness about the RFID technology seems to be lacking. If healthcare managers are unaware of RFID characteristics, its potential benefits and its limits, they will be inclined to opt for a well-known solution such as the barcode. Empirical evidence suggests that several pharmacists and healthcare IT managers overlook the barcodes technological limits while they are unfamiliar with the potential benefits of RFID technology. Third, the organizational readiness for RFID adoption depends on the technological investments that hospital has undertaken or is undertaking in the hospital pharmacy or in other units and services. The adoption of RFID for medicine and dose identification would be more profitable if it is aligned with the existing information technologies and legacy systems (CPOE, PIS, HIS or Wi-Fi,) and with

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the RFID projects and pilot projects within or outside the hospital pharmacy. RFID technology may be used in others units such as the sterilization unit, the procurement management service or the maintenance service. The hospital pharmacy could rely on the in-house acquired knowledge from RFID implementation projects but breaking down the hospital silos appears to be a difficult undertaking.

**Organizational mobilization** throughout the entire hospital is needed in order to implement successfully RFID in the hospital pharmacy. RFID appears to be considered by the clinical staff as another technology push or as another wave of ICTs (Information and Communication Technologies). If most IT project managers are committed to RFID adoption, the core mission of the hospitals, as noted by the participants, is still to provide comprehensive and high-quality healthcare services. Convincing the hospital administrators and healthcare professionals, including the pharmacists, that RFID would entail significant impacts at the point-of-care represents a critical and necessary step. Top management support, leadership, communication between hospital departments, wards and units, and training are also required to build the necessary level of organizational mobilization. This could be rather difficult to reach because the clinical and non-clinical staff and professionals are caught in their daily emergencies. Furthermore, the patients' acceptance, attitudes and even resistance must be considered. As stated by one pharmacist stated that *“two elements are essential to ensure the utilization of RFID technology for identifying medicines: it must be simple to use and be transparent for the patient.”*

From the empirical evidence, three **external influences**, namely the government and healthcare institutions, the pharmaceutical industry and the technology developers are significantly related to the RFID adoption.

Financial incentives, support and sponsorship from **government and healthcare institutions** act as a determinant of RFID adoption. This can be expected as hospitals are deeply influenced by regulations, programs and directive and may choose the data carrier advocated by governmental agencies, even if it is not the most appropriate. For instance, the American Recovery and Reinvestment Act of 2009 provides financial incentives to hospitals for the use of barcodes for the medication process whereas RFID adoption in Europe tends to be supported by international organisations such as BRIDGE (Building Radio Frequency Identification for the Global Environment). In the hospitals that participated to the field research, barcodes tend to gain approval from the government and healthcare organizations.

The technological investments undertaken by the **pharmaceutical industry** can also influence RFID adoption in the hospital pharmacy. The industry is considering two different track and trace systems in order to identify medicines at unit level throughout all their supply chain, including the hospitals at the downstream side. These systems, namely *End to-end verification* and *E-pedigree* rely on either carriers (barcodes or RFID) and, in some cases, on both carriers. One



governmental advisor observes that “*the fundamental problem [of both systems] is the interoperability among the different technological configurations: some laboratories would use the barcode while some distributors would opt for RFID.*” Considering the fragmentation of pharmaceutical supply chains, the emergence of a common standard is far from being reached. Hospitals are thus inclined to postpone the choice for RFID infrastructure in order to avoid the adoption of an incompatible technology.

Finally, **technology providers and consultants** may offset the influence from government and healthcare institutions. For example, some technology providers are developing pharmaceutical equipment that is compatible with both technologies such as RFID barcode scanners or automated dose distributors (such as Fulfill Rx or IntelliShelf-Rx from McKesson). This kind of hybrid equipment could influence positively the adoption of RFID in the hospital pharmacy according to several participants. However, one participant adds that “*most of the pharmaceutical equipment used in the hospital pharmacy such as automated distributors is compatible with barcodes; therefore we must rely for medicines identification on barcodes*”.

## 5. Conclusion

Based on the preliminary empirical results obtained from an on-going field research, in six different hospitals in North America, this paper identifies and analyses the most critical RFID adoption factors in the context of the hospital pharmacy. Results supports partialy previous work and this is particularly the case for some of the technological characteristics of RFID: complexity, peformance and cost hamper its adoption while compatibility with existing equipement and legacy systems increase its rate of adoption. Organizational readiness and mobilization stand out as critical a priori conditions for promoting RFID adoption. The influences exerced by the external environment, in particular those from the government and healthcare institutions, the pharmaceutical industry and the technology developers are also instrumental. Since these influences seem to be diverging, they seem to justify to a large extent a ‘wait and see’ behavior.

Supprisingly, some factors are not found as critical as could be expected. For instance, perceived benefits, although assessed in the literature as one of the most important determinant, do not play a major role: there is an overwelling consensus among participants that RFID could improve the quality of healthcare services in general, and, the management of medicines and doses in specific. However, its clinical utility cannot yet be fully demonstrated. Hard facts and figures are needed, in particular the frequency, type and consequences of medication errors have to be thoughtrouly appraised. Medicines inventory costs or supply cycle times are much easier to assess but are considered by some participants as marginal as they do not directly deal with the core mission of the hospital.

A deeper understanding of RFID adoption factors is useful for healthcare managers, government advisors and technological developers. Results suggest

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that the RFID adoption is highly complex in hospitals and that the most critical adoption factors seem to be interrelated and mutually reinforcing. For instance, organizational readiness influences organizational mobilization which in turn may affect the perceived level of RFID complexity. The latter varies with the strategies, guidelines or directives from key players in the external environment. The perceived level of RFID complexity appear to fluctuate with highly publicized pilot projects (nationwide or even international ones) undertaken by the pharmaceutical industry, with continuous technological improvements made by technology providers, and with changing priorities from governmental agencies. Meanwhile, the costs of health care and those associated with medicines are rising.

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