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Radio Frequency Identification: Beyond the myths.

A case for Health Care

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Abstract:

Radio Frequency Identification (RFID) is one of the most promising information system technologies for the health care industry today and in the future. Many experts and researchers consider that RFID should improve the tracking of patients, medical personnel, drugs, and equipment, decrease medical errors, provide positive identification of patients and medications, secure the access of sensitive places in hospitals, provide patients with safer medications and last but not least, it can facilitate better information management. In this paper, we question these promises by challenging seven myths associated with this technology: five are related to a misunderstanding of what RFID can really do and the other two are related to wrong or incomplete definitions of what RFID solutions are.

Key words: RFID, health care management, myths, information technologies adoption.

At the end of the 70's, computing was considered as a powerful instrument to increase the quality of health care but also to decrease its costs and rationalize processes within hospitals [1]. Thirty years later, companies and governments see RFID (Radio Frequency Identification) as the new solution to cure many of the recurrent ills of the health care system. RFID is "an automatic identification technology that can be used to provide electronic identity to an item/object" [2]. A typical RFID system consists in transponders (tags), reader(s), antennas and a host (computer to process the data). RFID readers send out radio waves to detect tags and read their data. There are many different RFID solutions which differ on parameters such as frequencies, prices, ranges, sizes, or energy consumption. This technology is said to be disruptive as it is "well-suited to linking the physical and virtual world" [3]: business applications are overwhelming [4].

RFID is not new. During World War II, the Royal Air Force used it to identify airplanes [5]. The first commercial applications appeared 20 years ago, today we use it in our daily lives (even if we're not always aware of it) and it could be absolutely everywhere within the next few years according to some experts[4]. Literature about RFID is abundant when dealing with technical [6] or ethical problems [4] but very few papers address managerial issues [7]. Since the American health care system is mostly driven by technology [8] RFID should be analyzed more cautiously and not only from an engineering perspective.

Many RFID specialists claim that this technology can enable health care to overcome existing technological and workflow limitations [9]. This new tool should help to improve the tracking of patients, medical personnel, drugs, and equipment, decrease medical errors, provide positive identification of patients and medications, secure the access of sensitive places in hospitals, provide safer medications to patients, and last but not the least, it can facilitate

better information management [6]. RFID should also "reduce drastically or entirely eliminate the time the nurses spend on non-patient care, to ensure correct materials are ordered by the procurement department, and to reduce storage, transport, and support costs" [4]. RFID not only has applications within hospitals but in the whole health care sector. According to the Food and Drug Administration (FDA), the potential benefits of RFID to hospitals and healthcare facilities include [1]

- "patient safety by ensuring that patients receive the correct medications and medical devices; preventing the distribution of counterfeit drugs and medical devices; facilitating device recalls (...);
- managing assets such as hospital equipment;
- tracking patients;
- providing data for electronic medical records systems".

Although hundreds of hospitals use RFID, this diffusion raises many issues such as the capacity to articulate this tool with the traditional procedures and processes within hospitals. Of course, RFID is a new opportunity for health care but relevant managerial measures have to be adopted to make an advantage of it without destabilizing the reliability of the existing routines. Even major companies usually recognized for their ability to sky the limits failed to reach the goals that they had fixed for the implementation process of RFID solutions. The most famous example is given by the largest retailer of the USA, Wal-Mart. The company's spokesperson, Tom Williams, said the company planned to implement the fast-evolving technology "in all 105 of its U.S. distribution centers and in the receiving docks of all Wal-Mart stores by 2005" [10]. The plans did not work out as expected [11] and RFID solutions did not provide as much value as intended: "the enthusiastic announcements two years ago of

[1] (http://www.fda.gov/cdrh/rfid/)[1] Document updated on-line in May 2, 2007.

new RFID pilot programs have become a wall of disappointed silence"[12]. Even if “Wal-Mart continues to update its RFID initiatives adding new uses for the technology and getting more suppliers and partners to comply with its mandates” [13] the integration throughout a supply chain is finally beginning “to move from technological dream to day-to-day reality” [14].

RFID solutions will not have the effects the industry expects if they are used as palliatives, as “organizational crutches”. To make RFID something else than a new burden which could bring conflicts and add costs for poor results, it is essential to challenge some myths associated with this technology (defined as a representation that individuals have of this technology based on shared beliefs which are widely diffused by the media and the industry). In the literature related to the diffusion of IT, many authors use the myth concept to go beyond the economic rationality framework and better understand how actors take their decisions while adopting and implementing new IT [15];[16];[17].

Challenging myths does not mean that myths should be avoided. Myths “are an important means for simplifying and understanding a complex world. They help reduce uncertainty, facilitate interaction and communication, and clarify relationships” [17], however, managers could improve their practices by knowing these myths and adapt them to their own organizational contexts. In the case of RFID, many papers in magazines used the notion of myths to describe what the managers’ opinions are on this technology [18]; [19]; [20]; [21];[22];[23]. These papers give interesting information on managers’ representations, but they cannot be satisfying for three main reasons: they often adopt the point of view of RFID vendors, they provide general visions about RFID without taking into account a specific sector, and they usually don’t go far beyond technological issues.

In the case of Radio Frequency Identification devices, two categories of myths can be distinguished: five are related to a misunderstanding of what RFID can really do (myths 1 to 5) and the two others are related to wrong or incomplete definitions of what RFID solutions are (myths 6 and 7). Before outlining these myths, we first present what researchers have written about RFID and why we chose to focus our research on the health care industry.

What do researchers say about RFID?

Four main domains of research on RFID can be distinguished: engineering (1), standardization process (2), ethics/privacy issues (3), and management (4).

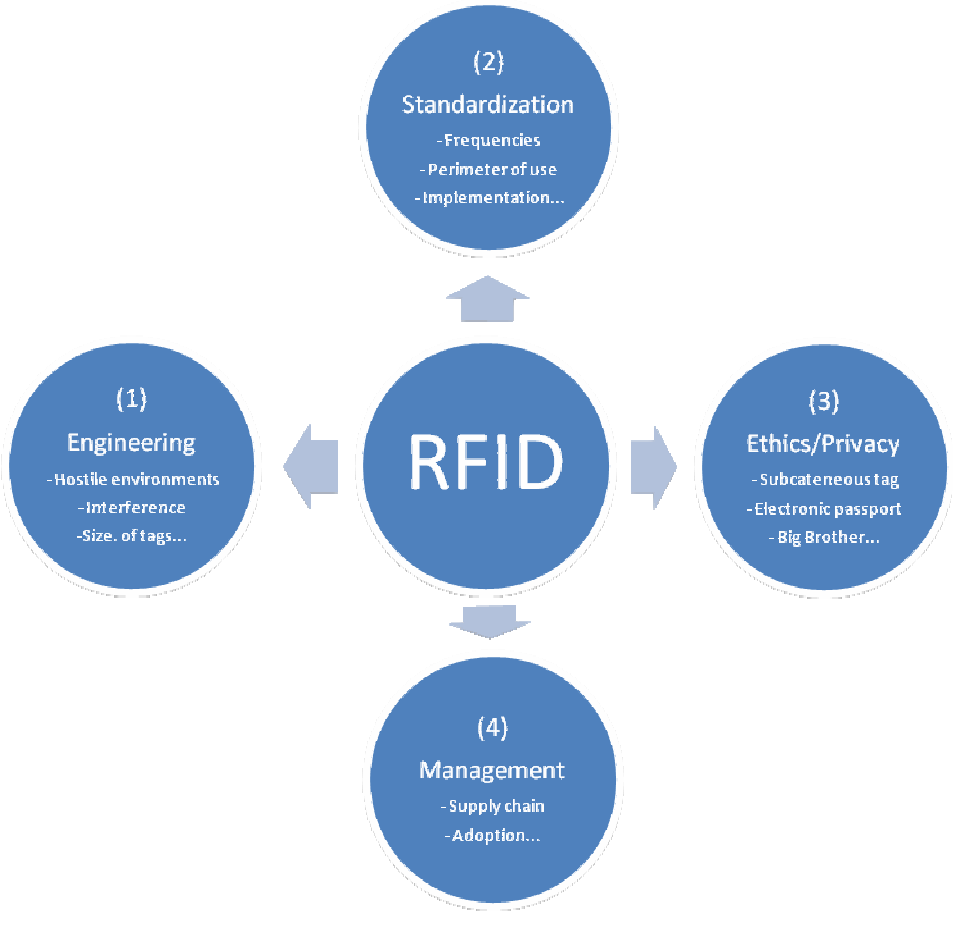


FIGURE 1

Main research area on RFID

(1) Engineering

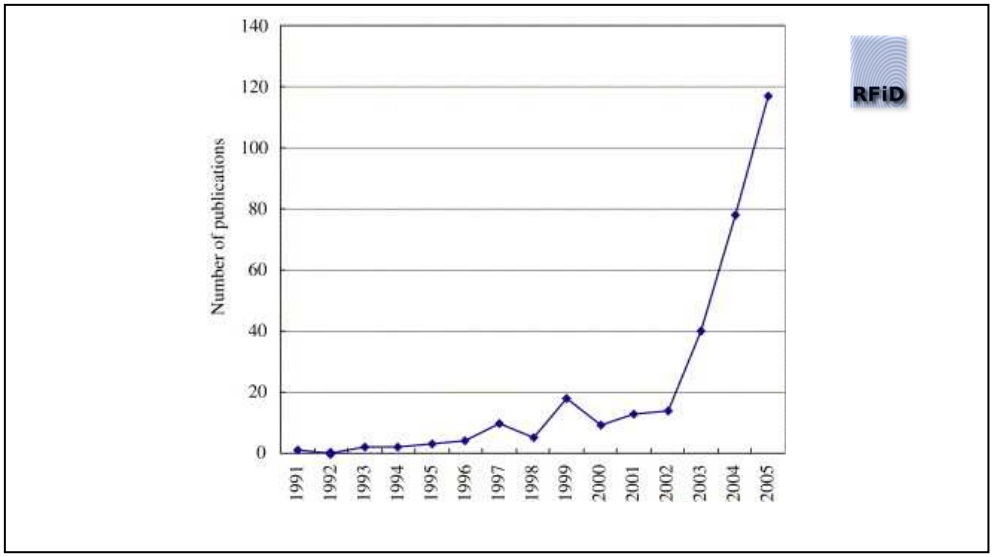
Considerable research studies have been conducted on the engineering of RFID solutions [6]. These studies have shown due diligence is necessary in selecting an RFID technology as the performance of different technologies is dictated by the material (liquid content, metal) of the tagged items. Caution must be used as well in designing the interrogation zone which is impacted by the orientation of the tags presented for reading, the reading range of the tags from the reader antennas, the speed of movement of the tags within the zone, the number of tags in the zone which result in read collisions and the proximity of the tags to one another within the zone [24];[25],[26];[27];[28].

(2) Standardization

There has been much controversy around RFID standards. Development of standards involves progression through standard bodies of individual industry, professional industry organizations (AIM, EPCglobal, EAN/UCC), and national and regional (ANSI, BSI, ETSI, CEN, CESI) regulatory bodies leading to international standards (ISO, IEC) [29];[30];[31];[32];[33];[34];[35].

Multiple types of standards apply to RFID as follows:

- Technical - deals with operating frequencies and air interface protocols;
- Data content and structure - defines the data and its coding on the tag;
- Tag types - read/write, active/passive;
- Conformance and performance - tag and reader;
- Application - how RFID is used in tagging and tracking containers, animals, pallets, tires, pharmaceuticals, etc.



(Chao et al. 2007)

FIGURE 2

Number of scientific publications on RFID

(3) Ethics and privacy

Privacy and ethical issues related to RFID is another vast domain of research. There is concern about the use of data collected by RFID solutions [36] and the regulation measures that should be drafted [18]. Some papers expose the threat of a new Big Brother [37]; [38] which could spy consumers [39]; [40] and citizens [41]. The debate which took place on the new electronic passport illustrates these fears [42].

(4) Management

(5) In contrast to the overwhelming number of trade publications and white papers on RFID (many case studies are presented by corporations like IBM[2], UPS[3] or Accenture[4]), there is a surprisingly low number of conceptual and empirical research contributions on this technology in the body of management literature [43]. Researchers in management analyze two main issues only: supply chain management [44];[36];[45], and the process of

[2] http://www-01.ibm.com/software/success/cssdb.nsf/topstoriesFM?OpenForm&Site=gicss67elec&cty=en_us
[3] http://www.pressroom.ups.com/mediakits/factsheet/0,2305,1202,00.html
[4] http://www.accenture.com/NR/rdonlyres/ABD67758-92D3-442D-AAA3-4CC9C93FE457/0/rfid_epc.pdf

adoption of RFID [7];[46];[11];[47]. Most of these works present a broad review of how RFID solutions can be used in one specific domain: logistics.

Their core assumption is that RFID is a wonderful opportunity which holds "the promise of closing the information gaps in the supply-chain" [47]. For example, Lee et al. [45] develop a simulation model to study how RFID can improve supply chain management. According to their results, even if some of the scenarios they studied are possible without RFID, they demonstrate how RFID provides significant benefits in a supply chain for inventory accuracy, shelf replenishment or inventory visibility [45]. These benefits are therefore well beyond the automation oriented analysis such as labor savings. Others ground their research on several examples of RFID applications within companies to show how RFID can improve the supply chain performance. We present below some of the most famous illustrations:

- A three-month trial was carried out in a Gap store in Atlanta to reduce stock-out situations and obsolete inventory. The result was an almost 100% on-shelf availability of the RFID-tagged merchandise and a 12% increase in sales of this merchandise in comparison to 'control' stores that were not using an RFID system [48].
- "Unilever uses the Texas Instrument RFID technology to support its smart pallet system designed to move, handle, and track its consumer products in its warehouse (…). As a result (…) the number of pallets handled daily has increased and the information on the movements of the physical loads has become more reliable" [47].
- Woolworths, UK used RFID solutions to track products through the supply-chain. The system used led to a shrinkage reduction, the reduction of labor for checking deliveries and claim processing, the reduction of inventory levels, the improvement of product availability and customer service [23].

- Even if Wal-Mart didn't require all its suppliers to implement an RFID solution, many pilots gave interesting results: the company has reported a 5-6% drop in supply-chain costs [49], a 20% cut in labor costs and access to 30 times more data from its pilot distribution centre in Oklahoma, managed in partnership with suppliers [50].

Concerning the second research domain, RFID adoption, the main barriers which limit diffusion are very similar to those to other technologies identified in the literature [7]: costs, technical (reliability and interoperability) and privacy issues are probably the most recurrent factors which limit RFID adoption [51]; [47]; [21]. Several researchers propose various methods to guide the decision-making process of RFID adoption within firms: they suggest to define a formal adoption planning scheme to launch the process [52], to use a flow diagram to characterize the best RFID solution [53] considering several criteria such as the scalability of the project, the type of surrounding materials, and the evaluation of compliance, cost, and environment [54].

In management science, the definition of RFID and its purposes are usually taken for granted. Analyses are often based on several examples but not on in depth-case studies or quantitative analysis. The general ideas about RFID are not really challenged by researchers. In this paper, we chose to address the usual representations on RFID. We chose to address these topics in the context of health care as this industry can be seriously transformed by RFID applications.

Why Health Care?

Three main reasons explain why health care experts should know more about RFID and study its impacts. First, the number of chips sold is increasing: today, hospitals are currently one of the largest buyers of RFID technology [55]; [56] and it is estimated that about 200 hospitals in

the USA are now using radio wave-based technology [57]. The RFID market in hospitals will reach $8.8 billion within four years only [58] and according to IDTechEx [48], the market for RFID tags and systems in the whole health care sector will be much bigger as it will rise rapidly from $90 million in 2006 to $2.1 billion in 2016[5]. The two conferences – "RFID in Healthcare", January 23-25, 2008, Las Vegas and November 6, 2008, London – are also a good illustration of the medical professionals' interest for RFID.

Second, health care concentrates all the issues related to RFID with the most accurate level. Technical, standardization, ethical and managerial issues are very sensitive in this industry. With regards to technical issues, the environment in hospitals is often a "hostile" one for RFID solutions: elements such as metal, heat, cold, liquid, and complex information systems make successful implementation harder. Moreover, health care is extremely regulated and even if the FDA tends to encourage the adoption of RFID, many rules constrain the implementation of such solutions. Ethical questions are often raised with RFID but these questions become obviously crucial issues in the health care industry. Finally, management is also extremely sensitive as mistakes can have serious impacts for patient safety: medical errors are too costly human wise and economically.

Third, there are a wide variety of RFID applications in health care. To analyze this heterogeneity we designed a table based on two dimensions: the various functions of RFID solutions – dispensation, security, geolocalization and inventory – and its focus – people, assets and places. We do not claim that this table is comprehensive but it captures all the major applications found in the literature review. For each cell, we develop an example to

[5] http://www.idtechex.com/products/en/articles/00000470.asp

illustrate what can be done with RFID solutions. These examples are either currently used solutions or just prototypes which might be implemented within few years.

	Dispensation (A)	Security (B)	Geolocalization (C)	Inventory (D)
People	Patient/blood (1)	Newborns (4)	Alzheimer patients (7)	Operations (10)
Assets	Drugs (2)	Preoperative (5)	Bottle of oxygen (8)	Drugs (11)
Places	Distance control (3)	Pharmacy (6)	Doctors (9)	Emergency (12)

TABLE 1

Major RFID applications in health care

(A) Dispensation:

(1) Start (Safer Transfusion with Advanced Radiofrequency Technology) uses a passive tag (with no power source contrary to active tags with an onboard power source) in the patient ID band and blood bags, RFID readers in the operating room procedure table, and a receiver with an RFID reader in the form of a laptop in each operating room. This system used by the Boston's Massachussetts General Hospital improves the cross-check process at the bedside [59].

(2) RFID technology is being added to all Viagra sold in the US to enable pharmacies and wholesalers to verify the unique electronic product code on Viagra Packaging [60].

(3) RFID solutions might detect the motion of the medicine cabinet door, followed by the motion of the bottle of vitamin B tablets, followed by the motion of the water glass to know that the occupant has taken a pill [61].

(B) Security

(4) Several hospitals such as the Baylor Medical Center at Frisco, Texas use electronic bracelets to secure newborns from being "stolen" and locate them precisely [62].

(5) "Improper positioning of the endotracheal tube during intubation poses a serious health risk to patients. In one prospective study of 219 critically ill patients, 14% required endotracheal tube repositioning after intubation (…) The use of handheld RFID detectors and RFID tag-labeled endotracheal tubes could allow for easy and accurate bedside monitoring of endotracheal tube position, once initial proper placement is confirmed" [63].

(6) In the Carolinas Medical Center in Charlotte, North Carolina, an RFID solution is used to secure cabinets in tracking high-cost consumable items. These supplies will register their use, order replacements and keep track of expiry dates [64].

(C) Geolocalization

(7) Patients can be geo-fenced by using RFID bracelets and fixed readers. This functionality could be of great help for Alzheimer patients [65].

(8) The University Medical Center (UMC) in Tucson, Arizona uses a solution to track and manage equipment such as infusion pumps, beds, monitors, wheelchairs and other portable devices [66].

(9) A French hospital implemented electronic bracelets for nurses to study how much time they spend in the patient's room. The goal is to make this time as high as possible.

(D) Inventory

(10) A solution developed through the collaboration between the University Hospital, Birmingham, UK and Napier University, UK enhanced the quality of care staff and patient safety using RFID tag wrist bands, which are linked to a patient's database, in order to reduce errors in patient care [67].

(11) "In hospital settings, an RFID-equipped drug cabinet can provide better control of access and inventory and provide alerts when supplies run low" [68].

(12) At the Saint Roch hospital, Nice, France, RFID bracelets are used to manage the medications process of the 70 000 patients admitted to the emergency unit [69].

These applications are obviously designed to increase performance in health care; the improvement of patient safety being certainly one of the main goals of RFID solutions [70]. However, this may never occur as neither the diversity of RFID solutions nor the complexities of medical organizations are taken into account. These hopes are based on several myths. In this paper, we highlight these myths to challenge them and understand why they might not be relevant in some contexts of use. We describe five myths related to what RFID can do and then two myths related to what RFID really is.

Distorted views about what RFID can do.

Myth1: RFID as the solution for all your logistics tracking issues

Today, logistics tracking is often associated to RFID and RFID is related to logistics tracking most of the time. In health care, this involves the tracking of surgery instruments, equipment, drugs but also of patients and employees. This association leads to a misrepresentation, or at least a limited representation, of what RFID is. First, it should not be forgotten that it is

possible to track a product or a process or even a person without RFID solutions. Many other auto-ID technologies exist [55]. Among them, some have data properties which are independent of the data carrier (barcode, datamatrix code, card technologies…) and some have data properties which are directly incorporated in the data carrier with a focus on unambiguous person recognition (biometric identification). Before adopting RFID solutions, trade-off studies between the various technologies should be carried out.

Moreover, RFID is not only about logistics tracking. It can be used for many other applications such as patient authentication, baby theft control, the monitoring of items such as beds or wheel chairs. Some applications are so specific that it is not relevant to use a generic term like "tracking". For instance, RFID can also be used to provide information about acidity, pressure, temperature, and digestive activity from inside the intestines. The data is transmitted wirelessly via RFID to a receiver worn around the patient's neck or waist; from there it can be downloaded to a doctor's laptop [71]. This example might sound anecdotic but it reveals the spectrum of possible applications.

Finally, managers should not focus so much on tracking as on improving performance (some managers seem to disregard this principle and become more and more obsessed in the tracking of everything). The goal is not to track but to rationalize processes, to improve the quality of care, and control costs better. One shouldn't mix up the means and the end.

Myth 2: RFID as a tool to deal with the new identification challenge

Identification would become one of the main challenges of the 21st century [72] and RFID would be one of the solutions to deal with this issue. Some American companies have filed several patents in this field. For example, IBM filed the patent #20020165758 to identify and

track people using RFID tags. However, this challenge is not new at all; it can even be considered as a natural trait:

> “In nature, identification is a matter of life and death. If you can't identify things, you can't count them, you can't work out whether or not you can eat them, you can't work out whether or not they are friends or foe" (Kevin Ashton, "Kevin Ashton, Auto-ID Center, at Forrester Executive Strategy Forum", videotape, 7-9 Nov. 2001).

In health care, identification of patients, disease and treatment have always been considered as a critical task. At the end of the 70’s, this question was already related to auto-ID technology such as that of bar codes:

> "The problem of identification of individuals, their medical samples, and observations about both in a computer-based information system is a fundamental source of error and uncertainty in all MISs. Corn flake boxes and railroad cars are now made with "zebra stripes", people are much more difficult to identify” [73].

Treatment, inference and diagnostic are the core of medical practices [74], a technology like RFID should have an impact on these tasks but it will not make them disappear. Therefore it is important to understand how RFID could help to deal with the recurrent identification challenges at every stage of the medical process. The study of the identification issues related to the computerization of hospitals which emerged several years ago may be a good way to start and to think about current issues.

Myth 3: RFID as a new Big Brother

78 % of consumers surveyed reacted negatively to RFID on privacy grounds and “more than half claimed to be extremely or very concerned about the technology” [41]. Even if this fear is

grounded on serious reasons, RFID shouldn't be looked upon as a "monolithic technology". Different situations have to be distinguished when it comes to privacy and ethical issues, otherwise, as it happened with the X-Ray technology, some States could draw up regulations which might appear ridiculous several years later:

> "The most consistent fear [with X-Ray] had to do with personal privacy (...) On February 19, 1896, Assemblyman Reed, of Somerset County, New Jersey, is said to have introduced a bill into the State Legislature, at Trenton, to prohibit "the use of X-rays in opera glasses in theaters or other public places." (...) The alleged 1896 bill may have been merely a joke. Serious or not, it says a great deal about public awareness of the amazing new rays and their possibilities, possibilities that seemed for a time to include the frightful thought that everyone's innermost secrets would be laid bare to "every friend with a camera" (Scarborough Post, The New Horror, Photography 8, no. 381, Feb. 27, 1846, p. 146-147)" [75].

RFID solutions can collect, transfer, and store data like many other information technologies (IT). In certain contexts, these functionalities do not imply an invasion of privacy. For example, the use of RFID to manage a stock of drugs in a pharmacy does not involve privacy issues. On the contrary, with some applications, RFID could be used by firms and governments to watch and control clients, citizens or employees. In health care these risks are very sensitive – there is concern with data mismanagement, data misuse and identity theft [76] – however, these issues are not original: it is inherent to the whole history of IT. This history tells us that beyond technical characteristics, regulation is a function of social systems:

> "the technologies that we use, the machines that we choose to make a part of patient care, are used in ways that reflect the underlying social concerns and beliefs of a society" [75]

RFID asks for specific measures and awareness but does not require a whole new regulation framework to protect people. Critical questions are still the same: who has an access to data and who controls it? What is the data for, and when will it be deleted? Many regulations have already been implemented. The 1974 Privacy Act is an example of this:

> "In response to a growing awareness of the potential abuses that arise from society's dependency on personal record tracking and the power of current technology to store and disseminate (…) data, Congress enacted the Privacy Act of 1974, the most comprehensive domestic privacy legislation to date"[77].

Several States in the USA passed new regulation measures on RFID. One of the most conservative ones is California with six bills voted in April 2007 to limit the use of RFID. For instance, the SB 362 prohibits any individual from forcing another to undergo the implanting of an RFID chip in that person's body [18]. In Europe a report issued by the European Parliament's Scientific Technology Options Assessment committee recommended that general ground rules for using the technology in consumer or employee applications should provide transparency about which parties are collecting personally identifiable data, and what data is being collected and stored [78].

Of course some can claim that Big Brother is not far from us, but this position does not address real issues as it focuses on a small tag whereas if one should condemn something, it should be the whole system. Indeed, technical tools are nothing without methods to analyze data. Data can be used for the best valuable reasons as well as for the worst. The Second World War gives us a testimony of this:

> "it was neither through the ideology of blood and soil nor through the principle of guns and butter, upheld until the end of 1944, that the National Socialists secured their might or carried out their destructive activities. It was the use of raw numbers, punch cards, statistical expertise, and identification cards that made all that possible. Every military and labor column existed first as a column of numbers. Every act of extermination was preceded by an act of registration; selection on paper ended with selection on the ramps"[79].

Most RFID applications raise privacy issues which are very similar to what they used to be [80]. Some of them lead to new ethical issues. Subcutaneous tags, even if they are still anecdotic, raise difficult questions about the possible fear that human beings can be turned into robots or can be controlled without their free will.

The question is not whether RFID is bad *per se* but how we can characterize diverse situations to address privacy and ethical issues with appropriate and relevant regulation measures. Health care is at the core of the contradiction: data has to be used and RFID solutions can certainly help us to do so, but depending on the way we use it, it can lead to harsh abuses. The same paradox has been identified with computerization:

> "In many ways, the computerization of health records improves the quality of care: data is accessed quickly from many locations; duplicate tests are less likely to be ordered; adverse drug interactions are more easily avoided; providers can share data more efficiently when consultations are necessary. On the other hand, an electronic records environment may also expand a provider's responsibility and accountability to the patient because the provider is directly responsible for ensuring the accuracy of the

information placed in the system, as well as for authenticating the identity of the person presenting an electronic card" [81].

Myth 4: RFID as a cost killer

The media and retailers of RFID solutions praise the potentialities of this technology to reduce costs. We present one example below:

"In the United States during 2000 to 2002, 2,591 cases of foreign bodies left in patients during procedures were reported. The fiscal impact of such incidents is placed at $17.25 million in excess costs (Patient Safety in American Hospitals, Health Grades 2004). Surgical instruments passively tagged can be accounted for with RFID readers on the surgical tray" [70].

Thirty years ago the same kind of hopes emerged with computerization. These two quotations give an illustration of the former forecasts:

- "proper automation of the hospital information handling process offers the potential for saving many dollars a day on each patient's bill" [82] "Nationwide the cost reduction is estimated to be as much as $1.5 billion annually if cost-effective information systems were installed in every hospital with 200 or more beds. Computer technology could be the single most important cost-cutting tool available to American hospitals today" [1].

Even if the huge rise of costs in health care (8% of the GDP in 1976; more than 15% in 2006 in the USA) cannot be attributed to one variable and that the reasons are diverse, this evolution should make us wary of forecasts some experts are making nowadays on RFID. Most of the RFID applications have been generally used for process optimization [55] but in

health care, even if efficiency is at stake, effectiveness has to be the first priority. In the case of drug preparation, the improvement of security comes before the reduction of costs.

Moreover, the exact assessment of the variation of costs produced by the implementation of RFID solutions remains a challenge. The direct costs (hardware and software) are quite easy to measure even if they change very quickly due to the increase of tags sold and technological progress. Moreover the diversity of RFID systems should also be taken into account because costs can be very different depending on the solution adopted. One of the main differences can be explained by the distinction between open and closed loops. In the first case, tags are used only once, whereas in the second case tags can be reused a thousand times. As for the indirect costs like training and the costs related to the adjustment of the solution, they are more difficult to appraise.

Finally, if RFID involves process transformation, the payback measured by a traditional ROI-type analysis might not be easy to calculate [45];[21]. Of course, professionals need this ROI and they will find one[6], but beside this heuristic and legitimating tool, strategic decisions and clear statements have to be made by the top management to go beyond prototypes and limited implementation.

Myth 5: RFID as a tool to reduce medical errors

"These scenes could occur in many American hospitals today: at a meeting of the medical staff's committee, the chief pharmacist reports that he has just completed reviewing 100 randomly selected charts for errors in medications. More than one-seventh of all medications ordered were administered incorrectly. Errors included giving the wrong drug, the wrong

[6] Some business conferences are even dedicated to it. For instance, the "Global RFID ROI 2008" conference took place the 29th and 30th of January in Munich, Germany. To give another example, "the Auto-ID Center posted an electronic ROI calculator developed by IBM and Accenture on its Web site" (Angeles 2005).

form of the drug, the wrong dosage, or the right medicine more frequently or less often than specified" [1]. In this quotation, "today" refers to 1977. However, roughly the same statement could be made in 2007: "Medical errors have become a leading cause of death, killing more people each year than AIDS or aeroplane crashes. These medical errors can be classified into five categories: poor decision making, poor communication, inadequate patient monitoring, patient misidentification, inability to respond rapidly and poor patient tracking"[83]. Just like computers 30 years ago, RFID is considered as a solution to enhance patient safety and to decrease the number of medical errors:

> "Employing innovative information technologies [RFID] in correcting these deficiencies and meeting the Joint Commission on Accreditation of Healthcare Organization (JCAHO) is the current trend in enhancing patient safety" [83].

However, like any other IT, the impact of RFID will not be the same in every hospital, or on every disease, effects will depend on the context of use and the process of implementation. Gidden's structuration theory is widely used to analyze the effects of IT [84]. The idea that the implementation of new technologies within organizations is only an "occasion for structuring'" [85] is now shared by most researchers [86];[87]. According to this theory there is not such a thing as technological determinism. On the one hand, the same health technology could have different impacts depending on the context of use and the representations adopters and users have of the technology [85]. On the other hand, "health technologies embody values and act normatively on health care practices" [80]. That is the reason why it is essential to identify the major representations (myths) concerning what RFID can do, and also to understand the misrepresentations of what RFID really is.

Misrepresentations of RFID.

Myth 6: RFID as a new bar code

According to the Zebra's website (Zebra is one of the leading companies of the RFID industry), RFID is just a new bar code:

> "Conceptually, bar coding and RFID are quite similar, both are intended to provide rapid and reliable item identification-tracking capabilities."
>
> (www.zebra.com/id/zebra/na/en/index/rfid/faqs/rfid_bar_codes.html 11/10/2007)

This approach might be relevant in some specific situations but to make a comparison, objects compared have to be comparable. In many cases, RFID solutions are obviously far different from bar codes. This difference is particularly important with active tags which can take measures (the temperature for example) and store a lot of data (with passive tags there is not a large quantity of data stored on the tag – it is to be found within the network which can be composed of many tags). Four major differences between RFID and bar codes should be underlined. First, with RFID, identification is unique; second, it is remotely readable (RFID tags can be read from a distance by anyone with the appropriate reader device); third the tag is rewriteable; and fourth machine-to-machine communication is at the core of many RFID applications. Eventually, "RFID systems should not be seen as a substitute for other identification systems, such as bar codes" [22]. Such a comparison between RFID and bar codes restricts the scope of possible applications and leads to a misunderstanding of the challenges associated with RFID.

In fact, it might be more relevant to compare RFID solutions and the systems attached to IT (Wi-Fi, bluetooth…) with the Internet rather than with bar codes. This new Internet is

sometimes called the Internet of objects or artifacts: it could “allow any artifact – even human beings – to become part of the Internet and to eventually be tracked” [88].

Myth 7: RFID as a simple tag

RFID is probably compared with a bar code because it is often defined as a simple tag. Even if the media analyze the growth of the RFID market with the number of tags sold, RFID is not a tag, nor a radiofrequency, it is a system linked to an information system (IS). As explained previously, this system is composed, of hardware (sensors, readers, antenna, tag), middleware and software used to collect and analyze data. In this system, the middleware is probably one of the most crucial parts – it can be compared to the bridge which links the applications and the physical architecture [2], it is “the glue that ties hardware components from lower layers with the higher applications layer" [88].

The tag is only the tip of the iceberg; many other challenges have to be addressed. As there is not an off-the-shelf RFID system, the coherence within an RFID solution (between tags, readers, frequencies, sensors…) is really crucial. However this coherence is useless if the interdependencies and the integration of the RFID solutions within the current IS is not warranted.

Even if all these technical issues are solved, there are still two major challenges: information management is required to create value from the data collected and the transformations of business processes have to be achieved to gainfully exploit the benefits of RFID.

DISCUSSION AND CONCLUSION

According to the OECD, "the hospital sector is a very promising sector for RFID applications as the technology enables increased patient safety and reduced costs and thus addresses two crucial challenges for the sector" [55]. These forecasts have already been made for other technologies but managers should know that RFID, like any other IT, can do nothing by itself. RFID will not reduce medical errors, RFID will not improve patient safety, and RFID will not reduce the counterfeiting of drugs. RFID should not be considered as a solution *per se*. Technological determinism does not provide any solutions and leads to misrepresentations of what IT can provide. In health care, RFID is nothing but an opportunity which can be used to address organizational issues, process reengineering and help medical professionals in their decision making. The seven myths highlighted in this paper can help managers to avoid this technological determinism by questioning what their real needs on the field are.

In fact, four main elements should be taken into account when adopting RFID. First, RFID solutions are a complex system which can be disturbed by its environment. For example, the same RFID solution designed to track trucks in a plane worked very well in a Boeing but did not in an Airbus! This anecdote reported by a manager during a conference illustrates perfectly why simple replication cannot be achieved. Second, RFID is one solution among others and a trade-off study is always required. Third, beyond these technical issues, the organizational context of use has to be taken into account to define what the major challenges are. Sometimes ethics and privacy issues might be the principal problems to deal with, but it might not always be the case. Other challenges could be much more important such as the appropriation of the system by the medical professions in their day-to-day practices. Fourth,

project management and the traditional theories about IT implementation are required to avoid major failures and to keep the project within reasonable cost and delay.

This paper is based on a literature review and the experience of authors on RFID uses in health care (some of them have been working on this subject for several years). However, more systematic data needs to be collected: in-depth case studies are required to better understand the impact of this technology on activities and organizational structures, and quantitative research needs to be carried out to design a typology of the various RFID solutions (functions, focuses, technical systems…) and define the major challenges for each situation.

Ten years ago, many managers thought that the Internet would become the solution to almost every issue; and was seen as the only way to make money. Today, we know that the Internet was not a relevant tool to improve performance without the right business strategy and an adequate organization. In 2001, M. Porter debunked some of the Internet myths as the first-mover advantage, the power of virtual companies, and the multiplying rewards of network effects [15]. In this paper, we put forward other myths related to the future "Internet of objects" which have to be addressed to avoid some of the failures that occurred several years ago with the Internet. Myths can guide managers in their first perception and grasp of what RFID is and what its uses are, but once the effective implementation is planned, these myths should be discussed with regards to the local constrains and the particularities of the context.

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