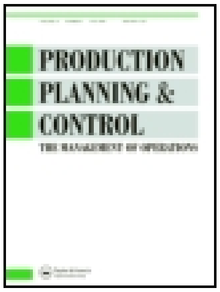

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Importance of issues related to RFID-enabled healthcare transformation projects: results from a Delphi study

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Importance of issues related to RFID-enabled healthcare transformation projects: results from a Delphi study

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Despite the high operational and strategic potential of Radio frequency identification (RFID) technology in terms of increased healthcare efficiency and effectiveness, and better decision-making, its adoption and use within health care remain fairly low, mainly because of the challenging nature of RFID projects. Further, scholarly research has yet to identify key issues related to RFID projects. The present study intends to fill this knowledge gap in the literature by identifying and rating key issues related to RFID-enabled healthcare transformation projects through a panel of experts using four rounds of the Delphi study. Finally, implications for practice and research are discussed.

Keywords: RFID technology; issues; healthcare sector; Delphi study; RFID projects

1. Introduction

The worldwide healthcare sector currently faces tremendous challenges, including escalating operating costs, the ageing population (Kaplan and Porter 2011), the high level of medical errors (National Academy of Sciences. 2007), the complexity of the healthcare value chain, the poor costing system, and the poor measurement of cost and outcomes (Kaplan and Porter 2011). For instance, US healthcare costs went from approximately 5% of the country's gross domestic product (GDP) in 1963 (Middleton 2009) to almost 17% of GDP in 2011 (Kaplan and Porter 2011), with a projection that this figure will increase to 20% by 2017 (Wurster et al. 2009). Moreover, medication errors are estimated to affect approximately 1.5 million people in the USA each year, yielding additional healthcare costs of roughly $2.3 billion in 1993 and $3.5 billion in 2006 (5) (National Academy of Sciences 2007). In addition, the healthcare value chain is considered by a large number of scholars and practitioners as one of the most complex sectors because it involves multiple stakeholders and organisational units (Porter 2010), as well as numerous requirements, including patient safety, the ability to track and trace pharmaceuticals, medical devices and the flow of products from manufacturers to patients (GS1-Australia 2010). More importantly, no viable means to measure properly the costs related to the delivery of patient care and to compare costs with outcomes currently exists (Kaplan and Porter 2011).

Information technology (IT)-enabled health care is considered as an important lever in addressing these challenges (Fichman, Kohli, and Krishnan 2011; Lee and Shim 2007). Indeed, IT can facilitate the transformation of the healthcare sector by redefining the relationships among key healthcare stakeholders (e.g. providers, payers and patients) through the emergence of innovative business models (Fichman, Kohli, and Krishnan 2011), thus improving patient management processes, enhancing service quality, improving operational efficiency and enhancing patient care (446) (Bush et al. 2009). Recently, radio frequency identification (RFID), a 'wireless automatic identification and data capture (AIDC)' technology (615) (Fosso Wamba et al. 2008b) has emerged as a disruptive and open innovation technology (Fosso Wamba 2011) that can further the transformation of health care (Ngai et al. 2009; Oztekin et al. 2010).

When compared with other AIDCs, such as bar coding, a ubiquitous technology in health care, RFID technology offers numerous advantages. The technology allows unique item-level product identification without line of sight and multiple-tag product reading. In addition, the technology offers enhanced data storage capability and data read-and-write capabilities. Also, RFID can be used for the tracking and tracing of healthcare assets and people (Bendavid, Boeck, and Philippe 2010; Bose et al. 2009; Symonds, Parry, and Briggs 2007). This increase in information flow and visibility

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through RFID technology results in the reduction in errors in patient care (Bose et al. 2009; Iris, Chon, and Blake 2009; Menachemi et al. 2007; Oztekin et al. 2010; Thuemmler, Buchanan, and Kumar 2007; Tu, Zhou, and Piramuthu 2009) and time saving up to 15% by nurses when searching for critical assets (Pleshek 2011). Moreover, RFID technology can capture the actual times related to the measurement of the costs of patient care, as well as track and trace the sequence and duration of key processes related to each patient. Therefore, this technology improves the ability of care providers to track the type and amount of resources consumed by each individual patient (Kaplan and Porter 2011).

Against this background, prior studies on RFID technology show that considerable attention has been allocated to RFID-enabled healthcare benefits (Bose et al. 2009; Iris, Chon, and Blake 2009; Menachemi et al. 2007; Oztekin et al. 2010; Thuemmler, Buchanan, and Kumar 2007; Tu, Zhou, and Piramuthu 2009) or to the limited number of issues related to RFID technology projects (Van Oranje et al. 2009) including RFID issues in technology (Cheng and Chai 2012), data management, security and privacy (Hawrylak et al. 2012), and organisation and financing (Bendavid, Boeck, and Philippe 2012; Catarinucci et al. 2012). In a review of academic literature on RFID technology, Ngai et al. (2008) found that most of articles were on RFID issues in the retail sector (17.8%), while only 3.6% of them focused on issues related to RFID-enabled healthcare projects. These studies have not yet identified key RFID issues in (i) technology, (ii) data management, security and privacy, as well as in (iii) organisation and financing issues. Also, a research agenda for the study of the adoption, usage and impact of RFID by Curtin, Kauffman, and Riggins (2007) suggests that these issues in (i) technology, (ii) data management, security and privacy, as well as in (iii) organisation and financing are interconnected. The authors believe that 'as the technical problems associated with implementing and using RFID technology are addressed and solved, the managerial and organizational issues will emerge as critical areas for IS research' (89) (Curtin, Kauffman, and Riggins 2007). These RFID issues may serve as a guide and control mechanism for healthcare managers with regard to decisions on the areas in which to dedicate their scarce resources and effort during the implementation process of RFID-enabled healthcare transformation projects, contributing to their success (Ngai et al. 2008). Therefore, they are anticipating increased research on issues that must be addressed to foster the adoption and use of RFID technology.

This present study is an initial effort towards bridging the existing knowledge gap in the literature. More specifically, this research draws on prior studies on RFID-enabled health care (Van Oranje et al. 2009) as well as RFID research agenda (Curtin, Kauffman, and Riggins 2007) to examine the following research questions:

(1) What are the (i) technological, (ii) data management, security and privacy, as well as (iii) organisational and financing issues related to RFID-enabled healthcare transformation projects?
(2) How are these three issues ranked in order of importance?
(3) What level of consensus exists about the relative importance of these three issues in RFID-enabled healthcare transformation projects?

To address these research questions, the present paper draws on the emerging literature of RFID technology and its potential in health care, as well as on a modified Web-based Delphi study. The remainder of the current paper is organised as follows: Section 2 presents RFID technology and its potential in health care, as well as IT project issues. Section 3 describes the research methodology. Section 4 presents the results and discussion. Section 5 provides the conclusion, limits, implications and future research directions.

2. Theoretical background

2.1. *RFID technology and it's potential in the health care*

RFID technology uses radio frequencies to track and trace item-level products automatically in real time (Poirier and McCollum 2006). The technology is considered by the 'Future Directions for IEEE Conference Business' as one of the 10 new and emerging technologies that can yield important operational and strategic business value in addressing key worldwide issues that are interrelated in the areas of megacity management, environment, disaster management, security, energy and health care (1) (Ward-Callan 2007). Any basic RFID system infrastructure comprises RFID tags, which are also called RFID chips or transponders, acting as an electronic database that can be attached to or embedded in a physical item to be identified and tracked. One or multiple readers or interrogators will communicate with the tags and retrieve the information to be sent to a host computer or RFID middleware to ensure communication between the RFID infrastructure and the different intra- and inter-organisational systems. This process initiates and supports business transactions (Asif and Mandviwalla 2005). Also, RFID middleware is the place where business decision rules are configured to ensure the automatic interpretation and semantic transformation of the data from the reader into data that can support the execution of business processes (Fosso Wamba et al. 2008a; Wang, Liu, and Liu 2010). In addition, the RFID middleware manages the RFID readers, as well as the events and data flows from RFID readers, aside from interacting with intra- and inter-organisational management systems (e.g. enterprise resource planning, warehouse and supply chain management systems) (Asif and Mandviwalla 2005).

In 2011, the RFID market was estimated at $5.84 billion, up from $5.63 billion in 2010 (Das and Harrop 2011). Analysts estimate that the global market for RFID readers and RFID tags only will be approximately $8.9 billion by 2015 (Marketresearch.com 2011). For the healthcare sector, the global market for RFID tags and systems will rise from approximately $94.6 million in 2009 to almost $1.43 billion in 2019. The rise will be primarily driven by the item-level tagging of drugs and various medical disposables and the real-time locating systems for healthcare staff, patients and assets for improved efficiency, meeting safety requirements availability of assets, as well as reduced losses (Harrop and Das 2009). For example, approximately 150 million RFID tags were consumed in the global healthcare sector in 2011 (Pleshek 2011).

All these impressive projections are primarily driven by the high potential of RFID technology in the healthcare sector in terms of reducing costs and improving outcomes. For example, RFID technology is a viable means to combat counterfeit medications, which represent a major threat for patient safety (Fuhrer and Guinard 2006) and an important financial loss for pharmaceutical firms (Dahiya 2008). For example, approximately 10% of the pharmaceutical products sold worldwide are considered counterfeit (Lefebvre et al. 2011), representing a loss of almost US$ 75 billion faced by pharmaceutical organisations in 2010 (Dahiya 2008). This finding is probably one of the reasons why numerous US regulatory organisations (e.g. Food and Drug Administration) and states (e.g. California) have been issuing mandates to pharmaceutical organisations to adopt e-Pedigree (or a unique identifier) for each pharmaceutical product moving along the pharmaceutical supply chain. Adopting such a system facilitates the tracking and tracing of products (e.g. attesting to the origin and composition of the product).

Various healthcare organisations are currently conducting pilot projects to assess the potential of RFID technology as an enabler of the tracking and tracing of healthcare critical assets. For example, the Texas Health Presbyterian Hospital in Dallas is using RFID technology to track and trace over 7000 items (e.g. IV poles, wheelchairs and hospital beds) throughout the hospital. This system is generating important benefits, including up to 15% of time saved by nurses when searching for critical assets and approximately $30,000 of monthly savings from rental equipments (Pleshek 2011). Furthermore, RFID technology can support all steps in the blood transfusion process (e.g. identification of blood bags at the collection point, tracking and tracing from the collection point to the healthcare facility) (Kebo et al. 2010). In short, RFID is 'an important element of pervasive health care and enables a fully automated solution for information delivery, thus reducing the potential for human error and increasing efficiency' (712–713) (Lee and Shim 2007). Finally, RFID technology is an enabler of the development of predictive maintenance strategies for medical equipment. The proper implementation of such strategies may result in better healthcare equipment servicing (Van Oranje et al. 2009).

2.2. *IT project issues*

A recent study by the Standish Group on IT projects shows that only 32% of all projects were successful (e.g. delivered on time, within budget, with required features and functions). The study also reveals that 44% of projects were either late, over-budget, and/or with less than the required features and functions and 24% of projects were considered failures (e.g. cancelled prior to completion or delivered, and never used) (The-Standish-Group-International. 2009). For example, inter-organisational clinical information system projects will fail because of key issues, such as inadequate buy-in and conflicting organisational missions, the need for centralised databases, data ownership issues, lack of financing, deep-seated professional and institutional resistance, and the high cost of network technology (557) (Sicotte et al. 2006). Poon et al. (2004) found that during the implementation of computerised physician order entry (CPOE) within healthcare settings, strong management leadership and high-quality technology are the key issues that need to be addressed to ensure project success. Moreover, the authors found that 'hospitals that placed a high priority on patient safety could more easily justify the cost of CPOE' (184). Finally, external factors, such as financial incentives and public pressure, play an important role during the execution of CPOE projects (Poon et al. 2004).

In their study of electronic medical record (EMR) adoption and use, Miller and Sim (2004) found that high initial cost, uncertain financial benefits, high initial physician time costs, EMR usability, difficult complementary changes, inadequate support, inadequate electronic data exchange, lack of incentives and physician attitudes were among the key issues for the success of an EMR project.

More broadly, various laundry lists of IT project issues/risks factors exist (Mark et al. 1998; Paré, Sicotte, and Girouard 2008; Roy et al. 2001; Sicotte et al. 2006). For example, Sicotte et al. (2006) developed a risk framework to examine issues associated with successful inter-organisational clinical information system projects.

The framework encompasses five dimensions. The first dimension is the technological risk (e.g. lack of a standard computer-based patient record system and a secure and reliable network). The second dimension refers to human risk (e.g. resistance to change and lack of computer skills and knowledge). The third dimension is the usability risk (e.g. lack of perceived system ease of use and perceived system usefulness). The fourth dimension is the managerial risk (e.g. lack of top-executive support and insufficient human, equipment and financial resources). Finally, the last dimension comprises strategic and political risks (e.g. power/political games and misalignment of objectives and stakes of partners).

Anja et al. (2003) produced a rank-order list of 19 risks associated with software projects in Nigeria, followed by a comparison of the list with early studies on software projects risks. The authors identified six risk factors, which are unique to the Nigerian context. These risk factors include 'under funding of development', 'import of foreign packages', 'energy supply', 'IT awareness in the country', 'huge and erratic capital requirements' and 'unreliable data network.'

The present study highlights the importance of context when identifying the risk factors associated with IT projects. This observation takes all its meaning and importance in the case of the identification of risks related to the implementation of RFID technology projects. Indeed, RFID technology is an instance of IT (Curtin, Kauffman, and Riggins 2007); therefore, the technology will share common issues identified by prior studies on IT projects. However, RFID technology has some more specific characteristics that are different from prior IT innovations (e.g. EDI, bare coding, software agents and Internet) including: sensing capabilities, enabler of process freedom (Curtin, Kauffman, and Riggins 2007; Fosso Wamba 2012). In short, 'RFID allows any tagged entity to become a mobile, intelligent, communicating component of the organisation's overall information infrastructure. (…). RFID systems cross firm boundaries, resulting in new opportunities to transform the supply chain for real-time optimisation' (88) (Curtin, Kauffman, and Riggins 2007). In addition, RFID is primarily product driven (Bendavid et al. 2009), and early studies on RFID adoption and use suggest that the research on the technology needs to consider a specific business and market context because market drivers will undoubtedly affect the way the industry approaches the implementation of RFID technology (Prater, Frazier, and Reyes 2005).

Following these recommendations, the present study builds on previous work (Van Oranje et al. 2009) and focuses on the identification and ranking of technological, data management, security, privacy, organisational and financing issues related to RFID-enabled healthcare transformation projects.

3. Research approach

3.1. *The Delphi technique*

The primary objectives of the present study are to develop the most accurate list of key issues related to RFID-enabled healthcare transformation projects, followed by the assessment of the relative importance of these issues, and the consensus about these issues among panel members. To achieve these objectives, a modified Web-based Delphi methodology is selected because previous studies have shown its relevance in achieving similar objectives (Malhotra, Steele, and Grover 1994).

The Delphi technique was initially proposed, developed and used at Rand Corporation (Steinert 2009) as an interactive method to gain consensus from a group of experts (Melnyk et al. 2009). Since then, numerous variations of the technique have been used by authors from various fields of research, including IT (Anja et al. 2003; Dekleva and Zupančič 1996; Doke and Swanson 1995; Jaana et al. 2011b; Melnyk et al. 2009; Nevo and Chan 2007; Okoli and Pawlowski 2004; Paré, Sicotte, and Girouard. 2008), operational research (Bititci et al. 2003; Melnyk et al. 2009), open innovation (Battistella and Nonino 2013), knowledge management (Holsapple and Joshi 2002), the healthcare sector (Lin, Tan, and Chang 2008; Schoeman and Mahajan 1977), and more recently (Kasiri, Sharda, and Hardgrave 2011), item-level RFID adoption in retailing. The Delphi methodology is considered as 'a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem' (3) (Linstone and Turoff 1975). The technique allows a methodical analysis of the inputs of selected experts on a particular subject matter through multiple iterations. The method is highly suitable for cases in which limited historical data are available.

The Delphi technique also offers anonymity to all participants, controlled information flow through the project leader, multiple feedback loops and an equilibrium distribution (291) (Steinert 2009). Finally, the Delphi method is well suited to the present study because it 'lends itself especially well to exploratory theory building on complex and interdisciplinary issues (e.g. adoption of RFID technology in the healthcare sector)' (446) (de Haes and van Grembergen 2008). In short, the Delphi technique 'represents an inductive, data-driven approach which is often used in exploratory studies where no or limited empirical evidence exists on specific topics or research questions' (1) (Paré, Cameron, and Templier. 2011b).

3.2. *Selection of panel of experts*

The present study defines an expert as 'an individual who has acquired knowledge in a specific domain (e.g.

RFID technology) gradually through a period of learning and experience' (5)(Okoli, Mbarika, and McCoy 2010). All participants invited to participate in the present study were authors and reviewers of papers that were accepted for a special issue on 'RFID technology enabled healthcare transformation' for a leading international journal. This choice ensures that each panel member has the required background and knowledge to understand, judge and debate on key issues related to the implementation of RFID-technology-enabled organisational transformation projects within the healthcare settings (Malhotra, Steele, and Grover 1994). A personalised invitation email explaining the objectives of the current study, the approximate time necessary to complete the questionnaire, and the likely number of rounds in the current study was sent to each of the respondents. Of the 25 invited participants, 16 agreed to participate in the present study. However, only 14 retrieved questionnaires were valid because the other two questionnaires were accomplished incorrectly or insufficiently. The response rate is 87.5%. In the second round, 14 panellists participated. The third and fourth rounds had 13 experts.

The sample size meets the minimum requirement size for a Delphi study. Indeed, numerous studies suggest that a sample size of at least 12 experts (Ewton 2003; Linstone and Turoff 1975) or 10 experts (Powell 2003) is sufficient for a Delphi study. Table 1 summarises the demographic profile of the panel. This group of respondents was primarily dominated by doctorate degree holders (92.9%), whereas others held a Master's degree (7.1%) (Table 1).

With regard to the number of years of involvement in RFID-technology-enabled organisational transformation projects, 42.9% of the respondents have 'more than five years of experience involving RFID technology projects', 21.4% have 'between two to five years of experience involving RFID technology projects', 28.6% have 'between 1 to two years of experience involving RFID technology projects', and only one respondent has less than one year of experience involving RFID technology project.

Table 1. Respondent profile (based on round 1).

Demographic categories	Frequency	Percentage
Level of education		
Doctorate degree	13	92.9
Master's degree	1	7.1
Total	14	100
Number of years of involvement with RFID technology projects		
>5 years	6	42.9
2 years < 5 years	3	21.4
1 year < 2 years	4	28.6
<1 year	1	7.1
Total	14	100

3.3. *Data collection and analysis method*

Prior to the collection of data, a pilot test of the questionnaire was conducted among four RFID technology researchers to confirm validity, as well as to verify the accuracy of the definitions of the preliminary list of issues in the questionnaire. Based on the suggestions of these researchers, a number of minor changes were implemented on the questionnaire to clarify the definition of some issues. Thereafter, four rounds of the Delphi study were conducted. In the first round or the brainstorming phase, consistent with the approach used by (Kasi et al. 2008; Keil, Tiwana, and Bush 2002), the panellists selected important issues from an initial online list of 15 issues (five technological issues; four data management, security and privacy issues; and six organisational and financing issues) derived from (Van Oranje et al. 2009). The panellists were also asked to add up to five new issues that they think are sufficiently important to address so as to improve the success of RFID-enabled healthcare transformation projects (Appendix A). The experts also provided open-ended feedback on each issue selected or added. The objective was to validate the existing list of issues and generate new relevant issues. Subsequently, a careful analysis of selected issues and feedback allowed for the generation of a combined list of 26 issues (eight technological issues; eight data management, security and privacy issues; and 10 organisational and financing issues). The study by (Van Oranje et al. 2009) is highly relevant to the objectives of the present paper because it offers an initial list of issues that may serve as a starting point for the current study. However, the present study differs from their study as it focuses more on the degree of difficulty to overcome the issues on the list.

In the second round, the panellists were presented an online randomised test, which is a combined list of 26 issues. The measurement scales were adopted from (Nakatsu and Iacovou 2009), which ranged from 1 (Unimportant issue) to 10 (Very important issue). For each issue, the panellists were asked to rate its importance using a 10-point importance scale as follows (Nakatsu and Iacovou 2009):

- 10 – Very important issue: The most relevant issue; it has a direct impact on the level of RFID adoption and use in health care and must be addressed to increase the level of the adoption and use of RFID in health care.
- 7 – Important issue: Relevant issue; it has a significant impact on the level of RFID adoption and use in the health care sector but should receive lower priority.
- 4 – Slightly important issue: Insignificantly relevant issue; it has little importance on the level of RFID adoption and use in health care.

- 1 – Unimportant issue: No relevance; it has no measurable effect on the level of RFID adoption and use in the healthcare industry.

Subsequently, the means and standard deviations for each issue, as well as the degree of consensus, as measured by the Kendall coefficient of concordance (Kendall's W), were calculated and sent to the panel for controlled feedback. Kendall's W was used to assess the level of consensus among members of the Delphi study panel. For Kendall's W, a value of zero indicates no consensus among the panel members, whereas a value of 1 reflects a complete consensus. Therefore, a greater value of W indicates a higher level of consensus among the panel members (Malhotra, Steele, and Grover 1994). In the case of standard deviation, the 'lower the standard deviation is, the higher is the consensus; thus, a 'perfect consensus' on an issue has a standard deviation of zero' (424) (Park et al. 2006). Furthermore, a reduction in standard deviation during the Delphi process shows a high level of consensus among the panel members (Park et al. 2006).

In the third round, each panel member received a personalised package that included the individual round 2 rating information and the group rating information of the panel, along with the Kendall's W. Then, each panel member was encouraged to analyse the group information and consider changing their ratings, if necessary, to align with the group evaluation. The fourth and last round of this Delphi study used the same controlled feedback mechanism. After the fourth round, the study was stopped because a moderate consensus was reached for the vast majority of the issues. In addition, a significant reduction in the standard deviation was achieved after each round. Moreover, the last round of the present study requested multiple follow-ups so as not to waste the valuable time of the respondents. Therefore, furthering the understanding on the persistent disagreements among experts for some groups of issues will be interesting. During the entire Delphi study, particular attention directed towards ensuring the anonymity of the respondents. For example, during the controlled opinion feedback process, only the aggregate information from the panel was sent to each panel member, along with his/her own information.

4. Results and discussion

The following section presents the results of the present study in a manner that is organised around each of the three groups of issues related to RFID-enabled healthcare transformation projects.

4.1. *Insights from the brainstorming phase*

The brainstorming phase constitutes an important milestone in the Delphi study process. This phase included an open-ended solicitation of opinions and ideas from experts (Okoli and Pawlowski 2004; Paré et al. 2011a) to provide responses to a broad set of questions (Paré et al. 2011a). The questions were analysed to eliminate redundancy and generate a consolidated list of questions for the subsequent phases (Paré et al. 2011a).

In this study, the panel of experts was provided with an initial online list of 15 issues that encompassed five technological issues, four data management, security and privacy issues, and six organisational and financing issues. They were asked to select key issues from the list that they thought should be addressed to improve the success of RFID-enabled healthcare transformation projects and to add the list of up to five new issues. Insights from the brainstorming phase allowed us to generate a combined list of 26 issues (8 technological issues, 8 data management, security and privacy issues, and 10 organisational and financing issues). The 11 new issues were then added to the initial list of issues (Appendix A).

Interesting feedback was received from the panel of experts in justifying their selection and/or adding issues. For example, an expert (PhD, with to two to five years RFID experience) stated that the research needed to transcend RFID issues and focus on RFID technology capabilities because it allows the 'expressive description of clinical patient profile on RFID tag to enable decision support to practitioners in any context (hospital, ambulance, home).' Therefore, the technology will constitute 'a new generation of decision support capabilities enabled by storing expressive information on RFID tags and devising efficient on-the-fly analysis techniques, can be a key driver for RFID adoption in healthcare.' According to this expert:

> the health care sector is one of the most complex environments where to implement RFID – multi stakeholders (IT, Bio Med, nursing, etc.) with all the decision power in the hand of the medical personnel – who do not necessarily understand what the technology can do for them.

Therefore, identifying and understanding user requirements towards RFID technology will be a critical challenge for pushing user adoption and compliance. Furthermore, this expert believes that the 'packaging of the RFID offer – for long time RFID vendors have tried to sell the technology instead of the benefits it can deliver (e.g. visibility). RFID is seen as another technology project,' limiting the understanding of its real potential in transforming health care. While the real potential of the technology remains underestimated, this expert believes that innovations in UHF (new tag form factors, new tags for metal and liquids) will help to solve certain technological issues and will facilitate the integration of RFID infrastructure with current intra- and inter-healthcare information systems. In line with this observation, another RFID expert (PhD, with more than five years RFID experience) postulates that 'EM (electromagnetic) conflicts with medical equipment' and is a significant concern when dealing with 'integrating RFID within the physical environment of the healthcare delivery organisation. And the effective use of common standards to disseminate RFID-enabled healthcare applications is lagging behind mostly because they still in development.' Furthermore, when addressing the 'tendency to underestimate monetary benefits from RFID-enabled healthcare applications,' this expert believes that most 'managers (are) not aware' of the real value of RFID-enabled healthcare transformation projects and, therefore, will not indicate strong support towards such projects.

4.2. *Ranking of issues: key analytical insights*

Tables 2–4 provide an overview of the key analytical insights related to the ranking of technological issues; data management, security and privacy issues; and organisational and financing, respectively. These issues are sorted in descending order, from the most important to the least important issue, based on the mean ranking from the fourth round of the Delphi study (the reference round for the ranking). The second column defines the issues, whereas the third to fifth columns represent the mean of the issues for round two to four, respectively.

Based on the panel rankings, the top three technological issues that matter most to RFID-enabled healthcare transformation projects were 'Integrating RFID infrastructure with current intra- and inter-healthcare information systems' (1st), 'Effective use of common standards to disseminate RFID-enabled healthcare applications' (2nd) and 'Lack of comprehensive RFID-enabled solutions' (3rd). According to a panel member (PhD, with more than five years RFID experience), 'Integrating RFID within the physical environment of the healthcare delivery organisation and the effective use of common standards to disseminate RFID-enabled healthcare applications is lagging behind mostly because they still in development.'

The next three issues were 'Integrating RFID infrastructure with current intra- and inter-healthcare business processes' (4th), 'Integrating RFID within the physical environment of healthcare delivery organisation' (5th) and 'Maturity of RFID-enabled healthcare technologies and applications' (6th), with a mean equal or greater than 7 for rounds 2, 3 and 4. The two least important issues were 'Managing scalability/scope of RFID-enabled healthcare projects' (7th) and 'Dominance of legacy systems in the healthcare sector' (8th).

Globally, these results are consistent with early studies on RFID technology in the manufacturing and supply chains (Fosso Wamba and Chatfield 2009; Kapoor, Zhou, and Piramuthu 2009). Fosso Wamba and Chatfield (2009) observed that 'integrating RFID infrastructure with current intra- and inter-organisational information systems' was a key contingency factor for creating value from RFID supply chain network projects in logistics and manufacturing environments. Similarly, recent studies emphasised that technological issues, such as 'lack of common RFID standards' (Ngai and Gunasekaran 2009; Whitaker, Mithas, and Krishnan 2007) and 'lack of comprehensive RFID-enabled solutions' (Teo Thompson et al. 2011), were among the key issues that mattered most when executing RFID-enabled organisational transformation projects.

With regard to data management, security and privacy issues, the results suggest that the top three issues that matter most to RFID-enabled healthcare transformation projects are 'Preserving data integrity and reliability' (1st), 'Managing integration of RFID-generated data', (2nd) and 'Identifying and addressing privacy concerns' (3rd). RFID data are considered as the 'fuel' of business intelligence for better decision-making across the supply chain. Therefore, ensuring that the information embedded into the RFID tags is preserved and reliable becomes critical. Moreover, identifying and addressing privacy are among the top issues currently discussed by academics and practitioners (Kapoor, Zhou, and Piramuthu 2009; Lee and Shim 2007; Thiesse 2007). For Lee and Shim (2007), 'security of RFID has also become a major issue to organisations since information on RFID tags can be easily stolen or breached. Therefore, future studies on privacy and security of RFID are needed' (723).

Indeed, privacy issues related to RFID-enabled healthcare transformation projects need to be carefully assessed and incorporated into project requirements to avoid their cancellation as a result of the protestations of the consumers, as was the case for the retailer Benetton (Smart and Bunduchi 2010). In the context of RFID tag implementations in supply chains, a security violation of an RFID-enabled item along the supply chain may affect the competitive advantage of the tag owner (Kapoor, Zhou, and Piramuthu 2009). With regard to RFID data, the same authors believe that '(RFID) data collected are of no use if not used properly' (529). Therefore, a proper management of the integration of RFID-generated data will be a prerequisite for gaining business value from RFID-enabled healthcare transformation projects through business analytics and better decision-making.

In addition, we have 'Common standard for information representation and exchange' (4th), 'Analyzing the vast amount of RFID-generated data for business intelligence and improved healthcare service delivery' (5th) and 'Sharing of operational/strategic information from RFID data' (6th), with a mean equal or greater than 7.23 for rounds 2, 3 and 4. These three issues are considered prerequisites to capture business value from the vast amount of data generated from RFID-enabled healthcare applications (big data). A number of scholars have suggested that data scientists, 'the people who understand how to fish out answers to important business questions from today's tsunami of unstructured information', will have 'the Sexiest Job of the 21st Century' (73) (Davenport and Patil 2012). The authors added,

> The challenges of accessing and structuring big data sometimes leave little time or energy for sophisticated analytics involving prediction or optimisation. Yet if executives make it clear that simple reports are not enough, data scientists will devote more effort to advanced analytics. (76)

The two least important issues were the 'Availability of middleware solutions to translate RFID data into business intelligence' (7th) and 'Availability of human resource to analyse the vast amount of RFID-generated data' (8th). The ranking of this last issue is surprising because numerous scholars believe precisely that the lack of human resources capable of analysing and generating business value from the amount of RFID-generated data (big data) (Davenport and Patil 2012) may represent a key challenge for firms exploring the potential of RFID technology. Indeed, they believe that 'as companies rush to capitalise on the potential of big data, the largest constraint many face is the scarcity of this special talent' (73).

For organisational and financing matters, the top three issues that may have a negative effect on RFID-enabled healthcare transformation projects include 'Designing and implementing RFID-enabled healthcare processes' (1st), 'Financial analysis of all types of healthcare costs that can be reduced using RFID technology' (2nd), and 'Determining the return on investment by correctly identifying costs and including non-monetary benefits' (3rd). Next are 'Adapting RFID within the culture and norms of the health system' (4th), 'Tailoring RFID system with the organisation's complexity, variability, and institutional context' (5th), 'Fostering change management' (6th), 'Lack of healthcare top management support for RFID-enabled healthcare projects' (7th) and 'Tendency to underestimate the monetary benefits from RFID-enabled healthcare applications' (8th), with a mean between 6.54 and 7.69 for rounds 2, 3 and 4.

The two least important organisational and financing issues are 'Availability of human resources to implement and monitor RFID-enabled healthcare applications' (9th), and 'Pushing for user's adoption and compliance' (10th). Designing and implementing IT-enabled processes are at the core of IT research on business value from IT (Melville, Kraemer, and Gurbaxani 2004). This finding is not surprising as financial analysis and lack of return on investment (ROI) are among the top organisational and financing issues. Indeed, a 'major impediment of RFID adoption is the vagueness of its cost-benefit analysis, which includes both unknown cost structure and unclear future payoff' (529) (Kapoor, Zhou, and Piramuthu 2009). This lack of visibility in assessing the ROI of RFID-enabled organisational transformation projects is among the main reasons justifying a lagging-behind attitude with pilot projects related to the technology.

Using the Kendall's W from Tables 2–4, a considerable increase in the value of W from round 2 to round 4 can be observed for technological issues (from W = 0.20 for round 2, W = 0.36 for round 3, and W = 0.54 for round 4); data management, security and privacy issues (from W = 0.30 for round 2, W = 0.50 for round 3 and W = 0.64 for round 4); and organisational and financial issues (from W = 0.07 for round 2, W = 0.14 for round 3 and W = 0.27 for round 4). Therefore, this result justifies the use of a Delphi study to assess how consensus is generated among the panel members.

5. Conclusion, limits, implications and future research directions

The present study provides a comprehensive list of technological; data management, security and privacy; and organisational and financing issues related to RFID-enabled healthcare transformation projects, followed by the ranking of the said issues. For each category of issues, the panel of experts identified the top issues that

Table 2. Results of ranking rounds: Case of technological issues.

Rank	Issue	Round 2 Mean	Round 3 Mean	Round 4 Mean
1	Integrating RFID infrastructure with current intra- and inter-healthcare information systems	8.21	8.31	8.23
2	Effective use of common standards to disseminate RFID-enabled healthcare applications	7.86	8.23	8.15
3	Lack of comprehensive RFID-enabled solutions	7.36	7.85	7.85
4	Integrating RFID infrastructure with current intra- and inter-healthcare business processes	7.00	7.54	7.54
5	Integrating RFID within the physical environment of the healthcare delivery organisation	7.50	7.69	7.31
6	Maturity of RFID-enabled healthcare technologies and applications	7.43	7.62	7.23
7	Managing scalability/scope of RFID-enabled healthcare projects	6.79	6.85	6.92
8	Dominance of legacy systems in the healthcare sector	5.64	5.77	5.69
	Kendall's W	0.20	0.36	0.54

Table 3. Results of ranking rounds: Case of data management, security, and privacy issues.

Rank	Issue	Round 2 Mean	Round 3 Mean	Round 4 Mean
1	Preserving data integrity and reliability	8.38	8.69	8.46
2	Managing integration of RFID generated data	8.08	8.31	8.19
3	Identifying and addressing privacy concerns	8.00	7.38	7.92
4	Common standard for information representation and exchange	7.23	7.38	7.54
5	Analysing the vast amount of RFID generated data for business intelligence and improved healthcare service delivery	7.31	7.08	7.38
6	Sharing of operational/strategic information from RFID data	7.23	7.23	7.31
7	Availability of middleware solutions to translate RFID data into business intelligence	6.77	6.92	6.85
8	Availability of human resource to analyze the vast amount of RFID generated data	5.69	5.38	5.38
	Kendall's W	0.30	0.50	0.64

Table 4. Results of ranking rounds: Case of organisational and financing issues.

Rank	Issue	Round 2 Mean	Round 3 Mean	Round 4 Mean
1	Designing and implementing RFID-enabled healthcare processes	7.15	7.85	7.96
2	Financial analysis of all types of healthcare costs that can be reduced using RFID technology	7.77	7.85	7.92
3	Determining the return on investment by correctly identifying costs and including non-monetary benefits	8.00	8.00	7.77
4	Adapting RFID within culture and norms of the health system	7.62	7.54	7.69
5	Tailoring RFID system with the organisation complexity and variability and institutional context	6.92	6.92	7.23
6	Fostering change management	6.85	7.00	7.15
7	Lack of healthcare top management support for RFID-enabled healthcare projects	6.54	7.08	7.15
8	Tendency to underestimate the monetary benefits from RFID-enabled healthcare applications	6.54	6.77	7.08
9	Availability of human resources to implement and monitor RFID-enabled healthcare applications	6.62	6.69	6.92
10	Pushing for user's adoption and compliance	6.38	6.38	6.46
	Kendall's W	0.07	0.14	0.27

may affect RFID-enabled healthcare transformation projects as follows:

- For technological issues: 'Integrating RFID infrastructure with current intra- and inter-healthcare information systems' (1st), 'Effective use of common standards to disseminate RFID-enabled healthcare applications' (2nd) and 'Lack of comprehensive RFID-enabled solutions' (3rd).
- For data management, security and privacy issues: 'Preserving data integrity and reliability' (1st), 'Managing integration of RFID-generated data' (2nd) and 'Identifying and addressing privacy concerns' (3rd).
- For organisational and financing issues: 'Designing and implementing RFID-enabled healthcare processes' (1st), 'Financial analysis of all types of healthcare costs that can be reduced using RFID technology'(2nd) and 'Determining the return on investment by correctly identifying costs and including non-monetary benefits' (3rd).

Meanwhile, the least important issues are the 'Dominance of legacy systems in the healthcare sector' (8th), 'Availability of human resource to analyze the vast amount of RFID-generated data' (9th) and 'Pushing for user's adoption and compliance' (10th), respectively, for technological; data management, security and privacy; and organisational and financing issues.

Prior to the discussion of the managerial and theoretical implications of the present study, some of the limitations need to be acknowledged. First, although the respondents have had several published articles on RFID-enabled healthcare applications and issues, they cannot be immediately assumed to possess the required knowledge to understand the 'high levels of complexity and nuance of the healthcare sector' (670) (Lerouge, Mantzana, and Wilson 2007) and to identify and assess accurately the critical issues related to RFID-enabled healthcare transformation projects. Second, the list of issues generated by the present study is specific to the healthcare sector. Therefore, further research might attempt to generate a generic list of issues affecting RFID-enabled organisational and inter-organisational transformation projects, as is currently the case for risk factors related to software projects (Anja et al. 2003; Schmidt et al. 2001). Third, even if the sample size in the current work meets the minimum requirement to conduct a Delphi study (i.e. minimum of 12 experts) (Ewton 2003; Linstone and Turoff 1975) or even 10 experts as suggested by Powell (2003), the sample is not statistically representative (Powell 2003). Therefore, caution should be taken when generalising the present results. However, as Powell (2003) points out, 'The Delphi does not call for expert panels to be representative samples for statistical purposes. Representativeness, it seems, is assessed on the qualities of the expert panel rather than its numbers' (378).

5.1. *Managerial implications*

From the managerial perspective, the following implications can be highlighted. First, the ranked list of key technological, data management, security and privacy, organisational, and financing issues related to RFID-enabled healthcare transformation projects may serve as a complete checklist for healthcare managers as they explore the potential of RFID technology. Second, the identification of the top three issues confronting RFID-enabled healthcare transformation projects for each dimension might serve as a guide and control mechanism for healthcare managers, with regard to decisions on where to concentrate their scarce resources and effort during the implementation process of RFID-enabled healthcare transformation projects, to increase their likelihood of success. In line with Jaana, Tamim, and Teitelbaum. (2011a), the present research posits that identifying and rating key IT-enabled healthcare issues are critical steps towards informing healthcare executives appropriate directions for their initiatives to face the said issues in an environment marked by an increased focus on IT-enabled healthcare transformations (e.g. improved quality of care, better measure of cost and outcomes). On the other hand, these crucial steps could assist healthcare executives in dealing with 'the limited success in implementing IT projects and reaping the benefits of health IT' (8).

5.2. *Theoretical implications*

The major theoretical implication of this paper is that by providing a ranked list of important issues in RFID-enabled healthcare transformation projects, the current knowledge on RFID-enabled organisational transformation in the healthcare industry will be expanded. This study may serve as a starting point for future research on critical issues affecting RFID technology projects in such sectors.

In addition, building upon our list of issues, future research direction may follow three main categories of issues on RFID-enabled healthcare transformation projects: (i) technological, (ii) data management, security and privacy, as well as (iii) organisational and financing, as proposed in the following paragraphs.

5.2.1. *Future research directions: technological issues*

Future research can build upon the provided list to assess the effects of RFID as an enabler of healthcare applications (e.g. asset, patient and staff management) at the focal firm level (e.g. within one healthcare facility), in-transit level (e.g. an ambulance moving between two healthcare facilities) and inter-firm level (e.g. between multiple healthcare facilities). Another interesting direction is the examination of the reliability of RFID-enabled healthcare business creation and realisation. For example, Pablo, Javier, and Rodrigo (2011) found that when the hand of a nurse accidentally covers RFID tags, the reading distance can drop from a range of 5 m to 8 m to less than 1 m, with unreliable reading accuracy, even if high performance RFID tags and RFID readers are used (6). Parlak et al. (2012) found that when RFID tags are operating near the human body, they experience performance degradation. They noticed that when stethoscopes are placed around the patient's neck, they are in contact with occlusions by the human body, which causes radio signal interference. Therefore, the best strategy for selecting the most reliable RFID architecture for a given healthcare setting should be developed. Our findings here may also help to explore the importance of the same issues on other technological factors (e.g. complexity, compatibility and relative advantage) as well as the adoption decision process for both the adopters and the non-adopters of RFID-enabled healthcare applications. Recently, Reyes, Li, and Visich (2012) found that RFID technical issues, including issues with hardware and software, are positively related to the RFID implementation level within healthcare settings. Therefore, the design and testing of hardware and software that may facilitate the implementation of RFID-enabled healthcare transformation projects (e.g. the integration of different RFID components and infrastructure with existing firm IS infrastructure) should be conducted.

5.2.2. *Future research directions: data management, security and privacy issues*

The current RFID-enabled healthcare market is primarily driven by the item-level tagging of critical assets (e.g.

drugs and wheelchairs) and real-time location applications (e.g. staff and patient). Therefore, strategies, tools and capabilities (e.g. human resources and IT infrastructures) that can manage and generate business value from the vast amount of data generated by these RFID-enabled applications should be developed (Zhu, Mukhopadhyay, and Kurata 2012). Moreover, tools and mechanisms for managing RFID data throughout their lifecycle should be designed. For example, the collection of data from a given critical healthcare asset to track and trace this asset when needed is an interesting research question (Oztekin et al. 2010). Indeed, 'a typical hospital is unable to locate about 15–20% of its assets when needed' (587) (Tu, Zhou, and Piramuthu 2009). The RFID data integrity and accuracy problems caused by factors such as reader collisions and the structure of the reading environment (e.g. metal, liquid and dust) are additional topics of interest. Furthermore, RFID data accuracy throughout their lifecycle (e.g. collection, exploitation and sharing) is considered a 'major beneficial property of RFID tag-enabled systems, false readings can drastically reduce the utility of RFID tags' (592) (Tu, Zhou, and Piramuthu 2009). Mechanisms, strategies and architectures that will facilitate the identification of security and privacy issues related to RFID-enabled healthcare transformation projects should also be determined. For example, determining the RFID architecture that allows the best mean of addressing the security and privacy issues for a given healthcare setting is an interesting research question. Two dominant architectures exist the following: (i) data-on-the-network architecture, where RFID-enabled patient data can be stored in a remote-centralised database and (ii) data-on-tag architecture that allows each patient to use an RFID-enabled card, acting as a mobile database where all patient information is stored (Thomas and Adam 2007).

In this study, our panel of experts was limited to the respondents who have published articles on RFID-enabled healthcare transformation. Future research might involve a broader sample of healthcare stakeholders (e.g. clinicians, users and healthcare managers). In their analysis of the anticipated consequences of CPOE systems in a hospital setting, Sittig et al. (2008) suggested that clinicians must be actively involved in the selection and implementation process. The CPOE project must not be led by an IT department. Rather, it must be a clinically-driven project chosen to meet one or more of the organisation's highest-level strategic goals (e.g. improving patient safety or the overall quality of care). Therefore, communication on the CPOE project needs to be conducted by individuals who can speak the languages of both technology and clinical workers (e.g. people with experience in clinical, IT, project management and clinical informatics areas). Their observations are in line with those of (Boonstra, Boddy, and Bell 2008), who highlighted the importance of considering all stakeholder expectations and interests in designing and implementing an IS artefact.

The real cost of implementing RFID-enabled healthcare transformation applications should be assessed in future research, considering that studies continue to indicate that 'the total cost of adopting RFID in health care is still significant' (958) (Parlak et al. 2012). In addition, tools and frameworks that may help different stakeholders involved in RFID-enabled healthcare transformation projects to identify costs, benefits and potential risks related to such projects should be developed. Prior studies on RFID-enabled healthcare transformation projects have shown that when not properly managed in terms of identifying all technological, data management, security, privacy and management requirements for a given healthcare setting, these projects 'might introduce new risks' (372) (van der Togt, Bakker, and Jaspers 2011).

Moreover, the impact of the technology on healthcare work practices (e.g. power balance and added workload) should be evaluated. The fact that RFID-enabled healthcare transformation projects may add staff workload is considered an critical barrier for RFID implementation projects (van der Togt, Bakker, and Jaspers 2011). Furthermore, future research may discuss other contingency factors, such as environmental upheaval, second-order organisational learning and resource commitment, which are identified as factors that affect the level of business benefits realised from RFID supply chain projects in the context of third-party logistics services (Fosso Wamba and Chatfield 2009).

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Appendix A. List of issues

	Origin
Technological issues	
(1) Managing scalability/scope of RFID-enabled healthcare projects	
(2) Integrating RFID within the physical environment of the healthcare delivery organisation	
(3) Maturity of RFID-enabled healthcare technologies and applications	ELI
(4) Effective use of common standards to disseminate RFID-enabled healthcare applications	
(5) Integrating RFID infrastructure with current intra- and inter-healthcare information systems	
(6) Lack of comprehensive RFID-enabled solutions (e.g., integrate solution for asset management, staff management, patient management, therapy management, etc.)	NIB
(7) Integrating RFID infrastructure with current intra-and inter-healthcare business processes	
(8) Dominance of legacy systems in the healthcare sector	
Data management, security and privacy issues	
(1) Identifying and addressing privacy concerns	
(2) Preserving data integrity and reliability	
(3) Managing integration of RFID generated data	ELI
(4) Analysing the vast amount of RFID generated data for business intelligence and improved healthcare service delivery	
(5) Common standard for information representation and exchange (e.g., multiple contexts: hospital, ambulance, emergency, home, etc.)	
(6) Sharing of operational/strategic information from RFID data	NIB
(7) Availability of middleware solutions to translate RFID data into business intelligence	
(8) Availability of human resource to analyse the vast amount of RFID generated data	
Organisational and financing issues	
(1) Fostering change management	
(2) Pushing for user's adoption and compliance	
(3) Determining the return on investment by correctly identifying costs and including non monetary benefits	ELI
(4) Designing and implementing RFID-enabled healthcare processes	
(5) Tailoring RFID system with the organisation complexity and variability and institutional context	
(6) Adapting RFID within culture and norms of the health system	
(7) Financial analysis of all types of healthcare costs that can be reduced using RFID technology	
(8) Lack of healthcare top management support for RFID-enabled healthcare projects	NIB
(9) Availability of human resources to implement and monitor RFID-enabled healthcare applications	
(10) Tendency to underestimate the monetary benefits from RFID-enabled healthcare applications	
(10) Tendency to underestimate the monetary benefits from RFID-enabled healthcare applications	

ELI: Early list of issues; NIB: New issues from brainstorming.