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TECHNICAL REPORT

Study on the requirements and options for Radio Frequency Identification (RFID) application in healthcare

Final report

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Executive Summary

Objective of this report

This report is part of a wider study on Radio Frequency Identification (RFID) applications in healthcare, and draws on inputs from an extensive review of scientific an grey literature; an analysis of market data, a two stage Delphi survey of key experts from industry, and academia, care providers, and others; a number of semi-structured expert interviews and seven case studies. By combining these methodologies the report provides a review of the deployment of RFID in healthcare settings in Europe, grounded in theory, expert opinion, and practice.

The report first gives a high level overview of the European market for RFID in healthcare. The report then identifies and reviews the drivers and enabling factors, the obstacles and the critical uncertainties affecting the current and future deployment and up-take of RFID and similar technologies in healthcare settings. Through an assessment of the case studies and supporting data sets the cost and benefits of RFID applications in healthcare have been assessed. Due to shortages in data, especially in Europe, a full cost-benefit analysis and an extrapolation of these to assess the overall contribution of RFID to the efficiency and quality of care in Europe is not (yet) possible. However, a framework for assessing costs and benefits is developed and where possible applied to single implementations. Finally the most promising[1] RFID functionalities and application domains are identified.

What is RFID?

Radio Frequency Identification (RFID) is a technology used to help identify, authenticate, track, and trace objects and people; and to gather and store information about them and their environment. The technology has been successfully applied in logistics and retail industries, where its use is now common. In Healthcare many applications are being tested in logistics to improve the operational management efficiency of healthcare delivery and quality of care.

All RFID systems consist of a transponder, a reader, a database and a software programme for processing the data collected. RFID systems can be closed or open. A closed system is defined for a strongly delimited environment (in terms of data exchanged and frequency power). Closed RFID systems do not need to be compliant with other data formats or frequency allocation schemes. Open systems, by contrast, have interfaces to other systems outside their own area of definition and may be functionally or organisationally external. RFID transponders are made up of silicon memory chips and copper or aluminum antennae, and are often sealed in paper or foil covers. Passive transponders have no processing capability and no internal power source. By using

[1] Promising in respect to reducing costs, improving quality of care and feasibility of roll out

innate properties of electromagnetic fields, the chips are turned on when an electro-magnetic reader is present, allowing them to simply transmit a serial number. Passive RFID chips usually only work within a range of five metres and are extremely reliable (compared to active transponders) with a near-unlimited lifetime. However, the current technological and operational focus seems to be in active transponders. These transmit signals of their own accord using internal power supplies and more powerful processing and memory storage facilities, which allow them to act like microcomputers. Generally, active transponders can transmit data up to a maximum distance of 30 metres.

The main drivers and enabling factors, obstacles, and uncertainties of RFID deployment in healthcare

The following paragraphs provide an overview of the main drivers, obstacles enabling factors and uncertainties associated to the implementation and use of RFID systems with healthcare delivery organisations.. While going through the list, it is important to emphasise that the order of the presentation does not reflect any specific rankings but a coordinated summary of the evidence collected for this study, through: literature review, Delphi survey, validating expert interviews and case studies.

Factors favouring RFID deployment in healthcare

The study identified a number of drivers for the development and implementation of RFID systems in healthcare settings:

Patient safety and quality of care

1. Patient safety/care quality improvements and associated cost savings resulting from RFID technology (including working routines, medication commissioning and processing, requiring visibility)

Organisational and financial needs and benefits

2. Management challenges resulting from the size and complexity of medical and other healthcare delivery activities (eg supply chain management)
3. Process transparency/traceability; distinct from supply chain management of medical devices/objects/equipment

Advocacy and Leadership

4. Senior management leadership and commitment to push forward the implementation of RFID and acquire staff support and involvement
5. Government policies or public/private initiatives aimed at fostering the use of RFID as part of a drive towards operational and strategic innovation; including publicity leading to a temporary "hype", around the technology and its benefits for healthcare.
6. Capacity and the nature of the healthcare system as a leading indicator for the wider environment in which RFID is used and disseminated

Obstacles to RFID deployment in healthcare

The evidence collected through the case studies and interviews with experts have highlighted several operational obstacles to the deployment of RFID in healthcare delivery organisations. As technology advances, these obstacles can be overcome. However, at the present, they are to be noted as issues. These obstacles are:

Technological issues

1. Wireless infrastructure is not uniformly available within healthcare delivery organisations;
2. Electromagnetic interference between eg RFID readers and medical devices
3. Difficulty of physically integrating parts of RFID technology (eg tag size) with the object of interest (eg metal containers, tag size)
4. Limited portability of RFID technology due to insufficient battery capacity

Data management, security and privacy

5. Errors in overall system integration associated with the use of RFID

Organisational and financing issues

6. Relatively high hardware and implementation costs compared to competing technologies such as barcodes or DataMatrix.

Uncertainties affecting future RFID deployment in healthcare

The evidence collected also identified thirteen uncertainties affecting future RFID deployment; some of these factors can evolve into obstacles but can also lead to faster implementation. These are:

Technological issues

1. Managing scalability
2. Integrating RFID within the physical environment of the healthcare delivery organisation
3. Determining maturity of RFID technologies and applications
4. Using common standards

Data management, security and privacy

5. Identifying and addressing privacy concerns
6. Preserving data integrity and reliability
7. Managing integration of RFID generated data

Organisational and financing issues

8. Fostering change management

9. Pushing for user's adoption and compliance
10. Determining the RoI by correctly establishing costs and including non-monetary benefits
11. Supporting healthcare processes with RFID (translation)
12. Matching RFID system with the organisation complexity/variability and institutional context
13. Setting RFID within culture/norms of the health system

Developing a conceptual framework for assessing costs and benefits

The initial objective of conducting a full scale cost-benefit analysis (CBA) of RFID deployment in healthcare in Europe was abandoned due to a lack of relevant data. It became apparent that – particularly in Europe – there is a lack of systematic data collection by the healthcare institutions through ex-ante and ex-post evaluations of technological innovations in healthcare systems.

The majority of existing evaluations largely fail to account for non-capital saving benefits. They also seldom detail the implementation costs associated with the launch of RFID applications (including business case development, system integration and initial tagging). The lack of transparency in evaluations also leads to a failure in identifying the social case for investing in healthcare RFID.

Instead, a three step approach was conducted:

- selecting and conducting case studies of promising RFID applications (potential for affecting cost and quality of healthcare, market-readiness)
- conducting 'economic' evaluations of the applications based on the quantitative data on outcomes collected during the case studies
- developing a conceptual framework for the evaluation of the economic impacts of RFID in healthcare

Costs and benefits for economic evaluation of in-hospital RFID applications

Implementation Costs
Hardware costs
Software costs
Middleware costs
Installation costs
Training costs
Process re-design costs
Labor costs (including business case development costs, system integration costs)
Maintenance Costs
Software costs
Hardware costs
Data back-up costs
Labor costs (system maintenance and expansion)
Efficiency Gains
reduction in capital expense outlays for purchasing assets and inventory
reduction in capital and operative expense outlays for renting and managing equipment
labor savings from automatic data capture and transfer
labor savings from improved process status visibility
cost capture improvement via automatic data capture
reduced care-provider turnaround rate due to improved work satisfaction
increased patient through-put
decreased patient subversion
Quality Gains
elimination of wrong patient/wrong medication errors
elimination of wrong patient/wrong procedure errors
improved care coordination leading to more timely & available care
improved coordination of auxiliary services (eg transportation)
improved patient satisfaction
improved infection control capacity
improved asset preventive and corrective maintenance
Other Gains
improved regulatory compliance
reduced insurance premiums
improved process and event audit capacity
improved management & forecasting capacity

Source: RAND Europe.

These categories can be used to guide the collection, integration and interpretation of the evidence necessary to transparent, systematic and comprehensive evaluation of RFID deployments in healthcare. They illustrate the benefit and costs associated with the use of RFID applications in healthcare settings that a a cost-benefit analysis (CBA) – let alone a full economic evaluation - of RFID applications in healthcare needs to consider.

Case studies: Assessing the cost and benefits of existing RFID applications

Seven case studies were conducted:

1. *Treviglio Caravaggio (Italy):* Application: active RFID system which displays the location of each orthopaedic patient (identified by a numeric code) during their clinical journey in order to provide immediate feedback to relatives at the emergency ward lounge.
2. *Birmingham Heartland Hospital (UK):* The application: "Safe Surgery System" comprises a digital operating list, enabled by automated patient recognition. It is a passive pre-operating theatre decision support technology (process management & identification system) using printed RFID wristbands and digital photo identification linked to an electronic pre-operative checklist.
3. *Amsterdam Medisch Centrum (NL):* Three simultaneous RFID pilots including: a) identification/localisation of persons in OR b) OR materials tracing; and c) blood products tracing.
4. *Jena University Hospital (Germany):* The application: a pilot of an RFID-assisted medication commissioning and medication preparation (at bedside) for patient safety in the intensive care unit using the platform's auto-ID infrastructure to identify, track and match medication accurately and in real-time from the hospital's pharmacy until they are administered to patients.
5. *Geneva University Hospital (CH):* Two applications. First: an RFID-based garment tracking application (1995-2008) to manage daily collection, ironing and redistribution of garments across 4 sites, 7 distributors, distribute 28,000 garments per week. Second: an RFID-based application for chemotherapy procedures, allowing to electronically capture the chemotherapy process from prescription to administration and commissioning of chemotherapy preparation.
6. *The Wayne Memorial (USA):* RFID-based real time asset management solution; tracking & management of portable assets & equipment.
7. *Royal Alexandria Hospital (UK):* RFID-based real time asset management technology. The application is used at present only by clinical technicians – to locate equipment (currently only IV pumps) for preventive maintenance, and covers predominantly IV pumps along with other key movable assets.

Of these seven cases one represents a failed pilot (AMC), two have decided to opt for DataMatrix solutions instead of RFID (Geneva and Jena), and the others have successfully implemented RFID, mostly in combination with other technologies like WiFi.

The case studies provide useful insights into the relevant costs and benefits that may be expected to arise and need to be monitored; as represented in the conceptual framework above. In addition the cases also allow us to draw some general insights:

- Most successful applications so far seem to be in logistics and operational management; and less in patient care and quality of care improvement.
- Compared to logistics, patient care delivery applications face greater implementation problems; in particular because critical treatments and processes require near 100percent

reliability and because the complexity of hospital environments raises the likelihood and consequences of electromagnetic interference between technologies

- We found no integrated ICT solutions in information about RFID applications is generated and processed in a structural and integrated manner
- Implementation and running costs vary significantly across cases and applications. This implies one size does not fit all, and therefore that 'pilots' should be chosen carefully and findings generalised only with caution. The further implication is that some applications are more 'likely' than others, but there is no automatic presumption that the ones most likely to lead RFID implementation are the 'best' according to balanced cost-benefit criteria.
- There are significant differences in perceived benefits among case studies that depend in part on the organisational implementation of RFID and the commitment to innovate and/or improve process automation
- There is a need better monitoring of cost/benefit data against pre-investment baseline in order to quantify the added value and ROI of technology investments

The case studies suggest that there is apparent potential for realising economic benefits in addition to improving the delivery of care when RFID applications are successfully adopted in a healthcare setting. This requires taking account of technical, organisational and financial issues.

The most promising (RFID) functionalities

Applications were assessed to determine their ability to reduce costs and to improve quality of care. The Delphi survey (assessing the views of experts from industry, academia, care providers and 'others') indicated that asset (especially inventory) management applications are rated highest for cost reduction. While patient tracking applications are seen as most likely to raise quality of care, staff tracking is judged to be less relevant on both cost and quality criteria. Views differ between respondent groups, with practitioners especially sceptical about the cost and quality benefits of staff tagging.

The most promising functionalities are the following:

- **Tracking assets:** RFID systems can allow healthcare delivery organisations to have a better operational overview of their medical assets, with positive results in terms of tools availability and general asset management.
- **Tracking patients:** Tracking patients allows for a better through-put and offers the potential for reducing errors. This application is particularly relevant to patients with dementia requiring the tracing and monitoring of their whereabouts within healthcare institutions, and possibly also in the community.
- **Identification of patients:** RFID systems can improve the overall reliability of identification and authentication of a patient. The potential benefits of their uses are an increase in patient safety connected to the reduction of errors, such as in cases of drug prescriptions and administration.

- **Automatic data collection and transfer**: as in other operational domains, RFID applications can improve the automatic collection of data and their transfer to back-office mechanisms which manage the overall supply chain management of an healthcare delivery organisations;
- **Monitoring of patients through sensing:** RFID can help in the collection of health-related data to be match with relevant indicators.

The identification of these promising areas for RFID deployment suggest that significant potential benefit can be achieved from this and complementary technologies. The actual ability to achieve these benefits depends largely on organisational, financial and technical considerations.

Conclusions

The overall picture of the potential of RFID in healthcare is nuanced: there seem to be many arguments in favour of a wide RFID roll-out (especially in hospital logistics and operational management), but considerable impediments remain. Moreover, there are important organisational factors that have to be taken into account for successful implementation of RFID. Based on the evidence collected during this study, it is possible to reach a set of conclusions about the potential use of RFID within healthcare delivery organisations in Europe:

Technical:

1. RFID is not unique in many of its functionalities. Other, more consolidated technologies such as barcodes and DataMatrix offer similar functionalities. In several contexts, RFID are seen as complementary to these technologies, increasingly in combination with WiFi infrastructures.
2. RFID applications need to be integrated in pre-existing technological environments, including medical equipment and ICT. Hence, the need for their "technological neutrality", in a sense that their supporting hardware and software should be in a position to be integrated with open standards as in the case of web services.
3. Interference of RFID and other wireless equipment with (critical) electronic equipment in the care delivery environment, especially operation and intensive care wards, remains the single biggest obstacle to RFID roll-out in healthcare, as there is a direct risk to patient safety.
4. Physical constraints like tag size, ability to attach tags, the hospital environment still impede or complicate the implementation of certain RFID applications.

Organisational

5. RFID is not only an IT instrument, but an important support tool for management and care delivery. It will only deliver its full expected results if it is embedded within the overall organisational and operational structure of the institutions. The introduction of RFID is likely to lead to operational and organisational changes.
6. Therefore, RFID application design, development and implementation require the strong commitment of senior management and the direct engagement of all relevant interests (data protection, workers' interests, ethics, etc.), especially during the design and testing phase.

7. Full endorsement by individual stakeholders within a healthcare delivery organisation may also require appropriate change management mechanisms to induce behavioral change and increase operational ability to exploit the new functionalities. The motivation needs to be constantly reinforced to avoid the risk of reverting back to the "old" way of doing things.
8. This points to the importance of awareness and ownership. The organisational and operational evolution may lead to a certain level of degree of resistance from interested parties, especially among those individuals who are concerned about the lack of regulatory and normative certainty associated with the use of RFID in the healthcare domain. Also there still exist – justified or not - negative perceptions about the overall potential health risks associated with the use of RFID. This is particularly important where a RFID system is rapidly implemented, risking low levels of awareness and buy-in among stakeholders. These issues need to be addressed in full transparency and due attention should be given to communication and awareness raising activities.

Financial

9. Beside the organisational aspects of RFID deployment, there must also be appropriate attention and resources allocated to the actual technology. Investments vary substantially among the different technological providers. It is apparent that no off-the-shelf RFID systems exist that would be ready to be implemented by healthcare delivery organisations. The lack of these COTS solutions (commercial off-the-shelf) is also confirmed by the fact that there are significant differences on the individual costs and solutions of RFID implementation. This has been strongly demonstrated in this study where costs were limited in the case of the Caravaggio-Treviglio or prohibitive in the case of the use of RFID by the Geneva and Jena hospitals.

Political/policy

10. Negative perceptions among different categories of users still exist and need to be taken seriously. It requires a continuous,frank and open sharing of information about potential societal risks associated with the use of these tools, for example privacy breaches. The sharing of information, nevertheless, should involve all interested stakeholders and users of healthcare delivery organisations.
11. All of these factors are to be supported by appropriate national and international policies aimed at creating an innovation friendly environment. These are to support healthcare delivery organisations in looking beyond their current technological infrastructure towards solutions, such as (but not specifically)RFID, that can improve their operational framework provided that they reflect the interest and objectives of all involved stakeholders.
12. However, caution should be exercised when considering additional regulation, carefully balancing the policy objectives with the risk of impeding the roll-out of beneficial RFID applications.

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