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Modelling the Clinical Risk: RFID vs Barcode

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1. Introduction

This chapter proposes an approach that can improve the identification of patients, products, equipment and so on in a hospital. The aim is to better the management of the clinical risk by automating the process through the use of Radio Frequency IDentification (RFID). The clinical risk management refers to the procedures for avoiding risks associated with direct patient care. It is the analysis about the probability of a patient being victim of an adverse event or inconvenience resulted, although involuntary, from improper medical care provided during the hospitalization. Research defines that the common denominator of almost all adverse clinical events is the lack of the patient traceability. In the specific context of a hospital, “traceability of patients” means managing a whole set of input and output data related to those processes defined as critical for clinical facilities.

In this work we will discuss a model to archive and manipulate data concerning the proposed system. RFID is, in fact, identified as a method for storing and retrieving data remotely by using small and cheap devices called RFID tags or transponders. For applying this technology in hospital environment it is necessary to build a network of these objects, each one with a unique number. So, only if there is a valid model to manage the produced output, one can easily retrieve information and realize an interesting use case.

In the proposed model, the adoption of an active instrument for automatic patient identification and assistance can be considered as the central entity of the process: “medical treatment of a patient”, this includes potentially every activity from initial consultation through discharge of a surgical patient. In particular, this approach allows for simplifying the reality in terms of observable entities and supporting a higher degree of interconnection among those sections that traditionally are called “functional areas” of the hospital organization. Indeed, a lot of different actors characterize a clinical environment and the use of RFID seems to be capable to track all of them and optimize their interaction (Liao et al., 2006). The proposed RFID applications are targeted to the:

- Verification of positive patient identification. This is realized by means of a smart wristband for each patient. The tag contains information about the patient name, date of

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birth, surgical information, allergic reactions, medication requirement, blood type, health condition;

- Monitoring of surgical equipment before and after the operations. This application is aimed to grant a more efficient knowledge of the hospital instrument thus avoiding the stealing and misuse of equipment;
- Asset identification, such as blood transfusion, pharmaceutical units, charts and specimen;
- Bed inventory;
- Tracking of hospital staff and patients. Scientific works demonstrate, in fact, that geographical location of transponders is realizable by using a network of RFID readers in an indoor area. The idea is to divide the area in a set of sub-regions and read the power level each tag produces in relation to a particular reading station (Sangwan et al., 2005).

This paper also deals with the impact that the application of the RFID model produces on the traditional organization of a hospital unit. To this end, it is worth noting that the staff work is partially influenced by the new process organization. Therefore, it is clear that for realizing a cost/benefit analysis it is necessary to consider the importance of training and transition.

The outline of the chapter is as it follows. Paragraph 2 introduces the definition of clinical risk management, sketches an abstract model of it and provides an overview of ICT impact on the healthcare process with particular reference to barcode and RFID technologies as they have been used and implemented in the healthcare according to recent literature. Paragraph 3 makes a comparison between barcode- and RFID-based data models in order to enlighten the different perspective and benefits introduced by RFID technology in the patient care. In particular, the shift from a model based upon the concept of medical record to a new representation where the patient is at the center of the healthcare process is thoroughly examined. This change allows for a step-by-step reengineering of the healthcare process from within, which is extremely difficult using the traditional approach. In addition to traceability requirements in fact, an RFID tag (positioned, for example, in the patient’s wristband) provides a real-time event trigger mechanism, which is very useful when a complete overview on the instantaneous state of the healthcare process is needed. A real-world example of how RFID can be easily integrated in the existing hospital environment is then presented in Paragraph 4. Paragraph 5 draws conclusion.

2. The Clinical Risk Management

The public healthcare recently and before the private one has been giving particular attention to the question of the clinical risk management. With reference to the Italian situation, for example, the prescriptive requirement for this issue may be due to the need to confirm the healthcare process for delivering quality services and therefore the recognition of those health protocols being valid for the institutional accreditation of all hospitals. The same consideration may be extended to most of Western countries as well. At the core of the quality process within the healthcare system there is also the traceability of any healthcare action referred to patients/users; because just the lack of such requirement is one of the main causes of the “clinical error”, hence it is often responsible of high clinical risk.
The “traceability” is defined by the norm UNI EN ISO 9000:2000 as the ability to trace the history, use or location of what is under consideration. In a hospital the maintenance of traceability is a critical concern involving transversely those processes controlled by the structure organization system, whether it is based on traditional paper records, both in the case of a fully computerized management system, as well as in all hybrid-type situations. In any case, the traceability maintenance is based on an appropriate set of information relating to input and output data of certain processes identified as critical. Some of the most critical processes within a healthcare structure concern the management of a large amount of information about drugs to be administered to patients, the examinations to be performed, the results of the tests, the diagnosis and clinical picture of patients until their discharge from a hospital department. The criticality index of processes depends on the criticality of the patients and their ability to communicate in a non-linear but actually exponential way.

The most advanced technological method, which is currently in use and able to minimize the risk by an error in the traceability process, without necessarily revolutionizing the entire management system of the healthcare setting organization, is the one involving the use of bar-coding printed on labels (barcode), which in turn are applied on the patient’s medical records or other (infusion bags, medication, wrist bracelet). The coding contains a minimum set of information that can be read by optical devices connected to an appropriate computer system.

A suitable alternative is provided by RFID technology, recently introduced in clinical engineering, which seems to offer considerable advantages in terms of reliability, efficiency, versatility and ability to provide information.

In comparison with the old barcodes through this technology a patient that wears a bracelet containing a RFID transponder, is physically and uniquely included in the management process of clinical data, while with traditional systems the patient can be recognized only by using personal data.

2.1. Modelling the Clinical Risk Management

The debate about the clinical risk began in the 70s in U.S. in order to prevent the increasing trend in compensation claims by patients who had suffered damage as a result of errors in delivering the treatment they were subjected to. The most significant system, which is mentioned as an example of the national healthcare monitoring is the Australian Incident Monitoring System (AIMS), with 50,000 reports in 2001, 26,000 of them were sent directly from health facilities, while the remaining part by the operators, often anonymously, to the departments in charge. In Italy, specifically in Emilia Romagna, a similar system, which involved 39 units from 5 local health authorities of the region, was tested in 2001.

The risk management is about the identification of risks associated with the organization activities and the use of appropriate and adequate practices to prevent these risks or minimize their effects. The fundamental elements of risk management are: risk identification, risk analysis, risk treatment and monitoring. In this context the main modalities of risk identification are: the use of administrative and information data, the incident reporting and structured review of health records.
In conclusion, throughout the text several benefits in using RFID technology in the hospital environment have been considered. They can be classified into two main categories: Benefits being tangible, measurable and attributable to a reduction in “cost” and Intangible benefits. In the first group there are the benefits related to the efficiency and referable to the increasing of high quality processes and, consequently, a reduction of resources committed to solving the problems introduced by real or potential non-compliance concerns (corrective and preventive actions). Some classic examples of error, which should be corrected or prevented, refer, for instance, to the surgeon operating on the wrong side because of a transcription error or the doctor and the professional operator administering the incorrect therapy due to a homonymy of patients’ names.

The intangible benefits can be subgrouped into further categories:
1. Benefits related to a strengthening of the information system;
2. Subjective benefits such as:
   a) Patient satisfaction in feeling more safe;
   b) Greater confidence in the structure by the patient;
   c) A better sense of belonging of staff due to the awareness that the system manages to avoid a large number of human errors; these factors are evaluated on the basis of the increase in the reference values of the quality indicators perceived by the users / patients and staff belonging to the structure (clinical audit).
3. Compliance with the requirements of Law for safe identification and treatment of data in accordance with the right to privacy of the patient;
4. Benefits attributable to the healthcare facility.

In light of what has been stated so far the authors have been considering the perspective that in the next future RFID-based models focused on a “patient-centric” view will be at the base of intensive healthcare process reengineering.
Fig. 4. – The patient’s identification page of a S.D.O. document. This is the first page of a SDO and contains almost patient’s personal data and summary information about hospitalization.
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Fig. 5. – The patient’s activity page of a S.D.O. This is the second page of a SDO and contains information about all the hospitalization, surgical, therapeutic and diagnostic procedures regarding a patient.
Fig. 6. – UML Use case of patient identification. This use case defines the filling process of the SDO for what concerns patient’s identification (S.D.O. first page).

Fig. 7. – UML Sequence Diagram of patient identification. This UML diagram analyzes the sequences of patient identification, data acquisition and RFID assignation.
Fig. 6. – UML Use case of patient identification. This use case defines the filling process of the S.D.O. first page for what concerns patient's identification (S.D.O. first page).

Fig. 7. – UML Sequence Diagram of patient identification. This UML diagram analyzes the sequences of patient identification, data acquisition and RFID assignation.

Fig. 8. – Use case of patient activity monitoring. This use case defines the filling process of the S.D.O. second page regarding the hospital departments in which the patient transits.

Fig. 9. – Sequence diagram of patient activity monitoring. This sequence diagram analyzes how information about the patient transit in hospital departments is managed by the proposed systems.
Fig. 10. – Use case of patient activity monitoring. This use case defines the filling process of the S.D.O. second page regarding the treatments (surgical, therapeutics and diagnostics) related to patient.

Fig. 11. – Sequence diagram of patient activity monitoring. This sequence diagram analyzes the sequence of operations in correspondence with the treatments of a patient (surgical, therapeutics and diagnostics).

7. References

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The book presents a collection of chapters dealing with a wide selection of topics concerning different applications of modeling. It includes modeling, simulation and optimization applications in the areas of medical care systems, genetics, business, ethics and linguistics, applying very sophisticated methods. Algorithms, 3-D modeling, virtual reality, multi objective optimization, finite element methods, multi agent model simulation, system dynamics simulation, hierarchical Petri Net model and two level formalism modeling are tools and methods employed in these papers.

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