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Implementation, monitoring and utilization of an integrated Hospital Information System – lessons from a case study

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Abstract

In most hospitals several heterogeneous Information Systems (IS) store parts of a still scattered patient record. Virtual Patient Records (VPR) are systems that aggregate known data elements about the patient from different IS in real-time. This papers aims to present the main lessons learned from the implementation and the usage during 6 years of a VPR system. Ten major lessons were divided in recommendations for software developers, information managers and institutional policy makers. Implementing and using a VPR is a difficult journey but can generate great value for the institution if most of these recommendations are taken in consideration.

Keywords:

Hospital Information Systems, Computerized Medical Records Systems, Integration of Information Systems

Introduction

Healthcare is information and knowledge driven. Good healthcare depends on taking decisions at the right time and place, according to the right patient data and applicable knowledge [1].

Patient data is more recorded now than ever before. Communication is of most relevance in today's healthcare settings, as health related activities, such as delivery of care, research and management depend on information sharing and teamwork [2]. Clinical care increasingly requires healthcare professionals to access patient record information that may be distributed across multiple sites, held in a variety of paper and electronic formats, and represented as mixtures of narrative, structured, coded and multimedia entries [3].

In hospitals, information technologies tend to combine different modules or sub-systems, resulting in the coexistence of several IS aiming at a best-of-breed approach. The integration of these IS is essential to support shared care and is a step towards full system interoperability. However, to integrate clinical ISs in a way that will improve communication and data use for healthcare delivery, research and management, many different issues must be addressed [4-6].

Many distinct technological solutions coexist to integrate patient data, using differing standards and data architectures which may difficult further interoperability [7]. Virtual Patient Records (VPR) are systems that aggregate known data elements about the patient from different IS in real-time.

This papers aims to present the main lessons learned from the implementation, monitoring and utilization during 6 years of a VPR system in a 1300 bed university hospital.

Methods

System architecture

A VPR was designed and implemented at Hospital S. João, aiming at delivering, at any point of care, an integrated view of patient data held in heterogeneous IS by retrieving clinical documents and linking federated databases. It is composed by a web-interface (VIZ), an integration system and a central repository (CRep) [8].

The web-interface was designed to include graphical components and layouts to summarise past patient data (patient chronological bars), and folders that reproduce the traditional types of patient record organisations (source, chronological and problem views). It allows ubiquitous access to heterogeneous data sources.

The integration system includes: (a) direct access to legacy databases; (b) a multi-agent based platform acting as the integration engine that ensures the communication between the various departmental information systems (DIS) and the central repository by retrieving and storing the clinical documents; (c) web-services to allow clinical data access by third party ISs; and (d) patient information viewing components to be integrated in DISs.

The central repository holds all integrated patient documents and the document version control files. It enables fast document access by implementing a hashing function to maximise the distribution of patients by directories.

Figure 1 illustrates the main features of the VPR system, namely the collection, verification, encryption, storage and presentation of the clinical documents. The final users, instead

of having to search patient reports on several different IS, use a single interface to perform that task.

System usage

Repository

The VPR has been working since 2004, regularly scanning eleven DISs and collecting an average of 3,000 new reports a day (currently it holds more than 3 million documents).

Security

To ensure confidentiality of the collected patient information the mechanisms implemented were: (a) role-based access control; (b) logging of user actions in VPR; and (c) secure communications using HTTPS protocol [9]. Sharing of logins and passwords between users has been found in 9.7% of distinct logins, which is lower than two other studied EPRs (10.5% and 22.3%) [10]. Although the role-based access control is a powerful tool, Hospital organisational issues limited its use.

To ensure the integrity of patient information the mechanisms implemented were: (a) an algorithm to detect patients' identification inconsistencies between ISs; (b) digital signing and checking for all clinical reports [11]. Patient identification errors have been detected over the years (25, 17 and 18 in 2005, 2006 and 2007 respectively).

To ensure system availability sensors were implemented to detect: (a) DISs unavailability; and (b) abnormal numbers of clinical records retrieved from each DIS. In 2005, 53 abnormal cases were detected corresponding to 44 real problems. The total VPR downtime in the last three years is approximately one hour.

Information usage

A visualization module for the VPR was made available in October 2004. The VPR has wide acceptance and growing usage among hospital health professionals (the number of users increased 29% in 2006 and 41% in 2007 up to more than 1,100 users).

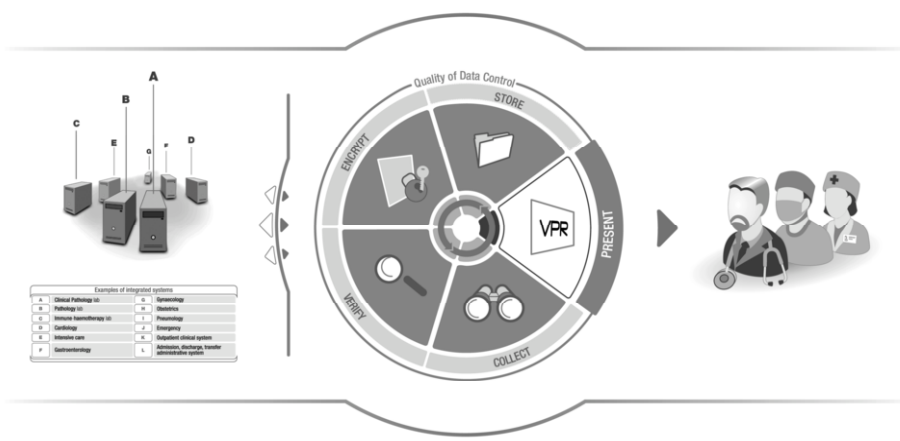
Past information of patients (data from previous hospital encounters) is still used by doctors in new encounters namely those in emergency room attendance (e.g. 52% of the reports viewed in emergency encounters were produced in previous encounters) [12]. The usage of patients' past information is correlated to the setting of healthcare (the half-life of information in documents is 1.5 days for emergency, 4.8 days for inpatient and 37.8 days for outpatient encounters) and to the content of reports (the half-life of immune-haemotherapy reports is 7 days, pneumology 26 days and anatomical pathology is 118 days). The main diagnosis of inpatient encounter is also related with half-life of information produced (e.g. the half-life of reports produced inpatient encounters with neoplasms as main diagnosis is 36 days and with injury and poisoning diagnosis is 17 hours). All these seem important factors to estimate future report relevance.

Discussion

The case study project presented in this paper resulted in the following main findings:

- Different models of integration (e.g. direct database linkage, web-services, and multi-agent systems) had to be used for effectively respond to the integration challenges. If these models are carefully adapted to each situation constrains (e.g. existing physical resources and providers know-how) then little stress is applied

Figure 1 - Architecture of the VPR system implemented



on each integration actor (hospital and several IS providers), which helps achieving proper solutions more efficiently.

- Multi-agent technologies proved to be a robust technology when operating for several years in a large Hospital. They were flexible enough to be used in a highly heterogeneous environment. Multi-agent technologies are suitable to solve complex data integration and communication problems in healthcare institutions.
- The integration of IS raised new security problems (e.g. clinical document version control), and allowed the detection of some previously hidden problems (e.g. time synchronization among servers). Our experience showed that integration could be used to make healthcare institutions take a step forward in the direction of delivering safer healthcare to patients.
- Although role-based access control tools were made available to the Hospital several years ago, the definition of groups and their roles is still practically inexistent. Also, sharing of logins and passwords among healthcare professionals was found to be significant. Defining access control in integrated healthcare environments is a much greater challenge on the organisational and cultural level than on the technical level.
- The dynamic monitoring sensors developed for the VPR that take in consideration the previous behaviour of healthcare professionals and IS, allowed a monitoring that increases both specificity and sensibility. Creating self-adjustable monitoring mechanisms allows effective management in a highly dynamic context.
- Automatically crosschecking patient data (e.g. patient identification) between different IS was an efficient way for the VPR to detect relevant data inconsistencies in all integrated IS. All information available in hospital information systems can and should be used to trigger alerts of malfunctions and inconsistencies, in order to improve patient safety, data quality and ensure a better healthcare.
- Major difficulties were found in the interpretation, data quality and maintenance in using already existing data dictionaries (e.g. patient, professionals or department identifiers). Most of these dictionaries are held mainly by IS suppliers. Healthcare institutions should have a close control on these dictionaries and re-use them in their installed IS; these dictionaries are core elements both in the interpretation of data and system interoperability.
- The usage of past patient information in the VPR case study varies significantly according to patient age, type of information, type of hospital encounter and medical cause (main diagnosis) for the encounter. As more and more patient information is stored, it is very important to efficiently select which one is more likely to be useful and promote it in a scenario where scarcity of resources (screen space, storage space, bandwidth and doctors' time) is very real.

Recommendations

Based on the previous findings, ten main recommendations when dealing with the implementation, monitoring and utilization of an integrated Hospital Information System were created. These were divided in three groups according to the role of person in the organization.

For software developers

1. to seek to comprehensibly integrate all existing IS by making use of different integration technologies;
2. to take in consideration that major differences in maturity exist among the different actors (hospital IT departments and IT suppliers);
3. to consider multi-agent systems when designing integration systems that operate in complex environments like large healthcare institutions;
4. to create user interfaces and data repositories that automatically adapt their behavior to how actually the users work with the IS;

For information managers

1. to create tools that continuously check the integrity of patient data among all IS;
2. to create self-adjustable monitoring sensors for each component of the IS;

For institutional policy makers

1. to allow health information systems to grow both within and beyond the institutional boundaries through integration aiming at semantic operability – *the whole is greater than the sum of its parts*;
2. to regard IS integration as a course to achieve a higher state of information and knowledge use;
3. to clearly define and test confidentiality policies before they are incorporated in IS;
4. to create processes that allow healthcare institutions to maintain their own dictionaries and terminologies of data used in all IS.

Conclusion

The lessons learned and the recommendations are the result of several years on practical experience in installing, maintaining and using a hospital wide integration IS. In the author's opinion, these practical recommendations are useful for most integration projects occurring inside healthcare institutions. These recommendations both can avoid some very difficult problems (e.g. maintaining multiple dictionaries on the same subject), and enable added value to the IS and healthcare institutions (e.g. improving the quality of patient data).

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