Information Systems for Health Care in e-Government

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Abstract: **This article discusses some aspects related to e-government with focus on health-care, describing Health-care Information System (HIS) involving- administrative services, medical staff and patients. Issues such as Quality of service provided and Privacy of data in accordance with enforced laws/norms and international standards are also covered.**

Modern hospital is a collection of different tightly integrated technologies, where HIS is a key member. HIS permits access to electronic medical record indicating the diagnostics and therapies, which helps the administration to determine the medical expenses and also the government for financial analysis.

Care has been taken to reproduce the normal work behavior while interacting with HIS.

Keywords: **e-Government, e-Healthcare, ICT, Health-care Information System, and Electronic Medical Record.**

1. INTRODUCTION

In a narrow sense e-Government means citizen's services, re-engineering with technology, or procurement over the Internet [TAM01]. From a more technological point of view, e-Government is the use of technology to enhance the access to and delivery of government service to benefit citizens, business partners and employees [TAM01], [D&T00].

In the process of reinventing the government Information and Communication Technology (ICT) provides infrastructure and software tools needed for a loosely coupled network of government units to collaborate effectively. Infiltration of this technology into government agencies tends to lead to institutional reforms [GOR02].

Last two decades, Italy witnessed intensified medical treatments accompanied by a reduction in the period of hospitalization as a method of care for patients. This practice of cutting down treatment time was with the sole aim of reducing medical expenses. This calls for upgrading the current healthcare structures incorporating either latest technological infrastructures or highly efficient ones, wherein the healthcare requirement should be conceived in a rational way from inception; resulting in a technologically equipped healthcare structure, more and more integrated in all its functions. From structural point of view, Modern hospital in-houses different technologies, which are tightly integrated [SEL90].

Information required for the formulation of a diagnosis or a therapy for the patient are assuming more and more relevance, and immediate exchange of the same within the healthcare structure is of fundamental importance. Pertaining to this framework, it is possible to define an *HIS* as a system for collecting, analyzing, storing, and retrieving all information connected to patient's management.

This also allows medical personnel's to file information in a more structured way, enabling them to resubmit them in a more useful format to concerned persons, irrespective of time and location of information. Since all information filed is immediately available for consultation, all problems related to use of paper-based patients' folders are eliminated. This Electronic Patient Folder is the central element of HIS, where all information related to the patient is integrated for his/her optimal diagnosis and treatment.

1.1. Hospital Information System

HIS is aimed at managing all the information needed for functioning of various aspects of a hospital. Information systems should be a well-coordinated collection, management, presentation and exchange of information.

At present there exist three independent healthcare information systems: *Hospital Information System* (*HIS*), *Radiological Information System* (*RIS*), and *Picture Archive and Communication System* (*PACS*).

Various connections have been designed among these three systems:

1) These three systems are fully independent even if they are able to exchange between each others series of data;
2) RIS is a HIS sub-system;
3) Due to its prevailing vocation in images management, PACS is an independent system (but these does exists a data inter-exchange);
4) PACS and RIS are integrated inside HIS.

Considering information contents managed by the system, it can be affirmed that there exist three main series of data: patients-related data, activities-related data, and resources-related data [ORO92].

This information is used for several purposes, such as:

1) Assistance to the medical and administrative personnel in carrying out their daily activities;
2) Planning activities of the organization;
3) Analysis of the work carried out; and
4) Acquisition of more aggregated information.

Currently available ICT tools enable easy integration of information and services into a single structure irrespective of its physical location in the network for the completion of their tasks. The HIS is designed on the basis of existing medical infrastructure which is, either facilitating equipment for diagnosis or organizing of activities; or an integrated system enabling filing, consultation, sharing of information regarding patient's management. Thanks to the facilities offered by the urban and extra urban communication networks as this integration process can be extended beyond a single hospital, thereby optimizing patients mobility, medical, and administrative data exchanges. Hence, an information system for healthcare applications should comprise:

1) Archiving and analysis of patient's data; and
2) Procedures for protection of recorded data.

The management of data must conform to the existing legal provisions enforced in the medical field and also to the recommendations spelled at the international level, thereby guaranteeing data protection and data confidentiality. Moreover, data should be protected from destruction and deterioration.

2. DESIGNING A HIS

The design of an information system consists of managing resources, methods, and defining interaction between these entities. HIS project in its first phase involves data collection, the rate of increment/multiplication of data, methods for automation of procedures, and to achieve the requested performance. Then the structure of information system has to be built followed by an access point for its location.

From general point of view, HIS have to be built on:

1) A distributed hardware system with a communication system; and
2) A distributed relational database.

Organizing the hospital, the procedures initiated by several Operation Units, and the integration of procedures constitutes the preliminary information needed for projecting HIS database.

The definition of information with their correlations, and the definition of access points with the list of people authorized for handling constitutes the first phase of HIS project. This information is the most critical point of the project, as errors made in this phase can lead to undesirable long-term effects. To assert a correct and well-ordered database, HIS contains:

1) *Specification (analysis of requisites):* where requisite information is collected for the database;
2) *Conceptual design:* from previous analysis a conceptual scheme of interaction between - entities, information, and actors are drawn;
3) *Logical design:* from conceptual design, a logical design is built, during which several issues crop up like- data consistency and integrity, its reliability, its safety, and its secrecy;
4) *Physical design:* from logical design, a physical design is built, defining and allocating relationships between data and several systems by fragmenting global information. Then we apply algorithms of choice based on relationship between databases, and minimizing the global cost of local and distributed application.
5) *Development phase:* in this phase, all activities are focused on procedures for management of information, its elaboration, and its storage.

2.1. Elements of Clinical Folder System

Clinical Folder System constitutes:

1) The information held in clinical folder residing in the central database, and in the local database of several units (functional islands);
2) Programs for synthesizing information, where data is captured from local database of several units (link programs) for updating the central database; and
3) Various applications of functional islands.

2.2. The Database

The archive of heterogeneous data is the main source through which the aid for diagnosis reaches the consultation unit.

The database must be developed in such a way as to take maximum advantage of distributed architecture i.e. a central database where data for synthesis is collected, local databases of several units, and a centrally maintained history where particular data can be found.

Primarily these are table's containing:

1) General information of the patients; and
2) Characteristic data of hospital till the patient is discharged (type of unit, medical in-charge of unit, admitting doctor, treatment doctor, address of pathologist, address of place of diagnosis, anamnesis, objective of examinations, clinical diary, visits of specialists, prescribed therapy, other events, transfer/discharge certificate, etc).

Local database contains data of specific medical examinations and reports of specialists visited.

In the functional islands beyond local database there are background programs, which describe new examinations carried out and feeds this data to central database; ensuring no duplicate or incorrect information is inserted [TAD99].

2.3. Consultation Units

The consultation unit consists of a series of integrated applications having varied degree of complexity, all grouped into a system to aid medical decision.

The previewed applications are:

1) *Management of the diagnostic protocol:* it allows the representation of diagnostic approaches adopted by the cardiology unit and aims to - standardize the diagnosis, simplify data recovery, and checking the severity of the patients.
2) *Access to external data beyond central database:* for data concerned with a specific patient, the consultation unit is provided with procedures for accessing other databases or other reachable resources through Internet. Consulting archives of units for getting data of patients already discharged (follow-up), and access to bibliographical information & information for druggists are also important.
3) *Post-processing:* this function comprises of all the techniques available for elaborating the data archives after their acquisition.

4) *In-depth analysis of clinical data:* various programs are available for elaboration of data and their graphical visualization using visual programming techniques.
5) *Programs for clinical consultation:* procedures of statistical and epidemiological types are available to aid in formulation of diagnosis and planning of therapy, and help systems for getting acquainted [OMB00].
6) *Global access:* it must be possible to access the information of Clinical Folder (also through Internet) by means of a web-browser, available to hospital staff remotely located and family doctor. From technological point of view it is necessary to link HIS to a web server and provide programs to access all clinical archives using dynamic pages visualizing structured reports, biological signs, graphics, images or video recordings of clinical interest [CEC99].

2.4. Information network

The architecture of the network must successfully support the information flow that takes place inside an organization. Introduction of computers systems increases the number of ways for accessing information and the quantity of available information, and aids in redistributing them where required. Networking system must be open, based on International Standard, and conforming to national and Internet framework.
The communication networks of every single department of an hospital or all the hospitals (LAN) should have the possibility to connect to - other departments which are far away from hospital, other national hospital, on-line services, general medical practioner's, Internet, etc.
HIS uses heterogeneous (alphanumeric, textual, graphic, etc) data and managing them is very complex. There are several access points of information and the data elaboration must be nearest to the patient. The need for information integration pushes towards a solution based on distributed database between several functional units residing inside the hospital.
Therefore we have to take into account the need of a service for providing "historical" data.

2.5. Subsystems of HIS

It is possible to logically split an HIS in three following sub-systems:
1) Government;
2) Administrative; and
3) Clinical.

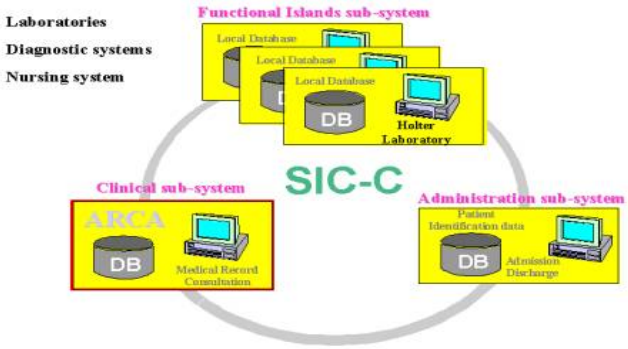
These subsystems are independent autonomous entities and have to be as though they are related to the same patients; their activities are based on different but inter-related information. HIS collects clinical information about patient to improve the procedure for diagnosis-care, and helps of come out with both a comprehensible clinical record and efficient consulting for research.
These characteristics are fundamental for the other two subsystems: the administration can derive medical expenses directly from data supplied from clinical information system and then send it to the manager of government subsystem for financial analysis.
The administration system supplies procedures and functionality for services, to manage patrimony and personnel's. The management module supports automatic financial accountability to integrate the government sub-system for visualising cash flow of every operating unit, and to permit the analysis for cost center and production factor type of activities. From cost center, "functional island", and medical record, the system allows to build patients medical expenses and compares it with the DRG economic system or the regional system of local health services.

3. CLINICAL INFORMATION SYSTEM

The *Sistema d'Informazione Clinico (SIC)* where the information collected by different components of the system is integrated for the optimization of patient's process and care.
In spite of over decade of investment and exploratory work in research and development of computer systems in health care, patient records today are often paper based. Implementation and deployment of Electronic Medical Record (EMR) systems lag behind available technological solutions. Of the several clinical information systems, which have become operational in recent years, only a few are capable of supporting a complete patient record and developing them outside the development site is still more difficult. Even though most data of clinical use are now available in electronic form there still remains the need for health care personnel to report much of information in written form i.e. data gathered by conversing with the patient, referring to patient history of therapy and examinations, physicians/nurses notes, etc. Yet data captured from medical instrumentation is a crucial problem in clinical departments as there is lack of standard protocol for data exchange and communication. Thus, timely and accurate transfer of patient information into the information system is an essential step in maintaining EMR; moreover interaction of clinical staff with computer systems is often labor-intensive.

3.1. The Information Infrastructure

SIC consists of three subsystems:
1) Administration;
2) Clinical laboratories; and
3) Clinical subsystem.



STRUCTURE OF INFORMATION SYSTEM

The administrative subsystem has to:
1) Identify the patient when it arrives;
2) Take account of his stay and the treatment given to him;
3) Admit the patient;
4) Manage medical tests and examinations; and
5) Transfer/Discharge the patient after treatment.

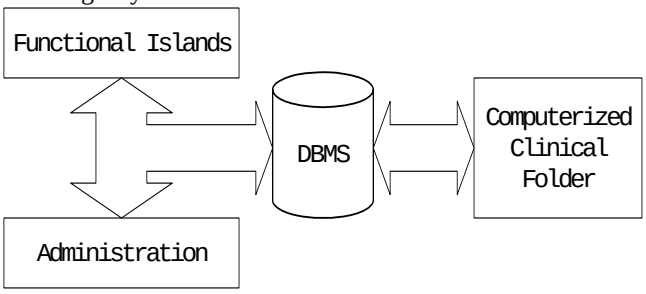
The database used for the administration, connected to clinical network is read-only accessible to the other subsystems.

A patient admitted in any department or to an ambulatory service undergoes a number of different tests, examinations, and physician-visits, which are usually performed within specific laboratories or diagnostic units. The integration of these heterogeneous sources of data in SIC is difficult for three main reasons:

1) Lack of standard specifications among medical equipments produced by different manufacturers;
2) Lack of standard medical protocols for diagnosis; and
3) Difficulties in linking new installations to existing computer systems.

Each laboratory is considered as a "functional island" with provisions for - conducting tests, archiving of local data for clinical research, and listing of equipments. Each unit is responsible for making available the test results in electronic form, as per format jointly established by the doctors.

Excerpts of signals or significant images are provided for documenting the test findings; while, identification of patient data is always obtained from administration with the exception of emergency cases.



INFORMATION FLOWS OF CLINICAL SYSTEM

The integration of the databases is done using two different methodologies:

1) *Middleware:* is constituted by a set of interfaces, which allows communication from local application of different island to the central clinical database for data to flow in EMR.
2) *Web:* allows browsing EMR and administrative data using a web-browser.

4. ELECTRONIC MEDICAL RECORD

The main objective of clinical sub-system is to integrate the entire clinical data about a single patient to build his/her EMR, ready to medical staff for interpretation.

The critical aspect of EMR is neither the design of information exchange from archives nor the realization of procedures to manage them, but the introduction of ICT for re-establishing pre-existent organization of departments into one single hospital. Re-organising of all the activities introduces a change in working behaviour which is unavoidable.However for optimising EMR it is necessary to continue as per changed work process by trying to exploit the hardware architecture to a maximum with minimal changes to the organization.

4.1. Logical organization of information in the clinical folder

The clinical folder looks like structured pages with collection of homogenous data. These pages can be characterized for homogeneity of data in the following:

1) *Identifying administrative data:* identification of patient and description of modes and types of treatments available.
2) *Anamnesis data and objective of examination:* data is compiled and the patient is admitted in the unit.
3) *Clinical diary:* directory of prescribed therapy, planning of therapy, request for performing treatment, recording sequence of biological parameters (blood pressure, temperature, etc).
4) *Diagnostic path:* directory of reports produced (data of types - alphanumeric, numerical, graphical information, physiological tracings or images, etc.) when the patient is under medication/observation. And directory of the events of use of surgical treatment.
5) *Transfer/Discharge data:* a certificate of transfer or discharge after medication.

4.2. Functional Aspects

The system deals with data related to the patient's admission and treatment, clinical tests, anamnesis and other data concerning patient's medical history. After completion of treatment, the system allows to issue a certificate of discharge/transfer to the patient (SDO).

The acquired data is structured based on medical complexity of the case and then recorded in the central archive. This central archive not only serves as an historical archive for scrutinising previous treatments, but also serves as a base for statistical, epidemiological or managerial surveys.

The program for management of clinical folder must comprise a series of serveral modules for:

1) Selection of patients clinical folder;
2) Acceptance of emergency admissions ;
3) Registering and consulting data related to anamnesis and medical tests;
4) Registering and consulting data related to reports concerning pathological tests, surgical operations, external experts consultations;
5) Managing transfer/discharge certificate, and
6) Permitting printing of documents(a paper copy of the clinical folder), as they are still essential for many implementations.

5. CONCLUSIONS

e-Government is not a mere technological infrastructure or strategy but rather a new integrated style of Public Administration organization and operations [GOU01]. In the efforts towards e-Government, ICT technologies were used as tools for developing HIS which is a very complex system due to its very nature of services and functioning.

e-Government promises to make government more *efficient, responsive, transparent* and *legitimate* [GOR02]. HIS attempts to meet-out the deliverables addressed by e-Government. Technological advancement has enabled integration of various medical equipments to the informative systems, thereby making it possible to integrate and synchronize all healthcare related factors under a single seamless organization. This made it possible to provide more rational information to its customers (patients) about available facilities and treatments.

The information produced by HIS is arranged according to its customers (patients) requirements. It is modeled to serve as an utility for patients, but is also based on requirements of the government and sanitary/hospital administration.
Traditional paper based folder was successfully substituted by an electronic (clinical) folder, thereby meeting the requirements of hospital medical/administrative staff, lawyers, and the government. The HIS apart from improving and making the system flexible and efficient, would also aid in development of the user staff. Success of HIS is also dependent on its ready continious adaptation to new- means of treatment, rules of taxation, etc.
HIS still lacks a standard set of protocols for communicating between various medical equipment, which is holding it back against full fledged implementation. In future, the access to the electronic folders will be extended to different units of the clinical staff and specific medical laboratories, drilling down to the patient's family doctor; so that HIS can as be seamlessly integrate into e-Government as one of its services.

REFERENCES:

[BER95] P. Berardi, C. Marchesi, M. Varanini et al., "Integration of Clinical Data for the Department of Cardiology", Health Telematics 95. Ischia.

[CEC99] Cecchetti G., Dalmiani S., Macerata A., et al., Progetto SPERIGEST 2 "Sistema CARCLI – Consultazione Cartella Clinica - Sottoprogetto D: Integrazione Informatica", Pisa: Area di Ricerca del CNR, Settembre 1999.

[CRI95] P. Cristiani, F. Pinciroli, M. Stefanelli, "I sistemi informativi sanitari", Patron 95

[DAL99] S. Dalmiani, G. Cecchetti, A. Taddei, A. Macerata, C. Carpeggiani, L. Chelozzi, C. Marchesi, "C3: Java-based Medical Record System for Cardiology", Medical Informatics Europe ' 99 – Fifteenth International Congress, IOS Press Ljubljana 1999.

[D&T00] Deloitte and Touche study report, "At The Dawn of E-Government: The Citizen as Customer", 2000.

[ERM98] F. Ermini, S. Dalmiani, G. Cecchetti, M. Emdin, C. Carpeggiani, C. Marchesi, A. Taddei, "Intelligent data retrieval system as a decision support in cardiology in an Intranet environment", IEEE Computers in Cardiology, Cleveland 1998.

[GOR02] Thomas F. Gordon, "E-government – Introduction", ERCIM News No.48, January 2002.

[GOU01] D. Gouscos, G. Mentzas, and P. Georgiadis, "Planning and Implementing e-Government Service Delivery: Achievements and Learnings from On-line Taxation in Greece", 8th Panhellinic Conference on Informatics, Nicosya (Cyprus), 8-10 November 2001.

[MAC95] A. Macerata, L. Landucci, et al. "Networking for health care administration ad delivery: the information system at the CNR Institute of Clinical Phyisiology". In Proceedings of Health telematics '95. Pisa Area di Ricerca CNR, 1995, 113-18

[MAC98] A.Macerata, A.Taddei, C.Carpeggiani, M.Emdin, G.Cecchetti, S.Dalmiani, C.Marchesi , "Cartella clinica automatizzata per il reparto di cardiologia", Convegno Sanità e Sistemi Medicali: automazione ed informatizzazione, Milano 1998

[MIL96] M. Miller, J. Cooper, "Security considerations for present and future medical databases", Bio-Medical Computing ,41,96

[OMB00] S. Ombrato, G. Cecchetti "An Open System for Managing Long Term ECG Recordings", IEEE Computers in Cardiology, Boston 2000.

[ORO92] Orofino E., "Sistemi informativi in sanità e classificazioni: stato dell'arte e prospettive in Europa". Tecnica Ospedaliera, n. 12, 1992

[SEL90] Selbrnann H.K., Pietsch-Breitfield B., "Hospital information systems and quality assurance". Quality Assurance Helth Care, vol. 2 1990, pp. 335-344.

[TAD97] A. Taddei, C. Carpeggiani, M. Emdin, R. Balocchi, S. Dalmiani, G. Cecchetti, A. Macerata, D. Pierotti, C. Marchesi, "Development of an Electronic Medical Record for Patient Care in Cardiology", IEEE Computers in Cardiology, Lund 1997.

[TAD98] A. Taddei, A. Macerata, C. Carpeggiani, S. Dalmiani, G. Cecchetti, D. Pierotti, C. Marchesi, "Electronic Medical Record System for the Department of Cardiology", TEHRE Conference on the Creation of a European Electronic Health Record, London 15- 18 November 1998.

[TAD99] A. Taddei, A. Macerata, S. Dalmiani, G. Cecchetti, C. Carpeggiani, L. Chelozzi, A. Fiaschi, C. Marchesi, "Medical record System for Cardiology and Cardiosurgery", IEEE Computers in Cardiology, Hannover 1999, Hannover 1999.

[TAM01] E. Tambouris, S. Gorilas, G. Boukis, "Investigation of Electronic Government", 8th Panhellinic Conference on Informatics, Nicosya (Cyprus), 8-10 November 2001.