

# Electronic Medical Records in a Cardiological Outpatient Clinic

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## Abstract

*In the outpatient clinic, a huge amount of information, both administrative, clinical and instrumental, has to be handled every day for patient care. A computerized method has been developed in our Institute able to track the patient from administrative admission up to discharge. For the purpose of obtaining electronic medical records in the patient who undergoes clinical and instrumental examinations, even in the same day, each clinical laboratory is provided by networked computers and results from instrumental data can be obtained on-line. The system is based on a relational database with clinical and administrative information and is integrated with a large Hospital Information System where the system covers the role of a Functional Island. Use of JAVA language, with its multiplatform capabilities, allows extensive installation in the clinical environment and full integration with other subsystems. A protected WEB front-end allows remote consultation of data. For follow up purposes, all the data collected from 1999 to nowadays during hospital admission of in- or out-patients can be collected, retrieved and updated.*

*At present 4600 cardiological outpatients have been treated by this system with substantial clinical achievements, time saving, and a better follow up organization.*

## 1. Introduction

Fully electronic patient records are at present one of the goals of both clinical and clinically related research Institutes. However, an organization that needs the control of clinical and administrative data is complex since it deserves handling of a variety of different data; not only medical records and administrative procedures but also management of data from non-electronic devices as special laboratory tests, have to be gathered and stored in a database [1].

Such organization is of paramount importance in outpatient clinics since it may help to draw proper conclusions in a short period of time allowing correct therapeutical decision and follow up organization.

A computer-network infrastructure has been realized in our Institute for patients admitted to hospitalization with the aim to integrate different clinical units as well as the administrative bureau [2].

After one-year experimentation period in the cardiological ward [3] a complete analysis of patient data flow of the Electronic Medical Record (EMR) routinely used in our Institute was available, and an approach to cardiological outpatients EMR started.

A cardiological outpatient EMR must have functional characteristics different from the cardiological inpatient electronic records due to the large amount of information coming from both administrative, clinical and instrumental sources which have to be viewed, collected and analyzed in a definite period of time in order to optimize patient management, on one side, and to avoid additional waste of time, on the other.

## 2. System description

The network-based information system set up in 1997 interconnects different units and health care services to achieve transparent access to patient data, reaching a total integration among the different sources of patient data. [4] The resulting EMR is a multimedia record formed by data collected from different databases located in remote sites, gathering together the information with visualization of text, documents, images, signals.

First of all a friendly, intuitive, graphical interface is required. Then, an extensive data retrieval support to allow queries to the database is requested. Customization and condensation of data is still important: the clinician can be interested in a summary for later review in the outpatient clinic, to get both details and a global insight for diagnostic or treatment purposes. Some of the system

key features are represented by the capability to integrate new functionalities and the possibility to change the interface.

An outpatient data flow analysis is shown in Figure 1.

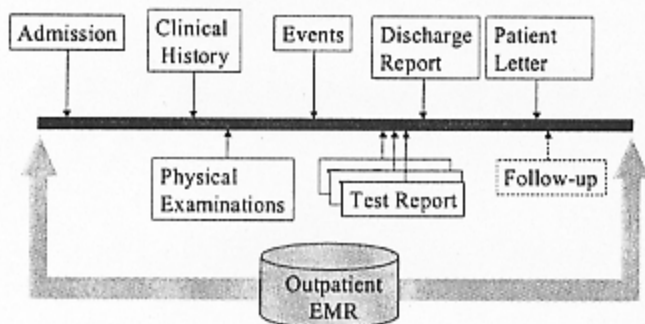


Figure 1: Outpatient data-flow

As a "status" snapshot we identify some collectable data and printouts, each corresponding to an action executed on the patient, administrative, clinical or instrumental.

## 2.1. System architecture

The core element of this system, partially inherited from the Ward one, is the clinical information system (SIC), which consists of three sub-systems (Figure 2): administration, laboratories and clinical ones. Administration is charged of patient identification and accounting, admission, discharge, and reservation. A commercial system with ORACLE database, connected to SIC network, is used for the administration, allowing read-only data access from outside.

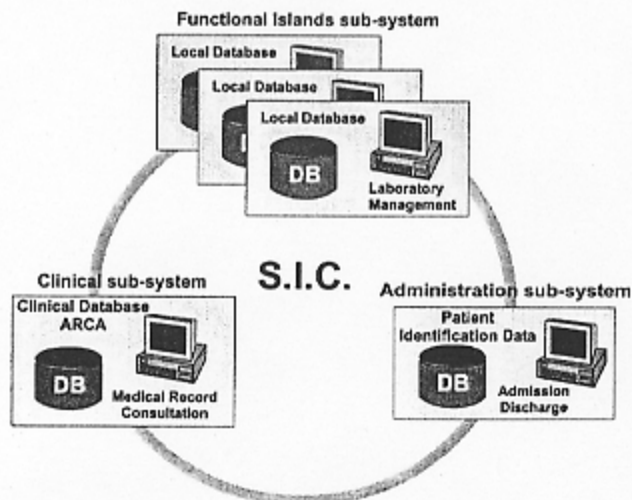


Figure 2: Clinical-Information System

The clinical information system integrates different sources of information related to the single patient admitted to the care department which are represented by a variety of tests and examinations performed within specific diagnostic laboratories: for instance, Clinical Chemistry, Echocardiography, Nuclear Medicine, which have been labeled "Functional Islands".

The functional Islands subsystems gather data from the internal archives to a central relational database (namely ARCA), whose duty is the integration of all information concerning the single patient to set up the EMR view; graphical interfaces allow handwritten reports of procedures which are not integrated in this network.

Central Database, an IBM DB2, is able to gather data through an interface software layer defined as Middleware. This layer is constituted by several applications written in Java and C++ languages (5), which directly interface each subsystem to the central archive (Figure 3).

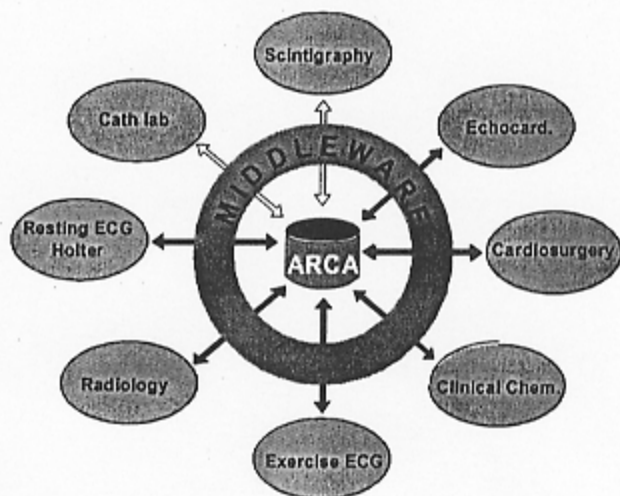


Figure 3: Data exchange model

An interface analysis was made for each functional island, in order to identify relevant data to be transmitted to the central clinical database; in many cases this work is performed starting a collaboration with manufacturers of the main diagnostic instruments used in the laboratories involved in the integration process, as sources of clinical data.

The integration in the SIC of these sources of data which are heterogeneous, like texts, signals and images, can be difficult mainly due to the lack of standards for medical instrumentation. A number of specific solutions was adopted: from the direct integration, connecting the equipment to a dedicated computer in the case that reports were available in electronic form, to the integration based on special HW&SW interfaces just

developed for data capture and, as last chance, to the manual structured data entry. In other situations, the use of DICOM and HL7 standards by instrumentations allows to perform an accurate and quick data analysis and integration.

## 2.2. System interface

The session is started by a password-based login procedure, which allows identification of the users and authorization according to the operator status to access patient information and to perform certain functions. The single patient is identified from the list of the patients already admitted and waiting in the waiting rooms of the outpatient laboratory. The exception is represented by emergency situations or network faults when the patients have to be admitted directly through EMR session using provisional identifiers. Once the patient is selected from the main EMR interface, the specialist can retrieve from the database all data relative to clinical history and physical examinations of patients already admitted to our Institution, both as in- or out-patients. These data can be used in the current session after proper editing and updating.

The single patient may undergo a series of different tests or clinical evaluations, which can be performed, or not, in the same day by different Laboratories. Diagnostic units consist of sub-units corresponding to peripheral collectors; they provide local data management, numerical processing and digital archiving of images and biosignals as well as free texts and upload to the central database a selected part of them.

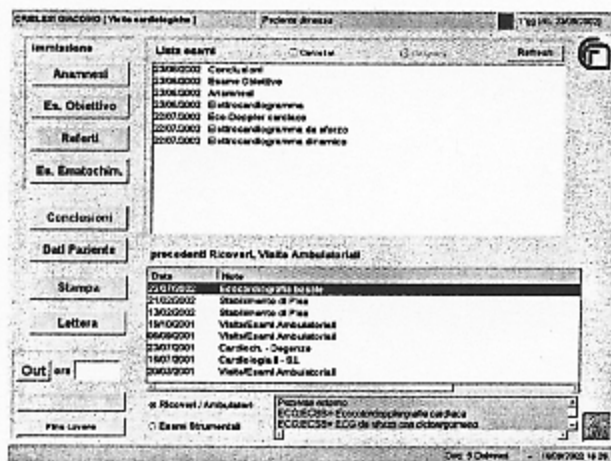


Figure 4: EMR Graphical interface

Each instrumental laboratory is considered as a functional island and provides test execution, local data archiving and availability of the results in an electronic form, which can be reached in all the networked

computers in the Institute, allowing integration of data coming from different sources in the same EMR.

Once the visit is completed and all instrumental examinations performed in the different laboratories or results of previous ones collected by the central archive, the specialist is able to draw proper conclusions and prescribe therapy which are embedded in an electronic form.

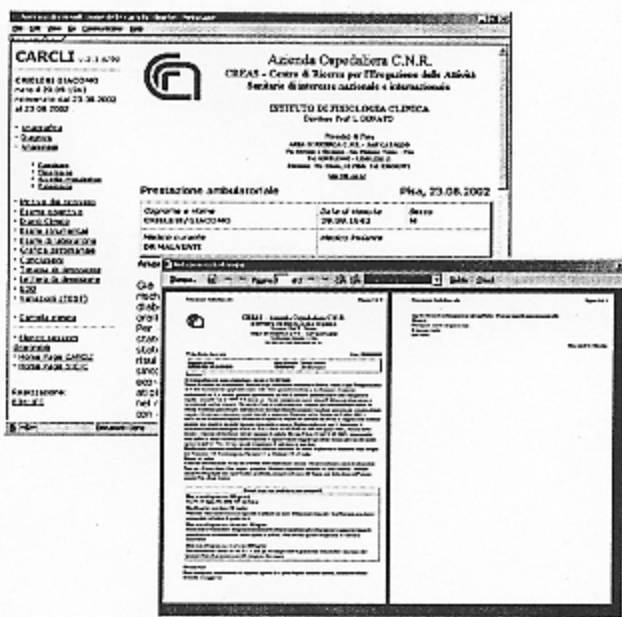


Figure 5: Example of WEB Medical report and patient discharge letter

At the end of the visit, a printed report (Figure 5) is given to the patient which consists, in part, of data written by the specialist as clinical history, physical examination, conclusions, therapy and follow up organization and, in part, of selected subsets of results coming from the different instrumental Laboratories. All the reports are Web based to reach an external protected viewing from other Specialists or family doctors [6].

## 3. Results

Outpatient cardiological EMRs started in 1999 with one physician testing and validating the system. With the extension of the computerized system to all clinical and instrumental Laboratories, an increasing number of users were involved with an increasing number of treated EMRs/year (Figure 6). At present over 4600 EMR have been prepared by physicians working on 25 networked computers in the outpatient clinical structure which is represented by clinical laboratories, basal, transesophageal and stress echocardiography, Holter monitoring, exercise ECG, nuclear medicine and MR imaging.

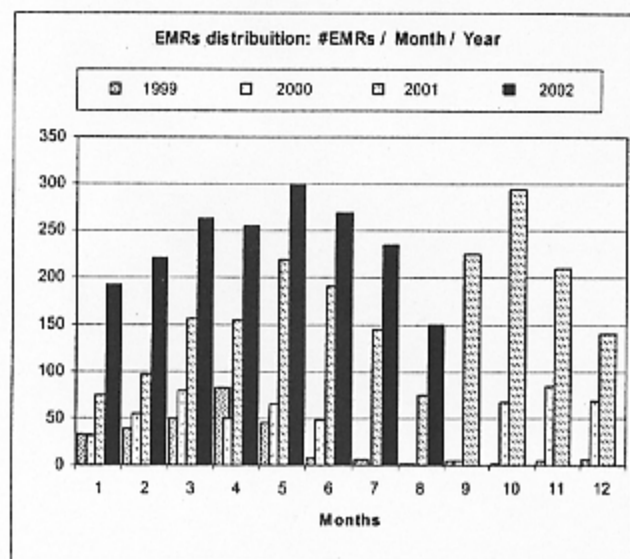


Figure 6: EMR distribution from 1999 to August 2002

#### 4. Conclusion

This system permits the integration of different sources of data, administrative, clinical and instrumental, in the same EMR for cardiological outpatients. The main advantages are represented by ease of use, retrieving of previously acquired data, integration of instrumental examinations even performed in the same day of the clinical visit. At the beginning the system may appear time-consuming requiring support by dedicated personnel. This has created some resistances by physicians in the setting of outpatient management, when time is of utmost importance. However, due to cooperation of network specialists and after a short period of training, administrative personnel, medical doctors, technicians and nurses are presently using this system on an everyday basis.

Flexibility, friendliness and effectiveness represent the major advantages of the user-interface design. Familiar windows-based style was adopted with attention to the harmonization of use of widgets.

This system has determined an improvement in the time needed for admission, organization of clinical and instrumental laboratories and preparation of a structured report to be given to the single patient, which is easy to understand.

Electronic storage of patient data allows easier follow-up organization both from the administrative and the clinical point of view. This last aspect represents one of the major advantages also for easy retrieving of data needed for research purposes.

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