

# Electronic medical record in cardiology: a 10-year Italian experience

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## SUMMARY

**Objectives:** the aim of this study was to report a ten years experience in the electronic medical record (EMR) use. An estimated 80% of healthcare transactions are still paper-based.

**Methods:** an EMR system was built at the end of 1998 in an Italian tertiary care center to achieve total integration among different human and instrumental sources, eliminating paper-based medical records. Physicians and nurses who used EMR system reported their opinions. In particular the hospital activity supported electronically, regarding 4,911 adult patients hospitalized in the 2004-2008 period, was examined.

**Results:** the final EMR product integrated multimedia document (text, images, signals). EMR presented for the most part advantages and was well adopted by the personnel. Appropriateness evaluation was also possible for some procedures. Some disadvantages were encountered, such as start-up costs, long time required to learn how to use the tool, little to no standardization between systems and the EMR technology.

**Conclusion:** the EMR is a strategic goal for clinical system integration to allow a better health care quality. The advantages of the EMR overcome the disadvantages, yielding a positive return on investment to health care organization.

**Keywords:** electronic health records, cardiology service, hospital.

Study conducted at the National Research Council, Institute of Clinical Physiology of Pisa, Italy

Article received: 10/17/2014  
Accepted for publication: 10/22/2014

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<http://dx.doi.org/10.1590/1806-9282.61.04.317>

**Financial support:** the EMR implementation activity was supported by the Italian National Health Ministry through a 3 years (1995-98) grant for the integration of resources in Cardiology (SPERIGEST project)

## INTRODUCTION

The improvement of health care efficiency and effectiveness in the last twenty years has underlined the importance of electronic medical record (EMR) systems.<sup>1</sup> EMR contributes to a high-quality, efficient patient care, reducing medical errors, promoting standardization of care,<sup>2-4</sup> as well as obtaining a reduction of costs through the reduction in duplication of services. Although EMR systems have existed for more than 30 years and despite government efforts to promote its use, less than 10% of hospitals have a fully integrated system and an estimated 80% of healthcare transactions are still paper-based.<sup>5</sup> In the United States (USA), the Veterans Administration health care system, with over 155 hospitals, represented the first and largest integrated healthcare delivery systems in the world.<sup>6</sup> Apart from of the Veterans system, few hospitals had a comprehensive EMR system, some had local information systems, used mainly for administrative rather than clinical purposes.<sup>7</sup> Since the Obama administration started encouraging providers to adopt

electronic health records (EHR), its usage has dramatically increased in the USA and, in 2012, more than 80% of hospitals have demonstrated meaningful use of EHRs.<sup>8</sup> Nonetheless, the majority of publications in the field reports slow user acceptance.<sup>9,10</sup> An EMR system was built at the end of 1998 at the National Research Council Institute of Clinical Physiology (IFC-CNR) in Pisa, Italy, to achieve transparent access to patient data, both administrative and clinical, reaching total integration among different human and instrumental sources,<sup>11,12</sup> eliminating paper-based medical records. The aim of this study was to describe a long experience (>10 years) in EMR use in cardiology.

## METHODS

### Network and setting

A network-based information system interconnected the clinical functionalities and all health care services across the IFC-CNR in Pisa, specialized in cardiopulmonary diseases. The IFC-CNR, in the second half of the 1990s gave

its priority to electronic data integration, activity supported by the Italian National Health Ministry through a 3-year (1995-98) grant for the integration of resources in Cardiology (SPERIGEST project).<sup>12,13</sup> In 2007, IFC-CNR health-care services converged into the *CNR-Fondazione Regione Toscana Gabriele Monasterio* where the EMR continued to be used. The clinical local area network (LAN) interconnected a Coronary Care Unit (CCU) and two wards (a total of 51 beds), and the outpatient clinic in Pisa. Two cardiac surgery (adult and pediatric ones) and two cardiology departments, with diagnostic laboratories located 60 km from Pisa, were also integrated in the clinical network system of the institute but are not the topic of this paper. The project was aimed at collecting, archiving and integrating all data related to hospital management, patient administration and care, from the outpatient clinic to hospital admission, diagnostic procedures, intensive care unit, cardiac surgery and, finally, discharge and follow-up.

#### EMR development

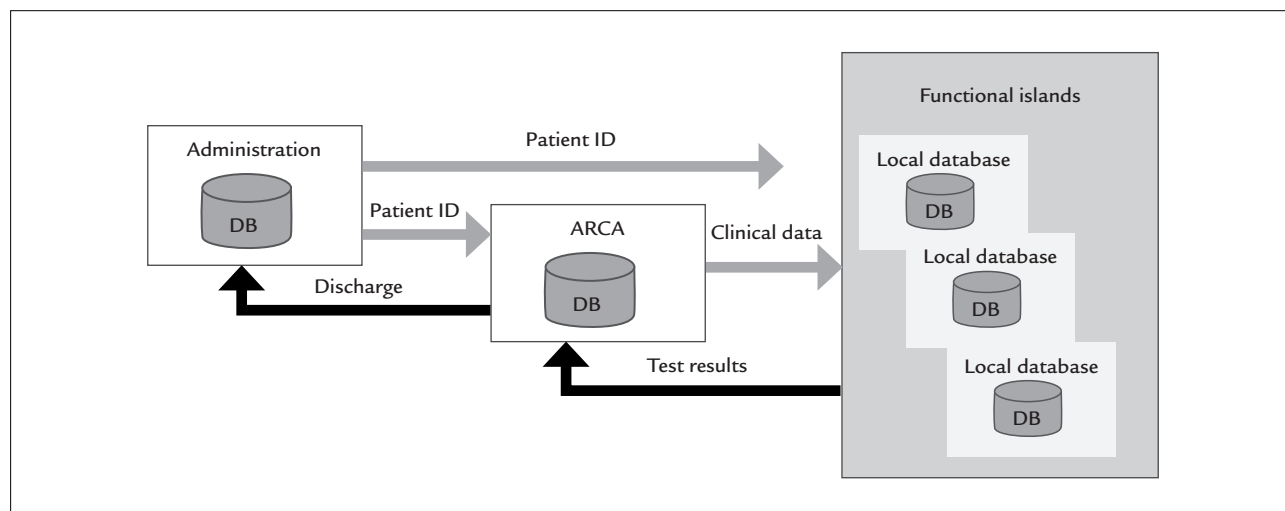
The EMR was a multimedia collection of data automatically selected from different remote databases, e.g. echo lab, cath lab, chemical lab, nurse system, administration, etc. (Figure 1). A minimum data set of patient/examination for each specific clinical functionality was established, information moving from the local health care unit to the central repository (ARCA). Structured data entry was implemented in addition to free text, whenever authorized by the doctor responsible for the clinical unit. The EMR included: patient demographics, medical history, examination and progress reports of health and illnesses, list of medications and allergies, medical notes, laboratory test

results, diagnostic images and reports (X-rays, CTs, MRIs, nuclear medicine, cath lab, echo, etc.), drugs, including side-effects and interactions, discharge letter, nurse record, physicians' notes, administrative functions as hospital discharge record and diagnosis related group (DRG) forms with standard ICD9 codes for diagnoses and procedures (Figure 2).<sup>11-13</sup> The EMR included a proprietary encoding to identify all diagnosis/procedures not inserted in ICD9 codes (the only recognized by the Italian National Health System) and appropriate transcoding tables to achieve their conversion in ICD9 codes. In the future, the same tables must simply be updated to accept the presence of any new coding systems.

#### Data analysis

The authors analyzed health activity related to a five-year time period 2004-2008, when the EMR was fully implemented in Pisa and data were electronically extracted, which included 4,911 adult patients. The following five indicators which seemed relevant to the local setting and to measure the EMR process<sup>14</sup> were examined:

1. Timely access to medical records: the time lag to access MR for consultation;
2. The readability issue: the amount of comprehensive words;
3. Identification of doctor writing notes /or prescription: amount of readable doctor signatures;
4. Integration with nursing notes derived from the electronic nurses system: the amount of nursing notes integrated in the EMR were reported;



**FIGURE 1** Information flow in the clinical system.

**CREAS IFC - CNR**

N. Acc.	Data Acc. 24.07.1998	Ora Acc.	Tipo di ricovero <b>ORDINARIO-PROGRAMMATO</b>	
Reparto <b>CARDIOLOGIA II - S.I.</b>		Classe <b>CORSIA</b>		
Cognome e Nome		Età	Sesso	
Luogo di nascita <b>LIVORNO (LI)</b>		Data di nascita		
Luogo di residenza		Nazionalità <b>ITALIANA</b>		
Luogo di domicilio		Telefono		
Stato Civile				
Professione/Posizione nella professione o condizione non professionale <b>PENSIONATO/A</b>				
CRA				
Causa del ricovero <b>MALATTIA</b>		Esate di Assistenza <b>090 006</b>	Ref. P.S. <b>NO</b>	
Diagnosi di ricovero <b>CARDIOPATIA CORONARICA</b>				
Provenienza <b>DAL MEDICO DI BASE</b>				

**CEDOLINO DI DIMISSIONE**

**TRASFERIMENTI**

Data	al Reparto

Numero giornate di presenza per ricovero in Day Hospital: \_\_\_

**INVIATO ALL'OSPEDALE DI**

DIAGNOSI DI DIMISSIONE		
Malattia principale causa del ricovero	arteriosclerosi coronarica	4140
Assoc. 1	ipertensione arteriosa	4010
Assoc. 2	ipercolesterolemia	2720
Assoc. 3	infarto miocardico	412

INTERVENTI CHIRURGICI / PROCEDURE		
Data	Intervento	Codice
1	coronarografia	8856
2	eco-color Doppler cardiaco	8872
3		
4		

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**FIGURE 2** Hospital discharge record form with standard ICD9 codes for diagnoses and procedures.

5. Comprehensible description of patient condition: it refers to the capability of understanding the patient's condition by reading the doctor's notes and prescriptions, inserted daily. It was classified as stable/unstable, undetectable.

#### Audit

Physicians and nurses who used the EMR system were asked to give their opinions, answering on the following points: ease of data entry (yes or no); overall ease of use (yes or no); reliability (yes or no); necessity of training for

program and customer support (yes or no); staff satisfaction and patient satisfaction (with answers ranging from "not at all satisfied" to "satisfied" and "completely satisfied"). The study complies with ethical requirements and the Declaration of Helsinki. The informed consent for the use of EMR anonymous personal data for epidemiologic study was obtained at hospitalization.

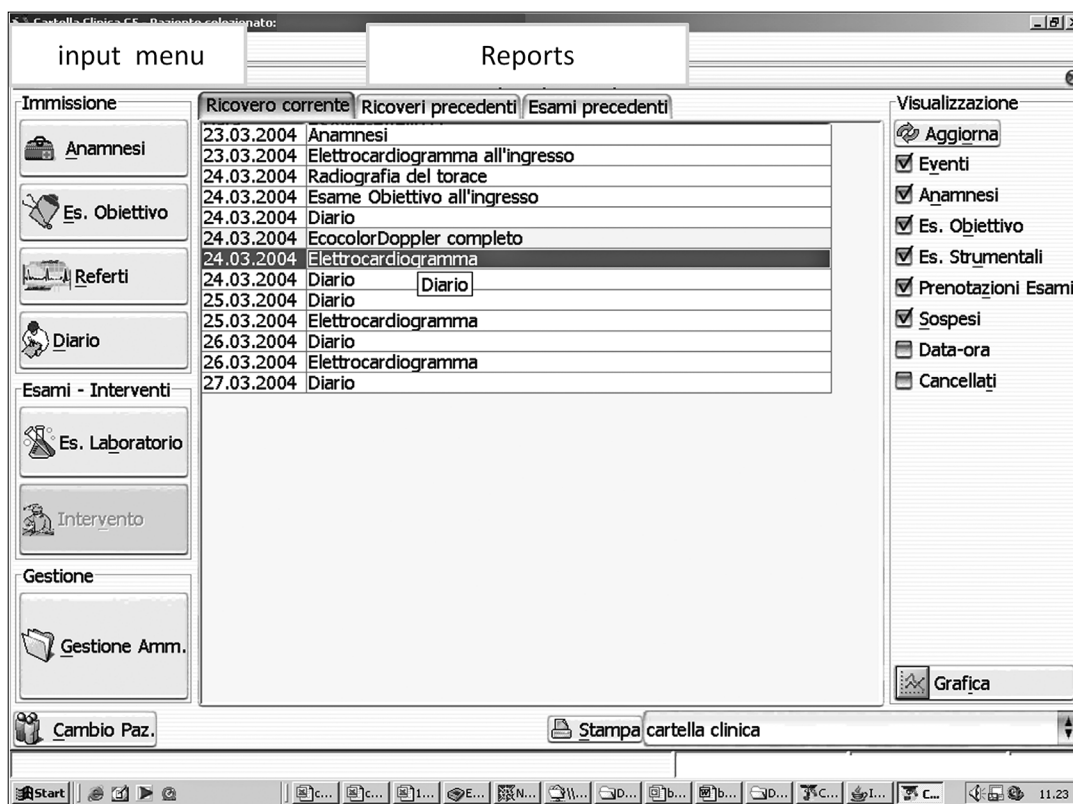
#### RESULTS

EMR had a patient-centered approach supporting medical, nursing and administrative integrated activity. Doc-

tors, through identity and authorization checking, interacted with the EMR from any workstation over the clinical network. Visualization of all patient admissions to the in or outpatient clinic was available (Figure 3). Predefined text and nomenclatures, as ICD9-CM code, were adopted to characterize cardiac patients' diagnosis and to support the hospital discharge schedule. Registry and structured database were implemented. Clinicians adopted free text data entry more frequently than nurses. External commercial software as the one for chemical lab analyzer was integrated after a period of data control. At the beginning, one out of five lab tests was repeated, since the results were not available at the point of care. Electrocardiograph (ECG) was the last device to be included in the EMR, requiring a further software customization for a complete integration into EMR. Selected ECG devices from one manufacturer only were chosen, according to manufacturer's agreement in supporting device integration. This way, the ECG recordings were sent from the local device to the central database updating the patient clinical record. Cardiologists were in charge of input diagnostic conclusions as soon as the ECG trace was available and physician identity was saved together with ECG examination data. The electron-

ic nursing system was integrated and included parameters, such as heart rate, blood pressure, fluid status, respiratory rate, temperature etc., being readily available to physicians. Access to medical records and EMR extraction data was immediate, following the identification control. Readability was clear and doctor identification was always feasible. Comprehensibility of patient condition was adequate, although nurses and doctors notes were scarce.

The large majority of doctors reported being satisfied with EMR; resistance by other users was due to changes in working practice and to EMR time-consuming aspects. All staff considered that EMR was ease to use but required a long training period inversely related to age and computer skill. The need of technical support was underlined by both nurses and doctors. Concern about the temporary loss of access to patient records, secondary to computer or network failure, was expressed by some physicians. Lack of integration with other applications was another complaint. The staff's comments on EMR advantages and disadvantages are summarized in Table 1. Patients verbally reported to nurses and doctors their satisfaction regarding the electronic management of their clinical data.



**FIGURE 3** Main frame of EMR with the input menu on the left and the list of diagnostic reports and images on the right.



## DISCUSSION

This study is not bringing new insights into this issue, but it was meant to describe a long positive experience with EMR to encourage its usage, underlining what could be useful to accelerate the road to wider its implementation and adoption. The 10-year experience using EMR offered a unique report of a fully integrated EMR system used in a small European hospital. Widespread use of computerized information systems has been hampered by different barriers including financial and technical matters, lack of interconnectivity and standardization, concern about security, personnel unfamiliarity with technology, need to learn how to use the tool, and doubts on clinical utility<sup>15</sup> despite the political effort to achieve widespread use of electronic systems.<sup>8</sup> These disadvantages were underlined also in this experience (Table 1), but the benefits of EMR outweigh the negative aspects. With more complete and quick patient information, health professionals improved practice efficiencies, accuracy of diagnoses and health outcomes. It is reported that as many as 30% of EMR applications attempts failed over the past years due to physicians dissatisfaction.<sup>16,17</sup> In this experience, the EMR system was well accepted by the personnel and had a positive effect on the daily medical practice. Researchers as well as clinicians underlined the benefits of EMR implementation. Historical patient digital data were directly available for physicians, facilitating clinical and epidemiological research.

**TABLE 1** Main EMR characteristics.

Advantages	Disadvantages
Total and ubiquitous availability of all patient clinical information	Disruptive element (computer)
Real time reports from diagnostic laboratories	Personnel have to change way to work (data input)
Logical formats and easy consultation of data (trends of vital parameters, images sequences, etc)	Difficult integration of diagnostic instrumentation
Fast and safe control of personnel work	Difficult integration of existing paper documentation
Standardization of procedures	Long phase of learning use
Easy comparison with historical data and guidelines	Constant presence of dedicated technicians
Increase of readability	High costs
Suitability of appropriate analysis	
Suitability of cost analysis	
Major efficiency of health system	

EMR: Electronic Medical Record.

A special feature of the system was its fast development and software implementation with a strong personnel involvement from the beginning, with solutions that could reduce the staff's work load. As for data entry, free text was allowed, although this reduced data integrity. Structured data were essential for administrative management and statistical analysis, but they required more entry time. On the other hand, the system had to be used in everyday clinical activity, where doctors and nurses had to spend a minimum amount of time to fill out the EMR.

Customization was the major goal of our implementation and modular software architecture was adopted, adapting the user interface and workflow to each specific institution and context. Ease of interface facilitated the effective use in daily activity. The patients' consultation was immediate and allowed to follow all admissions to any department and to access key information, such as the patient's diagnosis and lab results, which is one of the core capabilities that EMR should possess in order to improve quality and efficiency in health care.<sup>18</sup>

A faint legibility in handwritten paper medical records can have adverse medico-legal implications,<sup>19</sup> and contribute to medical errors,<sup>20</sup> prescription errors and low quality of communication with other providers and with patients. The Brigham and Women's Hospital in Boston, estimated net savings of \$5 million to \$10 million being achieved each year, following installation of a computerized physician order entry system, that reduced serious medication errors by 55%.<sup>21</sup> A high quality data system to support information and communications protocols could have a beneficial effect on patient treatment. There is a tendency to use short phrases or templates to insert electronic notes, both for doctors and nurses. Patient phenotype details and test prescription details present in some EMR sections, such as echocardiographic section, can allow an appropriate evaluation.<sup>22</sup>

Poor technical support in the follow-up and lack of training are two of the barriers reported in the literature,<sup>15</sup> which were partly overcome in this system because it had been built inside the institute.<sup>11</sup> The need for training (learning period) and the constant presence of dedicated technicians was underlined in our audit. System analysis and computer science has not been an integral part of healthcare training, either for doctors or for most health administrators.

The goal was that old chart patient records from previous admissions would be stored and retrieved in the new EMR. This was partly done in our system, integrating the electronic discharge patient report available since

1994. Other methods could solve this problem, as the scan of old documents were saved as images,<sup>23</sup> but it would be time-consuming and it was not performed.

The integration of existing instrumentation, such as echocardiographic instrumentation was a major request from doctors and administrative personnel. It was a critical point not always possible, mainly for the lack of interoperability.<sup>24</sup> This problem could be solved with the help of the manufacturer, as done previously to introduce ECG and lab results in this system.

Electronic signature, which has been adopted in most national and international standards,<sup>25</sup> was not in use during the reported experience and it was not implemented in our electronic system. Few doctors expressed concern about privacy and security, which is a possible barrier reported for EMR diffusion. Privacy in healthcare applies to both paper and electronic records and the authors followed all Italian government guidelines for privacy in health. Governments have set guidelines that all healthcare organizations will have to comply in regards to electronic health transactions. In the European Union, several Directives of the European Parliament and of the Council protect the processing and free movement of personal data, including purposes of health care.<sup>26</sup>

Most patients were satisfied with the complete and readable documentation offered by EMR. EMR could significantly detract the doctor's attention from the patient. A frozen computer could steal minutes or more from patient care. Some patients reported that doctors had to deal with how to enter data electronically and, thus, had less time for them, although this happened during the first EMR installing phase.

Financial matters were a perceived barrier to widespread implementation of EMRs. According to the Agency for Healthcare Research and Quality's National Resource Center for Health Information technology,<sup>27</sup> EMR implementations follow the 80/20 rule; that is, 80% of the work must be spent on problems regarding management changes, while only 20% is spent on technical issues. There are a few published estimates of the costs of implementation of EMR hospital systems. Wang et al. have provided a model for estimating the cost, and these include acquisition and implementation costs, slow and uncertain financial payoffs, and disruptive effects on practices.<sup>28</sup> Start-up cost only accounted for 80% of the total cost for this system, which was almost 5 billion Euros. The remaining cost was secondary to personnel costs, to train staff and for the maintenance of the system. These amounts were similar to the ones reported in the literature.<sup>28</sup> Furthermore, software technology advances at a

rapid pace. Most software systems required frequent updates, often at a significant ongoing cost and requiring periodically full-scale re-implementation, which disrupted not only the budget but also the workflow. A sufficient number of workstations, laptops, or other mobile computers were installed to accommodate the number of healthcare providers at any one facility, to facilitate the integration of services and to avoid delay in collecting clinical data and missing of information.

EMR systems are estimated to improve efficiency by 6% per year, and the monthly cost of an EMR can be offset by the cost of only a few unnecessary tests, especially at large hospitals.<sup>29</sup> A cost-offset effect can also derive from a reduction of physical storage of paper documents, which is obtained with EMR implementation. On the other hand, long-term preservation and storage of electronic records has to face other issues, such as the length of the storage, the methods to ensure the future accessibility and compatibility of EMRs archived data, and how to ensure the archives security. One proposal for long-term accessibility and usability of data by future systems could be based on the standardization of the information, such as it is in the XML language.<sup>30</sup> Medical records must be kept in unaltered form and authenticated by the creator.<sup>31</sup> A lot of technical work was located in this experimental setting to lock EMR at the end of hospitalization. The implementation procedures for security planning involved developing security policies and controls, and implementing tools and techniques to aid in security. An official draft was drawn up.

## CONCLUSION

EMR has become strategic for clinical system integration, allowing better health care organization. The advantages of the electronic system overcome the disadvantages, yielding a positive return on investment to health care organizations. The home-made EMR development has been critical for the success of the system.

## ACKNOWLEDGMENTS

Authors' contribution statement: CC and AM conceived the study, wrote the manuscript and are the guarantors of the study; AM performed EMR implementation and data collection. MAM provided expert clinical advice and contributed and commented on drafts of the article.

## RESUMO

Registros médicos eletrônicos em cardiologia: uma experiência italiana em 10 anos

**Objetivos:** o objetivo deste estudo foi relatar uma experiência de 10 anos de utilização de registro médico eletrônico (EMR). Estima-se que 80% das transações na saúde ainda são feitas em papel.

**Métodos:** um sistema de EMR foi implementado ao final de 1998, em um centro italiano de cuidados terciários, com o objetivo de alcançar uma total integração entre diferentes recursos humanos e instrumentais, eliminando registros médicos em papel. Médicos e enfermeiros que utilizaram o sistema EMR relataram suas opiniões. Foi analisada a atividade hospitalar amparada eletronicamente relacionada a 4.911 pacientes adultos hospitalizados, no período de 2004 a 2008.

**Resultados:** o produto final do EMR integra documentos com recursos de multimídia (texto, imagens, sinais). O EMR apresentou predominantemente vantagens e foi bem adotado pelos profissionais. A avaliação de adequação também foi possível em alguns procedimentos. Algumas desvantagens foram encontradas, como os custos de instalação, longo período de aprendizado para uso, pouca ou nenhuma padronização entre os sistemas EMR.

**Conclusões:** o EMR é um objetivo estratégico para a integração do sistema de clínica e para permitir uma melhor qualidade de cuidados de saúde. As vantagens do EMR superam as desvantagens, produzindo um retorno positivo desse investimento para a instituição de saúde.

**Palavras-chave:** registros eletrônicos de saúde, serviço hospitalar de cardiologia.

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