# EHR implementation: a literature review

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**Abstract.** During the last 30 years, governments and private healthcare organizations started to implement Electronic Health Records. These initiatives have evolved in different ways: some of them were quite successful while some others have found important difficulties. Although they share as a common purpose "to improve the health of the patients in a sustainable system", their objectives and strategies are also different in each project.
Through the existing scientific literature, this article reviews the theoretical benefits of using EHR and the different IT design high level decisions/approaches. It also summarizes the drivers for the adoption of EHR but also the barriers emerged from bad decisions.
The article finishes with a review of seven governmental initiatives on implementing EHR sharing the same general objectives.
Our categorization of findings (theoretical benefits, design decisions, and implementation drivers and barriers), as far as we know, is new in the literature on EHR implementation and we think it could be useful as a framework for analysis of new EHR scenarios and governmental initiatives..

**Keywords:** EHR, Electronic Health Record, EMR, Electronic Medical Record, Health IT, Review, Implementation.

## 1 INTRODUCTION

World Health Organization (WHO) defines eHealth as "*the use of information and communication technologies (ICT) for improving healthcare*"[1]. eHealth must to help the evolution of healthcare organizations to a new paradigm where the relation between the patients and health professionals is quite different. On the basis of any eHealth project there is the *Electronic Health Record* (EHR) (understood as an electronic record of the clinical data of the patient) because it is the framework on which all projects are built.

At the final of the 90's, public and private health organizations began to invest in EHR projects with the aim of improving health performance and efficiency. But the results were not homogeneous, and they are not common reported [2]. So, a comparative analysis of those available previous projects would help organizations to define their own strategy.

That is the main aim of this paper: a first literature review of some experiences reported by academic literature to analyze them in order to summarize some characteristics and to depict their geographical specificities if any. We hope that the items that appear from this analysis categorized as (theoretical benefits, design decisions, and implementation drivers and barriers), serve as framework points to be considered by other researchers and private or governmental professionals who address EHR research, analysis or implementation projects in different scenarios.

We conducted the search of scientific references through Web of Science and Scopus using the keywords *EMR, Electronic Medical Record, EHR, Electronic Health Record* and *Health IT*, in combination with terms such as *implementation, success, failure, experience, literature review, architecture* and *organization*.

This search strategy has brought to us a list of 117 articles most of them based on specific implementation of departmental solutions. And additional analysis of the abstract confirmed that only some of them studied a full EHR implementation in a healthcare organization, region or country. That results in 36 final articles. The critical analysis and classification of their ideas was then done using Atlas.TI.

In the next sections we present the results of that analysis. They are organized as follows: in section II the definitions and appearing of EHR pointed by that literature are presented. Section III states the findings on theoretical benefits, the IT design decisions, and the general implementation issues. In section IV, the key points of international governmental initiatives founded in the literature are summarized and preliminary compared. Finally, in section V we point the main conclusions and future work emerging from this literature review and analysis.

## 2 BACKGROUND: EHR DEFINITIONS AND APPEARING

According to its functionalities, a first definition of EHR could be derived from an expert panel convened on behalf of the Office of the National Coordinator for Health Information Technology in the US. This panel recommended that a EHR should have four core functions: providers' notes, results, orders and decision support algorithms.[3]

But the most EHR explanatory definition was settled by the Healthcare Information Management Systems Society (HIMSS) that defined an EHR as "*a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. This patient health information includes patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports. The EHR automates and streamlines the clinician's workflow. The EHR has the ability to generate a complete record of a clinical patient encounter — as well as supporting other care-related activities directly or indirectly via interface — including evidence-based decision support, quality management, and outcomes reporting.*"[4]

But EHR is not a new concept: the EHR just introduce the “electronic” paradigm in a culture with an old history. In fact, R.S. Evans in his article “Electronic Health Records: Then, Now, and in the Future”[5] shown that the ancient Egyptian (1,600-3,000 BC) used medical records in hieroglyphic inscriptions and papyri.

Paper medical records were not steadily used until 1900-1920 and it was thanks to Florence Nightingale considered the mother of modern nursing. She explained in her books the importance of having clinical notes and that the analysis of these is key to the improvement of the healthcare technique. [6]

It was during the 1960s and 1970s that, based on new computer technology developing, the foundations of the development of the Electronic Heath Record were settled.[5]

The last 40 years, the EHR has evolved along with the technology. But moving from paper to an electronic record is still a pending issue in many health organizations despite the decrease of the cost of the technology and the introduction of the personal computers in the late 80’s.[5]

# 3 FINDINGS ON EHR EXPERIENCES

## 3.1 The theoretical benefits

Expected benefits of EHR are based on improving the health of the population throw a set of tools and processes that helps doctors and nurses in their job. The most common are the following:

- The availability and accessibility of health information in any place and at any time, regardless of where the person needs attention [4].
- The improving of treatments since medical records of patients are available for healthcare professionals [4].
- Through the report of clinical decision rules, the avoiding of adverse events derived from drug treatment errors, including drug interactions, therapeutic duplication or wrong doses [2].
- The reduction of redundant procedures and tests, avoiding risks to health for the patient and achieving cost savings [5].
- The training of patients to exercise greater control over their own health, giving them access to their own personal health records, and allowing them to make informed decisions about the available options [2].
- The availability of massive amounts of health care data which are valuable for epidemiologic research [5].

Each of the six benefits cited has a financial effect. For instance, there are some studies that show that each year in the U.S. there are approximately two million medication errors in hospitals that cause a staggering 100,000 deaths and increase healthcare costs by about $20 billion. But some other studies increase the economic impact to $1 trillion [7].

The errors are an indirect cost, but the direct cost could decrease if we had a healthy population. Here the IT and EHR have an important role again. The healthcare organizations started to go ahead with the "patient engagement" involving the patient in having a healthy style of life or taking care of their chronic disease.

And this patient involvement is fundamental in a scenario where the increasing cost of healthcare is one of the main problems for most of the governments. During the last 20 years the health spending per capita has almost doubled, as shown in Table I. And, in fact, the aging population make this trend really worrying for politicians.

### 3.2 The IT design decisions

The literature shows that the decision of implementing an EHR has some relevant points that each organization must face:

- Commercial vs self-development vs open source.
- Best of bread vs integrated product.
- Centralized vs distributed.

Commercial EHR are standard products developed by companies. This companies provide a license and services for implementing the products. Then the evolution of the product is financed by the cost of the licenses [9]. Commercial systems are cheaper to purchase and implement when there is no need of being customized for the organization. This customization increase the cost and the complexity of the projects.[10]

Some healthcare organizations started in the 80's developing products for managing the administrative workflows, where the most common were the registry and the appointments management. But these solutions evolved to an EHR by adding new functionalities. At the end most of these projects have been migrated (or there is a plan to do it) because the cost of the evolution is not affordable for individual organizations.

Finally, as an exercise of transparency and as an attempt to standardize and decrease the cost of the EHR implementations, some open source projects started to be implemented in healthcare organizations. Examples of this solutions are iSante, OpenEMR, OpenEHR, OpenVista, AndroBase, OSCAR.[11]

**Table 1.** Health spending per capita evolution (OCDE 2015)[8]

| **Country** | **1995** | **2014** |
|---|---|---|
| Switzerland | 4,308 | 9,674 |
| Norway | 2,698 | 9,522 |
| United States | 3,788 | 9,403 |
| Monaco | 3,093 | 8,149 |
| Luxembourg | 2,842 | 8,138 |
| Sweden | 2,292 | 6,808 |

| | | |
|---|---|---|
| Denmark | 2,835 | 6,463 |
| Australia | 1,591 | 6,031 |
| Netherlands | 2,262 | 5,694 |
| Austria | 2,868 | 5,580 |

Best of bread is a common expression used in EHR meaning that each department has a specific solution that must be integrated between them. This situation has been the most common because the lack of products with a full functionality for covering all the workflows. Nowadays there are still few providers with an integrated solution, and they are still too expensive for most of the healthcare organizations.

A centralized EHR has the main characteristic of one single instance of the IT solution which provides the service to all the health departments. As an opposite of centralized, the distributed EHR is characterized by having different instances connected to each other. The clinical information is stored and maintained locally within the various healthcare providers and facilities. The central system maintains reference links pointing where the original data records are located. This model does not involve a central repository, since data may only be requested when needed by a user.[4]

### 3.3 The implementation

Making changes in healthcare organizations is a complex task in general and implementing an EHR is one of the most challenging projects. According to [5] some key factors to be considered are staff skills, organizational structure, culture of work, infrastructure, financial resources, return on investment, technology, and level of acceptance to change.

Drivers facilitate the acceptance of the EHR by the end users. But on the other side of each driver there is always a barrier that adds complexity to the process, as is summarized in Table II:

- Efficiency has to be a key point when any information system is introduced in an organization. But initially physicians have the perception of spending more time with the patient using the EHR [5].
- Cost savings are a common justification, but they collide with the high cost of implementing the system [12].
- Availability and accessibility of vital health information regardless of where the person requiring care is, is a clear advance compared to a paper based medical record. But there are still some concerns about possible missing data [4].

**Table 2.** Drivers and barriers in EHR implementations [5]

| **Drivers** | **Barriers** |
|---|---|
| Efficiency | Time consuming |

| | |
|---|---|
| Cost savings | Implementation costs |
| Access to patient data | Missing data |
| User perception | User resistance |
| Ability to transfer information | Lack of interoperability |
| Securtity | Privacy and security |
| Error reduction | Medical error |
| Competiteveness | Lack of agility to make changes |

- User perception improve because the functionalities that help their daily job, like algorithms for the clinical decisions. But on the other side the resistance to change is strong in some professionals in healthcare sector [2].
- The ability to transfer information to other providers helps to the continuity of care and for referral processes. But there is not an international standard for interoperability and this lack adds a lot of complexity to the process [5].
- Controlling the access to the medical record adds security features impossible in a paper environment. But on the other side, legislation about privacy can be a barrier as is happening in countries like Switzerland [13].
- The reduction of medical errors is one of the targets of the EHR. But if there is an error in the configuration of some process this error could cause a fatal health problem to the patient [12].
- Competitiveness has a direct relation with the ability of improving processes. But this implies fast developments and it is not common in health IT [14].

As can be seen, each driver has their own barrier or difficulty for the implementation. Only a clear and adapted strategy can help to overtake them.

In addition to the drivers and barriers vision, we want to underline Kathrin Cresswell's work [10]. She published a paper that complements a previous publication by Bates and colleagues on 'Ten commandments for effective clinical decision support' [15], which focused on lessons learned in the creation of algorithms on the EHR that help clinical staff for taking decisions. Cresswell's paper presents key lessons learned in the hope of informing the policymakers, health directorates, healthcare management, and senior clinicians. Her contributions are summarized in Table III.

**Table 3.** The ten key considerations of Cresswell [10]

| **Ten key considerations** |
|---|
| 1.- Clarify what problem(s) the technology is designed to help tackle |
| 2.- Build consensus |
| 3.- Consider your options |

| |
|---|
| 4.- Choose systems that meet clinical needs and are affordable |
| 5.- Plan appropriately |
| 6.- Don’t forget the infrastructure |
| 7.- Have a plan to train staff |
| 8.- Continuously evaluate progress |
| 9.- Maintain the system |
| 10.- Stay the course |

### 3.4 GOVERNMENTAL INITIATIVES

After reviewing the benefits, the strategies of design and the key points in the implementation process, in this section we briefly present some governmental initiatives found in the literature. We focus on their declared mission, budget, strategy and years of the implementation. The cost has been the variable analyzed and cost per capita are summarized in Table IV.

- UK

In 2002, the UK government launched the development of the National Program for Information Technology (NPfIT) which was intended to deliver an EHR system containing patient records from across the UK. The investment was 12.700 M ¬£, but a set of different problems during the implementation pushed the government to close the program in 2011. [16]

After this failure, the UK government focused on the Summary Care Record (SCR), storing a limited range of data in a centralized repository as the HCDSNS.

- Australia

The *HealthConnect* was created in 2001 as a project for sharing summaries of clinical data across the country. [17].

This project was implemented in some regions as a pilot, and in 2005 the government created the *National EHealth Transition Authority (NEHTA)* to accelerate the adoption of an electronic health information system across Australia. In July 2012, NEHTA launched the *Personally Controlled Electronic Health Record (PCEHR)* to engage patients and their careers in the digital health journey.

In 2014, there was a review of PCEHR to identify and mitigate issues. The PCEHR had an investment of 700,4M$.

- EEUU

In 2009 the American government approved Health Information Technology for Economic and Clinical Health (HITECH) act. [18]. The main mission of the HITECH was to improve the quality of the care and the financial sustainability of the public system (Medicare and Medicaid) throw the use of EHR and the integration throw the country.

**Table 4.** Cost and cost per capita of governmental projects

| | **Investment** | **Population** | **Period** | **Investment / capita** |
|---|---|---|---|---|
| UK | 15.115 M | 66,87 M | 2002-2011 | 25,12 € |
| Australia | 433,89 M | 25,17 M | 2012-2014 | 8,62 € |
| EEUU | 11.904 M | 327 M | 2009-2015 | 6,07 € |
| Canada | 2.450 M | 37,59 M | 2001-2019 | 3,62 € |
| Estonia | 9,4 M | 1,3 M | 2005-2008 | 1,81 € |
| Spain | 240 M | 46,66 M | 2006-2018 | 0,40 € |
| France | 210 M | 66,99 M | 2004-2013 | 0,35 € |

The strategy was to propose three stages and direct grants to physicians and hospitals, with a total investment of 13.000 M $ [19].

- Canada

The Canada Health Infoway (CHI) was created in 2001 to establish a national infrastructure to enable the exchange of health information throughout Canada. Its 2015 mandate sought to create of a baseline EHR for each Canadian that was accessible for all health care workers in hospitals, physicians' offices, pharmacies, and primary care facilities.[20]

Infoway started with 500M$ in funding. The government added 100M$ for telemedicine projects and 100M$ for Public Health surveillance projects in 2004. In 2019 the government had invested a total of 2.450M € in different projects leaded by Infoway.

- Estonia

In 2005, the Estonian government developed a strategy to create a more citizen-centric health care system through shared data across different levels of health care. The e-services aimed to improve quality by enabling better access and use of relevant health data as well as enhance health reporting and cost calculations. [21]

The Estonian E-health Foundation was the central agent in charge of standardization and development of digital medical documents.[22]

The government invested 9.4M€ in four projects: Electronic health record, digital imaging, digital registration, and digital prescription in a centralized development.

- Spain

The *Historia Clinica Digital del Sistema Nacional de Salud (HCDSNS)* project started in 2006 with the mission to share clinical information between the Spanish regions. HCDSNS is a repository of clinical reports and prescription profile of each of the patients.

This project was financed through "Sanidad en linea" plans with an amount of 240M€

- France

The *Dossier Medical Partague*, (DMP) project was approved by the parliament in 2004 with the aim of having it deployed quickly and creating a return on investment of 3.5 billion.

The DMP encountered multiple difficulties after its launch in 2004 which led public authorities to question the project's efficiency (in 2008 and 2013) before finally concluding that it had to be reoriented.

They demonstrated that only 160,000 DMP files had been opened (then the goal was 5 million), at an overall expense of 210M€.[23]

These examples show how governments have a key role on the implementation of an EHR, and that all they share a common mission: improve the health care organization and obtain a return of investment in terms of a reduction of costs.

As can be seen, the common target for each governmental EHR project is to increase the quality of care and to make an affordable public system. There is a clear difference between Anglo-Saxon and the European countries in terms of investment per capita during the years of the projects.

### 3.5 Conclusions

The EHR is a complex system which manages the health information of the patients, the workflows on the health organizations and must be a tool for helping the clinical staff.

The increase of the cost of the public healthcare made governments to think about strategies for doing it affordable. Studies show clinical benefits due the reduction of errors and as a consequence there are a lot of savings in cost.

There is not a unique strategy for the EHR projects, decisions around centralized or decentralized IT systems, commercial products vs self-developments and best of bread or integrated systems are still in discussion and it is needed a deep analysis for establishing recommendations on the design phase.

The implementation drivers presented in section 3 have their barriers and a good strategy is necessary for overcoming it. The ten considerations of Cresswell have to be took into account, because they focus in key points of any implementation project.

As a consequence, governments have launched initiatives investing in EHR projects. Most of the projects were for connecting health organizations or for having a repository

of basic clinical data. Our revision of 7 EHR projects from different regions shows that there is a huge difference in terms of investment between them.

As a future work we want to a) deepen the literature review by reviewing other specialized (non-academic) ehealth sources such as Global Health Observatory (GOH) or National Center for Biotechnology Information (NCBI); b) develop a differential analysis among at least those governmental experiences introduced in previous section and others that can appear during the deepen in the literature review, and c) contrast them with the ideas included as findings in our paper (theoretical benefits, design decisions, and implementation drivers and barriers).

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