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The Impact of Electronic Health Records on Healthcare: Global Benefits and Challenges

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Abstract

Electronic health records significantly impact healthcare, centralize patient data, provide efficient solutions for quick access to information, and help improve the quality of life and patient safety. The electronic system allows clinicians to make informed decisions and personalize treatment according to the patient's history. The widespread use of electronic health records reduces the time spent in hospitals for diagnosis and eliminates duplicate tests, thereby reducing costs. However, implementation varies around the world depending on the cost of implementation and the digital infrastructure of each country or region. In this context, the benefits and challenges of implementing electronic health records in different countries and their impact on medical practice in recent years, especially after the COVID-19 pandemic, were highlighted. The study of the impact of electronic health records on the quality of medical services includes a literature review, focusing on studies that address their implementation and use in different regions of the world, as well as aspects such as diagnosis time, patient safety, and cost reduction. The COVID-19 pandemic has accelerated the acceptance of the digitization of information, in addition to telemedicine, which became a necessity during the pandemic to limit physical contact and required digital data storage. Examples of good practices in the use and uptake of electronic health records have shown significant progress in reducing medical errors, continuous monitoring of patients with chronic diseases, collaboration between professionals, and reduced costs. The development of electronic health records brings numerous benefits to the healthcare system for patients and professionals, with the potential to fundamentally transform healthcare.

Keywords: Healthcare digitalization; COVID-19 (COronaVIrus Disease); Telemedicine; Personalized treatment; Electronic Health Record (EHR)

Introduction

The electronic health record (EHR) is a digital repository for patient data, encompassing historical information such as diagnoses, allergies, treatments, and vaccinations, as well as current laboratory results, MRI (magnetic resonance imaging), and CT (computerized tomography) images. Additionally, prescriptions and treatment plans can be integrated into the system [1]. The implementation of EHRs has a special importance in the digitalization of the medical system, providing access to updated patient information to the analyses performed by patients in different medical units, which saves time and resources; no longer a need to rush certain analyses because you cannot have access to information[2].

In this context, the objective was to underscore the advantages and obstacles encountered during the implementation of electronic health records in various nations and their repercussions on medical practice in recent years, particularly in the aftermath of the pandemic caused by severe acute respiratory syndrome (SARS-CoV-2). A comprehensive search of the literature relevant to this review was conducted using a variety of keywords, including 'EHR,' 'healthcare digitalization,' 'digital health and the impact of the pandemic,' 'EHR adoption in different countries,' and 'interoperability in healthcare systems.' The search was based on scientific databases such as PubMed, Google Scholar, and Scopus.

The COVID-19 pandemic has had a decisive impact on deploying standardized EHRs on a large scale, with the latest data as of 2024 showing that the EHR system development market may reach a global threshold of approximately $40 billion by 2026 [3]. Companies developing this software are growing rapidly, as this technology brings numerous benefits to the healthcare system. Electronic health records are more secure and lead to faster evidence-based outcomes [4]. Although they have taken this magnitude and the market is growing, several challenges make the implementation of EHRs globally difficult, such as financial, technical, legal, and ethical [5]. Initiating such an application requires a large investment, and there are maintenance and updating costs, which, for some countries or regions, is a considerable effort [6]. Moreover, standards and regulations differ from one country to another, making data exchange difficult [7]. In addition to the structure of the application and necessary funding, cybersecurity and personal data protection issues are equally important [8]. Cybersecurity is an issue faced by many developed EHRs as medical data are transferred over the Internet; one method used to eliminate this problem is the use of blockchain [9]. Finally, there is also the resistance of medical staff to the use of technology, which requires additional training [10].

Furthermore, other frameworks can store or transfer patient data, such as personal health records (PHRs) [11], electronic medical records (EMRs) [12], Health Information Exchange (HIE), and Digital Health Records (DHRs), EHR - Electronic Health Record; PHRs- personal health records; EMRs- electronic medical records; HIE- Health Information Exchange; DHRs- digital health records [13]. Different countries initially adopted one form or another of these systems, depending on their knowledge and needs at the time. Subsequently, the need for standardization was increasingly recognized, leading to the overlapping of certain functions to achieve extended interoperability [14]. Table 1 presents a summary of the defining characteristics of these applications and their differences, with a specific focus on EHRs.

Table 1. Main characteristics of electronic health systems and specific applications.

Type of Health Record System	Description	Difference from EHR	References
EHR	Used in healthcare systems, it contains the patient's medical history, test results, and treatment information. Accessible in several medical facilities	-	[15,16]
PHR	PHR is a patient-controlled version of the electronic health record. Include personal medical history, immunizations, allergies, and medications taken.	It is managed and updated by the patient, not by healthcare providers. It can be used to communicate with doctors but does not replace the EHR.	[4,17]
EMR	It is an electronic medical record managed by a single medical unit. It includes essential information for each patient (tests, treatments)	It is accessible in a single medical unit; data cannot be shared with other hospitals or clinics.	[18]
HIE	Enables the electronic transfer and sharing of medical data between different healthcare providers	It does not store information; it just facilitates the transfer.	[19]
DHR	Digital record that manages data provided by healthcare services, but also data collected from digital devices (smartwatches, wearable sensors)	It's also managed by patients, not just the health system, data also comes from wearables.	[20]

The Organization for Economic Co-operation and Development (OECD) has examined the progress of EHR systems in more than 20 countries, intending to use EHR data for general analysis and statistics. The study found that, although the number of healthcare organizations sharing data is increasing, by 2021, only 15 out of 27 countries will have implemented an EHR system in which data are managed at the national level [21]. Efficiency in healthcare is necessary to deliver the highest quality of patient care. EHRs are an essential tool in this process, helping decrease the time to diagnosis, as physicians have quick access to patient history and analysis. In this context, an analysis of the benefits and challenges associated with the use of EHRs, as well as their impact in different countries, is presented in this article.

Benefits and Challenges of Implementing and Using Electronic Health Records

The transition from paper medical records to electronic data storage systems helps to manage medical errors, and it is estimated that errors can be reduced by more than 60% [22]. Big data storage and processing technology is no longer an impediment. With the help of machine learning and artificial intelligence techniques, it is now possible to analyze and visualize unstructured data coming from different sources (biochemical laboratory data, molecular and genetic analysis, and vital parameters from various sensors). The integration of several types of information (laboratory analysis, treatments, and symptoms) allows for a comprehensive understanding of the problem, leading to rapid and accurate diagnosis [23]. In addition to the main purpose of using EHRs, they could be useful in clinical research, planning new services, predicting new trends in various conditions, developing targeted treatments, and public health [24].

Therefore, the main benefits of using EHRs are to increase trust in the healthcare system and patient safety through more effective treatment owing to faster and more accurate diagnosis and targeted treatments [25,26].

The ability to update patient data in real-time saves time, and communication between specialists is much more efficient. Even if the patient decides to seek the opinion of another physician or the interdisciplinary team, storing the patient's data in such a file ensures quick access to the patient's history, thus avoiding much of the analysis that has already been done [27].

In addition, EHRs contain predefined forms to assist medical staff with the patient's medical history and recommended tests, which reduces the time spent with each patient. Once implemented and used, electronic records can reduce costs for medical institutions [28]. An equally important topic as in the case of tests is treatment, so the pharmacist's perspective of keeping track of the drugs administered is closely related to tracking the process of disease progression/relapse and practicing tracking the effectiveness of the drugs [29,30]

Concurrently, data stored in EHRs can be advantageous in clinical trials, as the current challenges related to patient recruitment can be mitigated. The utilization of EHR data is contingent upon its anonymization under the provisions stipulated by the General Data Protection Regulation (GDPR). In instances where anonymization is deemed applicable, the implementation of rigorous security measures becomes obligatory. This type of research is useful in epidemiology and provides a snapshot of community health. The ongoing global health crisis, namely the novel strain of severe acute respiratory syndrome (SARS-CoV-2), has served to underscore the critical function of electronic health record systems. Beyond supporting medical staff, EHRs facilitated the adoption of telemedicine, thereby reducing physical contact and, consequently, the risk of infection [31].

The healthcare system has undergone several improvements due to the large-scale implementation of EHRs. These improvements have had an impact on patients, physicians and hospitals, researchers, pharmacists, and health plans. Figure 1 provides a comprehensive overview of the advantages inherent to each category, ranging from the reduction of time and expenses to the consolidation of data for research purposes.

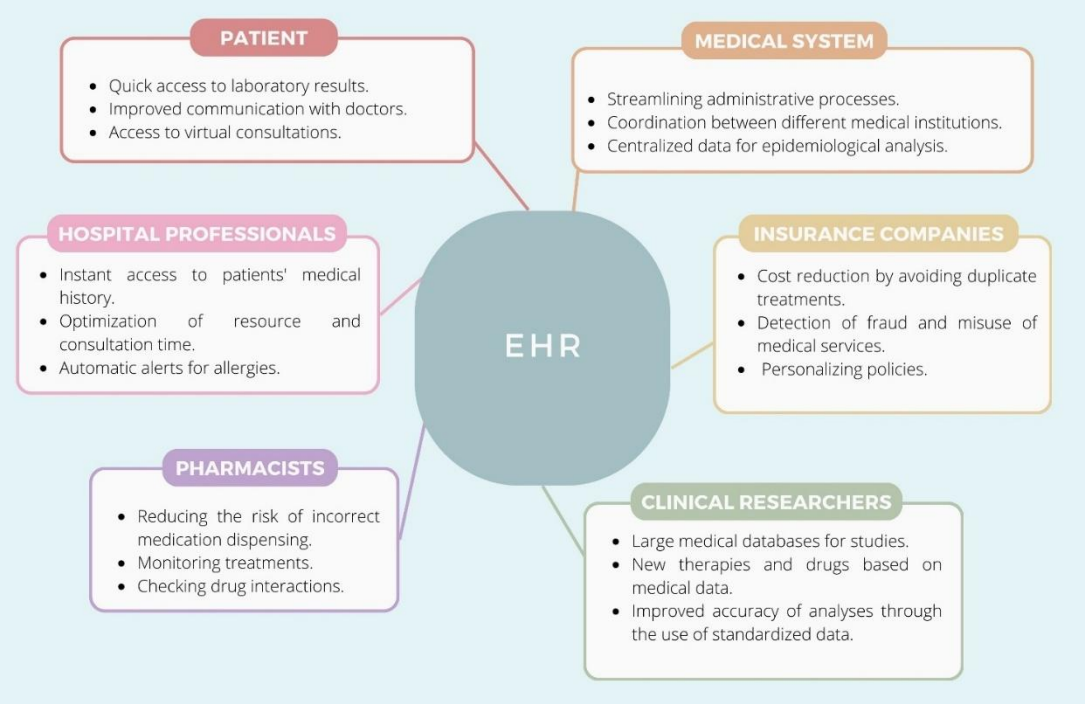

Figure 1. Schematic representation of EHR's main benefits and impact on the main factors involved in its use.

Although a multitude of benefits is visible, EHRs are not accessible to every healthcare facility on Earth's surface. Several impediments slow the process of investing in the digitization of healthcare systems. Even then, there can be privacy and security issues; for example, any unauthorized change to a patient's data can have serious repercussions for the patient. In less developed countries, the absence of ICT infrastructure makes it impossible to implement the functional digitization of health systems [32]. In addition, the resistance to change of staff or the inability to test new technologies makes the implementation of these systems increasingly difficult. Finally, because the health field is sensitive and the main objective is a better life, strict regulations are required. International standards developed by interdisciplinary specialist groups, such as ISO 13606-1:2019 [33] and ISO 13131:2021, [34] facilitate the transfer of information among multiple EHR systems, leading to interoperability. An analysis of how EHRs are implemented in different countries will provide a clearer picture of the status of EHR use.

Netherlands and Belgium

These countries use HiX, an application originally developed in the Netherlands that has now crossed borders into Belgium. In 2020, it started the development and implementation of HiX in Belgium, and by 2024, it has managed to bring 72 separate subsystems into a single integrated EHR, which means more than 2.5 million patient records [35]. Patient records can now be accessed and updated by all health care providers. The application also functions as a Hospital Information System (HIS), supporting both medical documentation and administrative processes. It also includes intelligent features that improve patient group analysis, quality, and financial indicators; uses secure security protocols as required by law; and uses break-the-glass to allow access to records in emergencies. Because it is modular, each operator can customize the application to suit their needs. In addition, the HiX application is user-centered, with an easy-to-use interface [36].

Denmark and Finland

Electronic Health Records implementation began in Denmark in 2016 and two years later in Finland. As there were some challenges at the beginning, a "physician builder" program was also initiated to allow medical staff to actively contribute to the improvement of the application [37]. The implementation of the Epic system in these countries has demonstrated the complexity of EHRs and that problem-solving is not easy, requiring theoretical and practical knowledge about communications and, therefore, IT. Therefore, the transition period from paper medical records to EHRs is a complex transition that lasts a year. Recent commission statements suggest the use of augmented reality (AR) and virtual reality (VR) systems that play a role in training and educating the staff. The software also uses artificial intelligence and machine-learning models to make predictions. Data storage and telemedicine services are facilitated through the implementation of cloud solutions [38]. All of these were designed based on international requirements (AES-256 (Advanced Encryption Standard) [39], HL7(Health Level Seven) [40], and FHIR (Fast Healthcare Interoperability Resources) [41]).

United Kingdom

The implementation of EHRs began in 2002 under the rules of a national NPfIT program that, by 2018, had eliminated all paper medical records. In 2011, this program was discontinued, but it did not stop EHRs from being widely used with real-time access and interoperability. No single type of electronic health record is used nationwide, and there are multiple vendors, such as Cerner, Epic, and EMIS Health. Patient portals were also used to improve access to the records [42,43].

United States

The initiation of the HITECH (Health Information Technology for Economic and Clinical Health) Act in 2009 was the key point for developing EHRs. Until 2014, most hospitals used such systems, but data security regulations came into force later, and interconnections between hospitals could be realized. The most popular EHR system is Epic; however, Cerner (Oracle Health) is also used [42,44]. The COVID-19 pandemic has highlighted the reporting of cases directly from EHR to public health institutions, these eCRs (electronic Case Reporting) work as an extension to EHR, no longer requiring manual Case Reporting, which automatically runs in the background [45,46].

China

Digitization of the healthcare system using EHRs began in 2007, and by 2018, it had reached more than 85% utilization, which is attributed to a government plan that prioritized EHR development [47].

In China, researchers have explored EHR implementation using openEHR, which aims to manage data storage and exchange without involving software developers. It uses two types of models: a reference model that provides the underlying structure for the data and an archetypal model that allows clinicians to define archetypes based on specific clinical scenarios [48].

These are only a few examples of EHR implementations that consider the most popular software. It was noted that the time from implementation was long, and improvements could be made along the way depending on current requirements, such as the pandemic that forced the shift to telemedicine. In addition, people travel for various reasons and may require medical assistance. In addition, specifically for the medical side, people from developed countries travel to countries that have lower costs for medical services, not only for innovative treatments [49].

It is estimated that more than 14 million people travel annually to medical facilities [47], requiring their medical records to be up-to-date and easily transferable to other medical units. From this perspective, the interoperability of EHRs or other electronic records is essential. International standardizations, such as HL7 FAIR, [50] are specific to enable real-time data exchange while ensuring data compatibility.

The future of EHR development is connected to technological advances, including artificial intelligence and machine learning algorithms for analyzing medical data. Furthermore, the integration of EHRs with telemedicine and wearable devices has the potential to facilitate real-time consultations, with data from wearable devices contributing to personalized healthcare. However, it is imperative to note that the advancement of EHRs will concomitantly necessitate the addressing of significant challenges related to data security and privacy.

Conclusions

The healthcare system benefits from significant improvements in digitization, data transfer power, or other technologies such as artificial intelligence, the Internet of Things, or machine learning methods. The transition from traditional paper-based medical records to electronic systems that can be shared increases the quality of life of patients and reduces medical errors. In addition, a large volume of data can be analyzed by providing meaningful statistics about the condition of a particular group, from symptoms and food to response to treatment or disease relapse at a given time interval. This information will help healthcare professionals to improve and make faster decisions in the future. Thus, the large-scale implementation of EHRs increases safety in the medical system, optimizes communication between specialists, reduces the time of analysis and completion of medical records, and therefore, costs, but also facilitates the development of clinical research.

It is obvious that to take all these benefits into account, some challenges must be overcome for these systems to become available worldwide. First, a technical infrastructure is needed to allow the storage and transfer of data. Second, strict data security measures are required, considering the risks that may arise in the case of unauthorized data modification. Finally, medical staff working with this software must be trained to adopt this change. Examples from the countries show that the trend is to adopt similar systems to facilitate interoperability.

The implementation of electronic health information storage and monitoring systems is essential globally but requires coordination, significant investment, and time to make the transition smooth for both healthcare professionals and patients.

List of Abbreviations: EHR - Electronic Health Record; PHR - Personal Health Record; EMR - Electronic Medical Record; HIE - Health Information Exchange; DHR - Digital Health Record; OECD - Organization for Economic Co-operation and Development; GDPR - General Data Protection Regulation; ICT - Information and Communications Technology; HIS - Hospital Information System; AR&VR - Augmented Reality and Virtual Reality; AES - Advanced Encryption Standard; HL7 - Health Level Seven; FHIR - Fast Healthcare Interoperability Resources; HITECH - Health Information Technology for Economic and Clinical Health; eCRs, electronic Case Reporting

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