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Challenges in Electronic Health Record Implementation: User Acceptance, Data Interoperability, and Patient Care Quality

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ABSTRACT

Electronic Health Records (EHRs) have become fundamental to modern healthcare systems, offering improved data management, enhanced clinical decision-making, and better coordination of patient care. Despite these advantages, their implementation remains challenged by issues related to user acceptance, system usability, and data interoperability. This review examines the key barriers influencing EHR adoption among healthcare professionals, including inadequate training, complex system design, workflow disruption, and resistance to change. Poor interoperability across diverse platforms further limits efficient data exchange, resulting in fragmented patient information and suboptimal clinical outcomes. Emerging technologies such as artificial intelligence, natural language processing, blockchain, and health information exchanges present promising opportunities to improve system functionality, facilitate seamless data integration, and support clinical workflows. Additionally, the incorporation of genomic data into EHR systems offers significant potential for advancing precision medicine and personalized healthcare delivery. Addressing these challenges requires a comprehensive approach that emphasizes user-centered system design, continuous professional training, supportive regulatory frameworks, and sustained technological innovation. Optimizing EHR implementation is essential for improving patient outcomes, increasing healthcare efficiency, and strengthening the overall quality, safety, and sustainability of healthcare delivery systems.

Keywords: Electronic Health Records (EHR), Healthcare Professional Adoption, Data Usability and Training, Data Interoperability, Patient Care Quality

1. INTRODUCTION

Electronic Health Records (EHRs) present several challenges in their implementation, particularly regarding adoption among healthcare providers. Resistance to the use of EHR systems has largely been attributed to inadequate training, which has been associated with increased errors and workflow inefficiencies among healthcare staff [1,2]. These challenges contribute to clinician fatigue and reduced efficiency, raising concerns across healthcare institutions globally.

1.1 Usability and User Acceptance

The usability flaws of many DSE systems make it difficult for the user to adopt the system. The platforms used for the operation of the DSE systems could be large, and thus the healthcare providers may not be able to employ them effectively. The difference between the expectations of the physician and the abilities of the system could hamper the efforts of the supplier to interact with the patients and could finally affect the service that the latter receives negatively. Findings show that it not only affects the conviviality of the system but also the future gains of using the DSE system could be hindered because of these flaws of the system [3].

To tackle these important challenges, it is important that the healthcare organizations put emphasis on the development of training programs that would address the specific needs of the individuals using the program. The importance of the training program that aims to improve information technology skills and introduce people to the use of the DSE capabilities cannot be overestimated, and it has been shown that such programs are capable of achieving a reduced resistance and heightened level of trust towards the new system among the healthcare staff [4]. Moreover, involving the healthcare staff directly during the development of the DSE systems could enable the staff to work using the system with ease, and the system could also be aligned with the way the staff work.

Furthermore, to deal with the challenges of data interoperability that also pose another significant barrier during the deployment of the DSE, it is also necessary to adopt standards and administrators who would foster the free exchange of information across various health systems. Data interoperability is essential to ensure that the required information gets to the various physicians concerning the patients with a view to offering appropriate treatment. If the data shared through the deployment of the DSE cannot be shared across various systems, silos are formed that hinder the sharing of the information across the various systems of the health care delivery system [5]. As important as training and friendliness are, a further key consideration is the promotion of a symbiotic relationship between different parties within the field of health care, such as decision-makers, software developers, and health care professionals, so that a maximum benefit of DSE could be achieved. This symbiotic relationship could lead to the formulation of strategies and best practices that could further improve the protocols of user acceptance and data exchange [6]. This diverse and multifaceted approach would not only lead to happier users but also ensure that the proposed DSE systems achieve the end-goal of enhancing the level of quality of care of patients through rapid access to essential information related to the field of health care. With the ever-changing environment of the field of health care, research studies that could address these issues could play a pivotal role in achieving a maximum benefit of e-eye data related to the field of health care [7].

1.2 Data interoperability Challenges

Data interoperability represents a basic challenge within the implementation of EHRs because various systems hinder effective communication and data exchange. This issue affects patients because medical professionals are unable to view the patients' medical history and other critical information related to the patients' well-being [8,9]. Fragmented IT infrastructures within medical organizations have been revealed to cause inefficient and potentially incorrect medical operations, establishing a compelling requirement for interoperable technologies [10,11]. The challenges are wide-ranging and include both the technical and regulatory aspects. The fact that these standards such as HL7 and HL7 FHIR are not universal makes data format and exchange mechanisms varied, thus impacting interoperability [12]. The lack of a common

framework makes it more costly for the healthcare organizations because, through the use of a variety of technologies, the differences are bridged [13].

Cultural resistance to change also remains a challenge within the corporate environment. Healthcare professionals accustomed to the old systems may be averse to adopting new systems that are interoperable but require changes within the way the professionals work themselves [7]. Change management strategies are essential within the cultural resistance to change and the development of flexibility. At the policy level, the adoption of interoperable standards and facilitation of collaboration between various parties are important and play a key role within the development of seamless care transitions and the leveraging of EHRs for beneficial use [5,14].

1.3 Emerging technologies Solution

Emerging technologies bring new possibilities of enhancing the interoperability of data within the EHR environment. Blockchain technology, for example, presents a secure and shared environment that could enable institutions to share information with each other effortlessly [15,16]. The essential properties of Blockchain technology for example the immutability and transparency of the Blockchain ecosystem, may address issues associated with data integrity and patient privacy to some extent and instil trust in the focal actors involved in the healthcare landscape [17]. By means of such a progressive and revolutionary technologies, key users in the healthcare sector like doctors, nurses e.t.c will be able to make sure that patients' records are secure and would not be distant with time [18].

Additionally, use of APIs and HIEs are very promising in terms of advancements for greater interoperation of data. APIs help in sharing data in just some seconds, and that's critical for stronger health care information. HIEs, in turn, provide a means by which patient data can be shared in a secure manner between multiple health care organizations, with the possibility of a single view of the patient information that could support clinical decisions at any point in time [19]. Even though there won't be protocols put in place while the community itself will not have been working towards standardization of data adaptability as well [20].

1.4 Policy and Regulatory Frameworks

Derived from our review of current legal and regulatory approaches, some possible new strategies to facilitate EHR interoperability are beginning to emerge. Regulations such as the U.S. 21st Century Cures Act intend to enhance EHR interoperability, limit information blocking behaviors and make the flow of data a fundamental operating tenet for healthcare organizations [21].

Policy makers can be instrumental in devising strategies that promote the proliferation of technology and collaborative relationships among providers to address interoperability issues [5]. The translator effect of EHR systems for personalized medicine means the need to build the sustainable, interoperable future strategy in this area [22].

Smooth data sharing remains elusive, but technological developments and enabling policies also provide considerable room for improving the quality of care and clinical practice. Studies show that when EHR systems work well, they have the potential to improve patient outcomes by enabling accurate diagnosis, treatment and interventions [23]. An easy-to-use EHR that fits practitioners' workflow makes it easier for health care workers to use an EHR system, creating better outcomes for patients [24]. These advantages could, however, be forfeited if systems are poorly implemented or rejected by users. Potential negative impacts include extended time for documentation, reduced face time for patients and patient dissatisfaction, all elements fueling physician burnout [6, 8, 25].

Long periods of time spent on complex systems not only impede patients' engagement but reduce the number of satisfied patients [8]. These barriers highlight the need to focus on technology and humans during EHR implementation.

To solve usability problems systematically, concentrated work on evaluation and improvement is crucial [8]. Iterative feedback mechanisms, and usability studies to debug and refine functionality, are extremely useful for trouble-shooting issues with the program overall, or modifications made as clinicians continue to engage with the system. Adopting user-centered design approaches in the development of systems can lead to greater integration into medical workflows and may inhibit lowered adoption rates [26]. In addition, with end users in the project from beginning to end the usability is much improved and care can be provided [4]. A second important factor of EHR effectiveness is interoperability. Interoperability has the potential for various systems to communicate with one another, interpret shared data and use the information in a useful way [5]. While this enables collaborative approaches among various parties involved in patient care, absence of standardized protocols results in fragmented pictures and impairs a comprehensive view which is vital for well-informed medical decisions [5].

Narrowing the interoperability divide demands broad policy efforts, as well as investments in information infrastructure that facilitate secure and standardized data exchange [27]. Further progress also necessitates the adoption of data standards and health information exchange tools [5]. This will enable the clinician to take advantage of the data to improve the accuracy of both the diagnosis and the treatment and ensure continuity of care through the data. Furthermore, the two important challenges of user acceptance and interoperability significantly influence the success of the adoption of EHR systems. Resistance by the healthcare providers may also come from concerns related to the usability of the EHR system and the "intrusion of technology into the world of healthcare" [28]. Studies have repeatedly showed that the adoption of the EHR system and the degree to which the features of the EHR align with the practical world of medicine are the most important factors that influence the adoption of the EHR system in a healthcare environment. Advances such as Natural Language Processing and Machine Learning are poised to enable the customization of EHR functionalities to adapt to a specific healthcare environment [26, 29].

Figure 1. Challenges and Solutions in EHR Implementation

The key challenges to adopting Electronic Health Record (EHR), the steps to be taken to solve these challenges, and the resulting outcomes are well explained through the flow diagram above. Challenges such as usability issues, interoperability issues, and resistance to change are presented on the left side of the diagram. The strategies such as training and user-centric design, legislation and regulation, and the use of emerging technologies such as artificial intelligence (AI), Blockchain, Natural Language Processing (NLP), and APIs are presented through the middle column of the diagram. The anticipated outcomes of these

strategies are presented through the right column of the diagram and include positive adoption, efficiency, and patients and provider satisfaction. Source: Author's conceptual framework

1.6 Future Directions

Technological advancements such as Natural Language Processing (NLP), Machine Learning, and the like open up fascinating possibilities for tailoring the EHR system to the challenges of a real-world medical environment. The latter systems could have checks and a potential impact on the effectiveness and benefit of the system in terms of documentation, data recovery [26, 29]. On the other hand, one of the first priorities is to create standard data structure and open standard for a healthcare information exchange in order to reach an integrated eHealth environment. [5] In general the technologies and methods enable medical personnel to view an entire file on a patient, so that early intervention can be positive. In general, these methods not only overcome the implementation of, and challenges associated with the use of EHR systems but also achieve an end goal to enhance healthcare services based on this technology [30, 31]. Thec potentially important role of ICTs in the medical scenario is clear that they can provide a right and detailed information required for right time interventions guaranteeing that end recipients, who are soliciting for medical services, have right amount of information.

1.7 EHRs in Precision Health and Genomic Medicine

The incorporation of genetic information into Electronic Health Records (EHRs) is a new frontier that has emerged to improve the precision of health and personalized medicine. As opposed to the use of EHRs, which only documents medical interactions, the incorporation of genetic information into EHRs allows medical professionals to provide personalized preventive, diagnostic, and therapeutic strategies based on a person's genetic profile. For an example, a genetic information that could be inserted in EHRs is the pharmacogenomic information, which can give instruction on drug prescription and administration that appear to be less likely to cause adverse reaction in patients such as: who should receive the drug and what dose is not deleterious or that can lead to right response in the patient [32].

The EHR clinical decision support systems also facilitate genomic medicine, such that genetic risk factors are consistent with routine medical care. These systems also allow for identification of those patients that carry the genetic diseases and also help the physician to make highly informed claims regarding which trajectory is to be taken in terms of those patients' treatments [33, 34]. The promising discoveries as a result of the more advanced development in artificial intelligence led to new horizons with novel applications that transcend from multi-omics data and medical records into therapeutic realm, not only for genetic medicine but also for other disciplines including immunology and systems biology [35].

Nonetheless, incorporating genetic information into EHR faces distinctive challenges in interoperability. Genetic information is typically large and complex, coming from diverse sources of the government that are difficult to normalize. Adoption of standardization approaches such as HL7 FHIR Genomics is crucial to enable interoperability and integration of genomic data across diverse EHR systems [36]. The pace of the development of interoperability during the last two decades demonstrates how challenging it can be to bring genetic information and medical data together, especially for research and to support applications that target the delivery of healthcare [37].

More recently there is an applicability in the

context of post-genomic EHRs, which is not merely genetic, incorporating proteomics and metabolomics and environmental for precision medicine at mass scale are introduced [38] as: Taking the integration way of genome information with its post-genome information is actually transforming EHRs to be live systems that store but also can implement precision medicine. The incorporation of generated information is compatible with the general aims to increase medical accuracy, optimize the interventional strategy in medicine and disseminate symbolic prevention strategies according to particular population needs, and other issues [39]. In addition, there is the significance of AIs developments, genetic interchangeability and EHR system making paths that are revolutionary toward satisfaction in the promise of precision medicine [40].

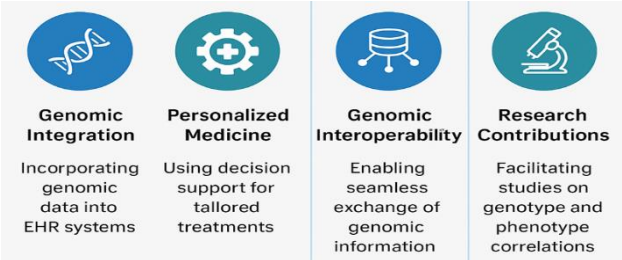

Figure 2. EHRs and Precision Health

The illustration above showed how the electronic health records (EHR) can be utilized by integrating genomic data with the goal of precision medicine. The processes involve the application of information derived from genomic sequencing and biomarkers that thus may be stored in genome databases and standardized using HL7 FHIR Genomics. It is then incorporated in the patients' longitudinal EHR records. This information is then processed using CDS (Clinical Decision Support), AI and NLP algorithms able to combine considerations drawn from clinical and genomic data assembled in the course of the GS. The knowledge could indicate personalized ways of treatment or prophylaxis and used to improve the personalized medicine and the role of research in genotype-phenotype analysis. Source: Author's conceptual framework

CONCLUSION

The successful implementation of Electronic Health Records (EHRs) requires a comprehensive approach that addresses both technological and human factors, particularly system usability, data interoperability, and user acceptance, which remain key barriers to effective adoption. Emerging technologies such as artificial intelligence, natural language processing, and application programming interfaces offer significant potential to improve system functionality, streamline clinical documentation, and enhance data exchange; however, their effectiveness depends on proper integration into clinical workflows, continuous system evaluation, and adequate user training. Furthermore, the integration of genomic data and clinical decision-support systems into EHRs presents important opportunities for advancing precision and personalized medicine. Healthcare organizations must therefore adopt strategies that promote user-centered design, interdisciplinary collaboration, and sustained investment in infrastructure. Optimizing EHR implementation will ultimately improve patient outcomes, increase healthcare efficiency, and support the development of a more integrated, evidence-based, and patient-centered healthcare system.

List of Abbreviations

API - Application Programming Interface
DSE - Dossier de Santé Électronique

(Electronic Health File, French equivalent)
EHR - Electronic Health Record
HIE - Health Information Exchange
HL7 - Health Level Seven International
IT - Information Technology
NLP - Natural Language Processing

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