

Health Information System in a Cloud Computing Context

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Abstract. Healthcare as a worldwide industry is experiencing a period of growth based on health information technology. The capabilities of cloud systems make it as an option to develop eHealth goals. The main objectives of the present study was to evaluate the advantages and limitations of health information systems implementation in a cloud-computing context that was conducted as a systematic review in 2016. Science direct, Scopus, Web of science, IEEE, PubMed and Google scholar were searched according study criteria .Among 308 articles initially found, 21 articles were entered in the final analysis. All the studies had considered cloud computing as a positive tool to help advance health technology, but none had insisted too much on its limitations and threats. Electronic health record systems have been mostly studied in the fields of implementation, designing, and presentation of models and prototypes. According to this research, the main advantages of cloud-based health information systems could be categorized into the following groups: economic benefits and advantages of information management. The main limitations of the implementation of cloud-based health information systems could be categorized into the 4 groups of security, legal, technical, and human restrictions. Compared to earlier studies, the present research had the advantage of dealing with the issue of health information systems in a cloud platform. The high frequency of studies conducted on the implementation of cloud-based health information systems revealed health industry interest in the application of this technology. Security was a subject discussed in most studies due to health information sensitivity. In this investigation, some mechanisms and solutions were discussed concerning the mentioned systems, which would provide a suitable area for future scientific research on this issue. The limitations and solutions discussed in this systematic study would help healthcare managers and decision-makers take better and more efficient advantages of this technology and make better planning to adopt cloud-based health information systems.

Keywords. Cloud Computing, Health Information System, Electronic Health Record

1. Introduction

Healthcare as a worldwide industry is experiencing a period of growth based on health information technology. Despite the considerable practice and innumerable benefits eHealth has brought, various challenges complicate the implementation of such advancements. These include the high cost of implementation of health information

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technology projects due to high consumption and operation costs. On the other hand, maintaining, supporting, and updating IT projects is confronted with fundraising challenges. Additionally, the need for specialized personnel to develop, manage, and maintain IT projects is another challenge. In order to overcome eHealth problems, most organizations move towards new models with advanced technologies.[1]

Cloud computing, as one of the new advancements in the world of technology, has had a great impact on various spheres of knowledge. Cloud computing is a new IT-based model providing service. It can host different sources of information by creating an integrated platform. Such integrated information platforms provide suitable data analysis and model discovery opportunities in health sciences. [2]

High implementation, maintenance, and manpower costs complicate successful realization of IT-based health projects. Cloud storage, through the property of service providing payment considerably decreases implementation costs and enhances the degree of financial savings. Additionally, increasing the volume of medical data on the one hand and restrictions on the storage and maintenance of this data on the other hand had necessitated the possibility of using high-volume data storage tanks. [3] Health service providers intend to provide tele-medicine services via cloud computing. They focus on electronic files as necessary tools for implementing cloud computing. Fusing electronic health records technology and cloud computing will enhance the quality of medical services. [4]

The advantages of cloud computing facilitate the implementation of electronic records. Thus, stakeholders are more inclined to cooperate and invest in this issue.[5] On the other hand, since the possibility of interoperability between systems is one of the greatest problems of transforming electronic data, it seems by standardizing health information before migration to the cloud and integrating related data in this platform, a suitable solution for overcoming this barrier will provide.[6]

Applying health information systems as the most prominent sub-category of eHealth, confronts several challenges. Hardware limitation in storing and maintaining health data, slowed down data access due to the increased volume of stored data, security issues, privacy and data backup, and sharing health information which has been traditionally stored are some main challenges.[7] It seems that cloud computing is able to overcome barriers that health information systems are dealing with. Several studies have focused on cloud computing in the realm of health issues. However, different forms of health information systems, such as electronic health records have not been analyzed. Based on problems and complications surrounding health information systems and considering the potential of cloud computing in resolving these problems, it seems that reviewing related texts can provide helpful information on the extent of use and success of health information systems and cloud storage. Thus, the main objectives of the present study include:

- Investigating the advantages and limitations of the implementation of health information systems for cloud platforms.
- Solution for successful implementation of health information systems for cloud platforms.

2. Methods

The present systematic review was conducted in 2016. Following are the main stages of

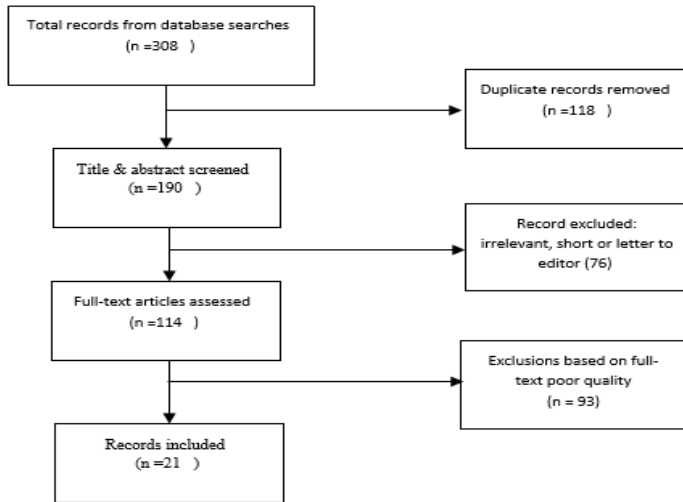


Figure 1. Flowchart of the search process

the study: research strategy, designing the extraction form, inclusion and exclusion criteria, and the quality of the articles. Research strategy provided considerable contribution in finding good answers for study questions. First, necessary keywords were extracted based on the objectives of the study. Then, related papers were searched based on found keywords, AND/OR conjunctions, and search strings. Cloud computing, health information system, advantages, benefits, challenges, issue, solution were keywords that make search strings and were searched in Scopus, Science Direct, Web Of Science, IEEE, PubMed and Google Scholar in the period 2000 to 2016 . The search process is shown in Figure 1.

Inclusion criteria: all papers (journal and conference articles) in English with available full texts as well focus on cloud-based health information system and the potential of providing sufficient answers for research questions qualified for the study.

Exclusion criteria: irrelevant papers (which not cover health information system or not describe the advantages and limitation of health information system implementation in a cloud platform), short studies, letters to editors, papers that provide only authors opinion without scientific methods to test evidences or not report specific outcome about health information system implementation in cloud platform were removed.

Quality assessment was carried out by research team simultaneously and separately. If assessors disagreed about the quality of a certain paper, a third party would issue the final creed. After studying the relevant papers, related data were put in a data collection form that was designed in Excel sheet. Then, all extracted materials were compared and their connections, similarities, and differences were determined. Finally, the found materials were fused to provide a suitable answer for research questions and justified conclusions were presented.

3. Results

Electronic health record, personal health record and electronic medical record were the subject of papers. Ten articles had discussed the advantages and limitations of the

Table 1. Papers with cloud based electronic health record content.

No	Authors	Domain	Result
1	Bagha [6]	EHR implementation	effective interoperability, scalability, maintenance, accessibility, and lower costs, in comparison to traditional health records
2	Lupse [8]	EHR implementation	Increasing cooperation between wards, enhancing the quality of services, and reducing the cost of IT infrastructure.
3	Rodriguez [9]	security	destruction of previously stored service, network security, external audit, backup, physical security, and confirming personnel qualification
4	Wu [10]	security	The study used selective EHR to control information access and patient-confirmed control access policies to increase security
5	Preethi [11]	security	Attribute-based encryption method was used to enhance the security of data
6	Abdullatif [12]	security	a flexible and reliable access control mechanism is suggested to provide quick access to electronic health records
7	Schweitzer [13]	conceptual	A cloud-based EHR provides a general, basic model that enables the user to experience synchronization in accordance with their local requirements
8	Chen [14]	conceptual	Propose a model for access control
9	Fernandez [4]	conceptual	Flexibility, scalability, performance enhancement, economic saving, and high accessibility are the main advantages of cloud computing
10	Fernandez [15]	conceptual	four main challenges against implementing cloud computing, which include trusting cloud provider, developing legal frameworks and cooperation with legislating offices, data security, and standardization of platform

implementation of electronic health record on cloud platform. Two research projects investigated the implementation of EHR in a cloud platform. Four studies examined security and controlling EHR access in a cloud platform. Four other studies examined generally concepts about the use of cloud computing in a successful implementation of electronic health records. They also presented useful solutions. The result of this is shown in Table 1.

This section focuses on presenting cloud-based electronic medical record design and models. A cloud-based medical record system was implemented through a web-based portal and cloud-based server in Nigerian villages to enhance the quality of health care services. Access security was guaranteed through username and password. [16] Paradamean's study designed a cloud-based framework for developing electronic medical records in Indonesia. This model, through a central cloud-based medical record system, provided the opportunity of maintaining, sharing, and transmitting medical histories between clinics and hospitals. [17] The outcome of both were successful. Haskwe investigated a cloud-based electronic medical record system which was launched at an Institute of Mother and Child in Kenya, and used to assess the role of cloud infrastructure in completing electronic records of patients. He finally concluded that a cloud model removes many deficiencies of EMR and remedies the quality of data completion visibly. [19] Two other study propose EMR cloud based model that lead to better scalability, security and interoperability between health systems. (Table2)

In the scope of personal health record three studies have examined the design and implementation of PHRs. The benefit of these implementations is shown in table 3. Three other studies have investigated issues of security and access control in electronic personal record and provide models and recommendation that lead to patients full access to their PHR information, store and share personal health information securely and enable them to allocate private access to his information for desired organizations, groups, or medical teams securely. (Table 3)

Table 2. Papers with cloud based electronic medical record content

No	Authors	domain	result
1	Boyinbode [16]	National implementation	The outcome was successful sharing of medical records
2	Pardamean [17]	National implementation	integrates organizations and decreases complicated business processes
3	Radwan [18]	designed a model	Medical records of patients remain in information systems of hospitals and developers need not implement electronic health applications again.
4	Haskew [19]	EMR implementation	a market improvement in the completion of records of babies during the period of implementation
5	Sobhy [20]	designed a model	The model presents a mobile, flexible platform which resolves scalability

4. Discussion

According to the study, the main advantages of cloud-based health information system can be categorized into the following groups: economic benefits and advantages of information management. According to several analyzed studies, the main impetus which encouraged organizations in adapting cloud-based systems is economic benefits; organizations won't need costly infrastructures, pay merely for services they receive, save money, and invest in other areas and sections. The need for hiring full-time personnel is removed and maintenance costs are considerably reduced. The cost of electricity consumption falls significantly and reducing the production of foot points helps preserve the environment.[4, 13, 15]

In terms of the benefits of information management the following can be considered; high access to data and information in such a way that patients and other beneficiaries will be able to use databases anywhere, anytime if they have access to internet. The clarity of data increases and higher quality is a justified expectation. Clouds allow storage of huge volume of data and remove the majority of huge data management problems. Easy implementation is an important advantage of clouds; users are able to enjoy and apply services without having to apply a particular hardware or software and required software is easily updated due to centrality of cloud management. Scalability of clouds makes changes in response to user expectation and this result in sustained development of health information systems. The agility of clouds makes health information systems very mobile, because it enables users to ask for required service without any initial actions toward service preparation. [4, 9, 15, 23]

Table 3. Papers with cloud based personal health record content

No	Authors	Domain	Result
1	Van Gorp [21]	design and implementation	My-phr lead to patient information totally reliable & it lowers the number of accessibility problems by using web
2	Hsieh [22]	design and implementation	CDA standard for portability and interoperability between people and systems/ Attribute-based encryption
3	Enkonomou [23]	design and implementation	PHR integrated with cloud-based EHR that lead to scalability, availability for the patient, sharing information, enhancing the quality of services, and empowering patients through making their medical history available
4	Chen [24]	security and access control	This model makes PHR information available with higher security; it supports availability to different users simultaneously
5	Wang [25]	security and access control	Designs and implements an integrated cloud-based platform for PHR based on Cipher Text Attribute-based encryption.
6	Chein-Hsing [26]	security and access control	A framework based on which the owners of electronic personal records can have full control over their information in a cloud platform.

The main limitations of the implementation of cloud-based health information systems can be categorized in four groups of security, legal, technical, and human. Security barriers are one of the main reasons for resistance of some companies in adapting cloud-based systems. Uploading health information, which are mostly classified and private, on a server implies the loss of data management and this is a source of great concern for organizations. The possibility of malicious attacks is another aspect which threatens users if necessary security considerations are not taken into account. Consequently, weak key encryption might impair encryption and reveal the password to malicious people. Managers and personnel of cloud system, might exploit access permissions as well. This is a huge threat for the security of patient information.[4, 15]

Another limitation of cloud systems is legal deficiencies, such as a lack of legal framework for managing and transmitting electronic health information. The contract between the customer and the provider is one of the main issues. If contracts do not include the necessary legal requirements, customers will not adopt such technologies because they do not have sufficient legal and security backup. Governments and organizations play a vital role in establishing regulations for both provider and user. [15]

The main technical problems in the adoption of clouds in health information systems are establishing interoperability and the transmission of health systems to a cloud-based form. Since different systems are designed based on different programming languages, operation systems, and data models.[6]

The main human problems of the implementation of cloud-based health information system include uncertain qualifications of the provider and personnel, reliability of the contract between the customer and the provider. Because of high sensitivity of health data, if the qualification of providers is not determined and their reliability is not assured, the risk of unsecured data transmission comes up. [4, 5]

Based on the results of the present study the following strategies have been suggested. To protect security and confidentiality of data, mechanisms such as encryption, role-based access control, data transmission prior to migration to cloud form, digital signature, access assessment, network security, destruction of formerly stored services in the provider, having multiple backups, and preserving them in different places are some solution. Some studies have recommended different encryption methods, such as attribute-based encryption and multiple layer identity determination. Making patient information unidentifiable by deleting identification information, anonymity of the user, and confidentiality of user access are some other strategies.[9-12, 14, 25, 26] in addition two other study examine this issue and solution comprehensively. Hauf proposes a framework to preserve information security in health clouds that include: evaluation information security risk, elimination of security risk, control of outsourced processes, requirement control and management of information security events.[27] Abbas categorizes the privacy preserving approach in health clouds into cryptographic and non-cryptographic mechanism and recommend some solution to improve the provenance security, data search and integrity verification approaches of health information in cloud.[28]

The role of legislating organizations and governments in the definition and implementation of binding rules is very important. For example, HIPPA has set a series of principles and general requirements for the protection of electronically transmitted data. Additionally, this organization has issued a set of requirements that a cloud provider must observe and the contract must contain. Most studies have insisted on complying with these requirements as the main criterion for judging the reliability of a provider. [13, 14, 20]

Based on the results of this research, using a set of general guidelines and standards in developing information systems is the main step in the promotion of interoperability. Using standard data models and data formats in health information systems are two main solutions. Some studies have recommended the use of standards, such as HL7CDA, or HL7-based XML, as the main solution for establishing interoperability between systems.[6, 8, 22]

Considering high sensitivity of health data, migration process to the cloud form is complicated unless there is a complete trust between customer and provider. Therefore, it is recommended for the organizations to do full-length research before selecting a provider and choosing the best option after that. Studying the history of such people and assessing their qualification is quite essential before the inauguration of the cloud-based project. [9] Based on the results, despite limitations of cloud computing, organizations and health service providers have given positive feedback about this technology. Some mechanism and solution were discussed and it seems it would be a suitable area for future scientific research. Limitations and solutions discussed in this systematic study help healthcare managers and decision makers take better and more efficient advantage of this technology and also better planning to adopt cloud-based health information systems.

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