ORIGINAL PAPER

Capabilities and Advantages of Cloud Computing in the Implementation of Electronic Health Record

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ABSTRACT

Background: With regard to the high cost of the Electronic Health Record (EHR), in recent years the use of new technologies, in particular cloud computing, has increased. The purpose of this study was to review systematically the studies conducted in the field of cloud computing. **Methods:** The present study was a systematic review conducted in 2017. Search was performed in the Scopus, Web of Sciences, IEEE, Pub Med and Google Scholar databases by combination keywords. From the 431 article that selected at the first, after applying the inclusion and exclusion criteria, 27 articles were selected for surveyed. Data gathering was done by a self-made check list and was analyzed by content analysis method. **Results:** The finding of this study showed that cloud computing is a very widespread technology. It includes domains such as cost, security and privacy, scalability, mutual performance and interoperability, implementation platform and independence of Cloud Computing, ability to search and exploration, reducing errors and improving the quality, structure, flexibility and sharing ability. It will be effective for electronic health record. **Conclusion:** According to the findings of the present study, higher capabilities of cloud computing are useful in implementing EHR in a variety of contexts. It also provides wide opportunities for managers, analysts and providers of health information systems. Considering the advantages and domains of cloud computing in the establishment of HER, it is recommended to use this technology.

Keywords: electronic health record (EHR), cloud computing, advantages, capabilities.

1. INTRODUCTION

Today, the advancement of technology specially is medical sciences has turned healthcare organizations into customer-oriented environments (1, 2). These organizations are in a quest for quality improvement. This will not be achieved without any time access to high quality information (3). According to the definition of the International Organization for Standardization (ISO), Electronic Health Record (EHR) is storage, secure exchange and access to patient information in digital format by several authorized users. This information includes the patient's past, present, and future information. The main objective of EHR to support the maintenance of integrated, efficient and quality health (4). In other definition, EHR include all information related to the health of citizens from before birth (information about pre and postnatal fetuses, such as in vitro fertilization information) to after death (information derived from autopsy, landfill, etc.). This information stored continuously and electronically over time. If necessary, without contact with the location or time, all or part of this information will be available to authorized persons (5). Generally, integrated EHR stakeholders are all members of a society. All healthcare providers are stakeholders and customers. EHR has a significant change in providing healthcare, reducing errors and increasing impact of health care (6). Ease of access to all information on patient history improves care, focuses on information and thus reduces medical diagnostic errors. The simultaneous availability of specialized medical centers to the EHR is a considerable benefit. Also, it is important to maintaining and protection the information from decomposition, collapse and destruction for any reason is another.

Developing a benefit of EHR is encounter to some of barriers, which can

Figure 1. Search strategy of this article

sponsible for protecting the privacy and security of patients (9).

A developer will be able to develop safer, cheaper, and better applications by cloud computing capabilities and features, for example economic scalability. Upgrading these programs is easier than existing program. Each program that runs on any of the computers in the organization is able to update individually. It is fast and easy to do with this technology. Cloud data sharing is easily available for all devices that can connect to the server at any location and in any form. The purpose of this study was to review systematically the studies conducted in the field of cloud computing.

2. METHODS

This study is a systematized review that was done to identification the capabilities and advantages of cloud computing technology in the implementation of the EHR based on the results of studies conducted over the past 10 years (2007- 2017). Data gathering was done by a checklist. Search was performed on Pub Med, ISI Web of Sciences, Scopus databases, as three major medical science databases that cover all areas of medical science, IEEE database and the Google Scholar search engine. The key words used were as follows:

In order to increase the quality of searches, we use an expert in search in database. Several other criteria were defined in searching on database and were considered by the end of the study. Figure 1 shows search strategy of this article.

According to Figure 1, searches were done in 10-year period (2007-2017). Due to the repetition of some studies in databases, all duplicate titles were deleted (number of removed articles were 62 articles). In the next step, educational reports, letter to the editor, and unrelated articles to cloud computing field in the EHR were deleted (the number of articles removed were 229 articles). The abstracts of the articles were then evaluated some of them did not provide sufficient explanation were excluded from the study (the number articles removed were 111 articles). After that, the of quality studies were evaluated and low level quality articles were deleted (number of articles removed 2 papers). In evaluating the quality of studies conducted on Cloud Computing, two papers were excluded out of 29 available articles due to poor quality of study. Finally, 27 papers were selected. In this study, a self-made checklist was used. Data were summarized and reported using content analysis method, based on the research objectives.

3. RESULTS

After searching, screening and qualitative evaluation of the articles during the systematized review, 27 articles were selected.

Advantage and capabilities of cloud computing for EHR implementation in the select studies classification in ten main domains of cost, security and privacy, scalability, mutual per-
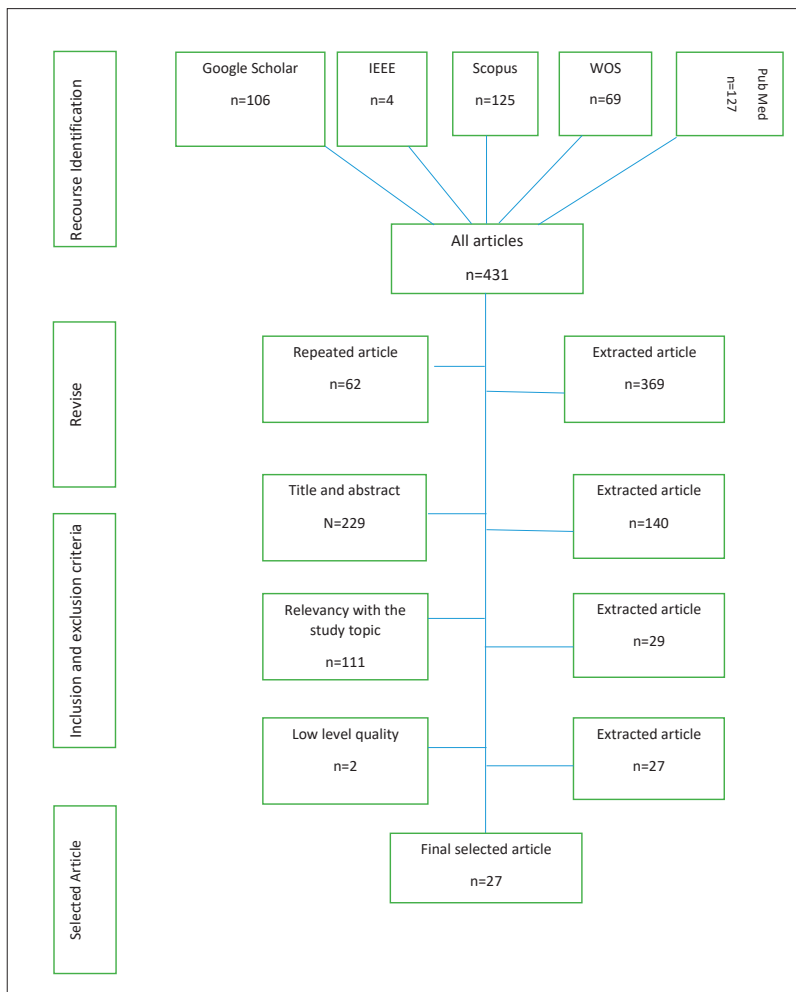
be categorized as technical, organizational, personal, financial, and moral-legal barriers (7). With regard to this of barriers for the implementation of EHR, the use of new technologies such as cloud computing is effective in its successful implementation. Cloud computing is the computation that was done by a group of remote servers that form a network. It leads to centralized storage of data and online access to services and computer resources; simply cloud computing is the acquisition to computing resources through the internet (8-10).

Today many healthcare providers and insurance companies use some types of EHR, most of them storage it at centralized databases. Typically, the patient may have different health care providers. Also, a patient may use different health insurance companies; sharing information among healthcare providers throughout the administrative boundaries facilitates the communication between these sectors.

Infrastructure in the cloud (Infrastructure as a Service– IaaS) is a kind of cloud service model that enable users to provide processing, storage, networks and other computational resources. It thus allows the consumer to set up and run favorite software, such as operating systems and applications. The cloud infrastructure consumer cannot manage and control the infrastructure. However, it provides control of the operating system, storage, deployed applications and possible control of the selected network components. In the Cloud Infrastructure model, healthcare software developers are re-

(" Cloud Computing" or "saas" or "iaas" or "paas")	1#
(" Electronic Health Record" or" Personal Health Record "or" health information system" " EHR" or "EMR" or "PHR" or "CPR")	2#
1# AND 2#	AND

Table 1. Search keywords

formance and interoperability, implementation platform and independence of Cloud Computing, ability to search and exploration, reducing errors and improving the quality, structure, flexibility and sharing ability.

Figure 2 provide Based on the findings of Table 2 that showed the main domain and domain of Advantage and capabilities of cloud computing for EHR implementation.

4. DISCUSSION

With regard to the result we can classify the capabilities and advantages of cloud computing use in EHR in ten main domains, which are discussed below.

4.1. Cost

Cloud computing help to customers to reduce the hardware, software and services cost, and also help to eliminate the installing and maintaining of software costs. Also by increasing the speed of access to data and improvement of health care by EHR the cost of health care decreased (12, 18, 24, 32, 36-38).

4.2. Security and privacy

One of the challenges in the EHR is security and privacy of the data in the storage location and during the exchange. Protecting the privacy of data in a cloud environment requires strong security laws. Based on the security standard rules that defined in the HIPPA (Health Insurance Portability and Accountability Act); cloud environments maintain a privacy of health data in through some ways. For example: Use of encryption and decryption concepts such as character-based encryption, unique encryption, public and private key encryption, combination of private and public key encryption, symmetric, authentication, digital signature, etc. (13, 14, 16, 19-25, 27, 32, 35-37).

4.3. Scalability

A desirable feature of a system, network, or process that help to system to reduce workloads (39). For example, scalability can refer to the ability of a system to increase overall performance when adding resources (such as hardware). The role of scalability in the design and execution of complex and large systems, such as databases and knowledge databases, is very important. Users can provide resources at the time of demand and do not need to be prepared for maximum resource consumption times. This is another feature of cloud computing in the field of electronic health records (12, 13, 18, 19, 24, 27).

4.4. Mutual performance and interoperability

The cloud services can be provided by several cloud providers. For example, a provider may offer storage and processing services for high-resolution images, while another provider can provide storage or data mining services, analysis and other services for the patient's electronic records. The main issue here is interoperability. This is an accepted framework or some open protocols providing servers in an easy way and integrating data among cloud service providers (40). The goal is to make the services available easily through standard models and protocols without worry about infrastructure, development models or implementation details (12, 16, 28, 37, 41). The acquisition of medical data from different sources requires a high degree of data interoperability. Most medical information systems store clinical information about patients in proprietary formats. The interoperability of EHR systems help the patient's care effectively and efficiently by facilitating the retrieval and processing of clinical information about the patient from different locations. Transmission of the patient's information automatically between care sites promotes fast and reduces duplicate tests and prescriptions (12).

4.5. Implementation platform and independence

The possibility of cloud computing implementation different databases such as SQL, ORACL and CASH on the one hand and the ability to install which is not necessarily Windows-dependent and can be installed on a mobile phone on the other hand causes to the independence of this technology and the devices used in this field. The system does not use any type of hardware, because the documents and applications are all in one form, and have the ability to exchange and collaborate (12, 31, 41).

4.6. Ability to search and exploration

The ability to search in so much of information and data about millions of patients in a database embedded in the cloud based electronic health record environment and the use of various search methods, including the method of combining vocabulary and phrase keywords is of exploration methods

Row	Subject matter	subscales
1	Cost	Reducing software, hardware, installation and maintenance costs
2	Security and Privacy	Encryption and decryption, Authentication, Digital signing, Public and private key, Symmetric key, Hybrid key, Time encryption, Unique key delivery to email individuals, Two-factor authentication, Confidentiality, Audit, Anonymity, Unlink ability, Hiding the search pattern
3	Scalability	Provision of resources at the time of demand, the possibility of development
4	Interoperability	Significant interactions between stakeholders, the link between sectors and separate systems, reducing rework, and increasing the speed of exchanges sharing, interpreting and useful use of information.
5	Implementation platform and independence of Cloud Computing	PC, Laptop, Mobile, Windows, SQL, ORACLE, open EHR
6	Ability to search and exploration	Ability to search in so much of data, use of unique keywords, hybrid keywords, phrased search key, regular and coordinated search.
7	Reducing errors and improving quality	Reducing mistakes in exchanges, increasing access speed, integrating the multiple types of electronic health records
8	Structure	Layer structure, hierarchical structure, task split, pay attention to details
9	Flexibility	Use of multiple and separate sites, use for all shareholders
10	Exchange and sharing ability	Fast transfer, time dependent, permission of file owners

Table 2. Cloud Computing Advantages and capabilities in EHR

(12, 20, 23, 31, 33). Data in the Electronic Health Record can include four categories: a) Clinical data; b) Insurance and financial data; c) Data about drug and usable for researchers; d) Patient behavior and emotional data (32), that to retrieve this information separately or in combination of these categories. The ability to search by defined methods are possible.

4.7. Reduction of errors and improvement of quality

The implementation of the electronic health record in the context of the cloud provides the right information at the right time and right place needed. Healthcare data stored in the cloud can be collected and reported as quality indicators of health care quality as reported by the AHRQ. (32, 41).

4.8. Structure

In the implementation of EHR, the layered structure has been designed to separate the different domains and pay attention for more details in each layer (11, 13, 22, 33). Separating tasks and performing specific areas on each layer make works on this system more specialized. For example, in a client layer, transaction and logical programs and human-machine transactions are performed, and in the other layer (server) the collection, storage, deletion, and eternity of the dataset occur (11). The hierarchical structure increases the possibility of security by controlling access and also the ability to develop the system and the possibility of scalability in this architecture will be facilitated by hierarchical structure (12).

4.9. Flexibility

An electronic health cloud should be able to use for different health care providers with different needs. This feature should be feasible for operations, users, auditing, management, and service quality. The cloud computing infrastructure should be flexible enough to be configured for different needs of healthcare providers. Also, electronic health supplements should be high flexible in adding new services needed to support health care processes. It should also be easily customizable to meet different needs, and this ability can be done with minimal effort and cost (12, 16, 26, 33, 41).

4.10. Exchange and sharing ability

In health information systems, exchanging and sharing data and information are essential and sensitive due to separated parts from each other (14, 22, 38). Sharing the electronic health record on the cloud and using the Internet has two big obstacles. To break these obstacles, two items should be prepared, as follows: a) Access to integrated EHR specification; b) Access to a centralized and secure collaboration infrastructure (24).

5. CONCLUSION

Considering the advantages and domains of cloud computing, such as cost, security and confidentiality, scalability, mutual performance and interoperability, implementation
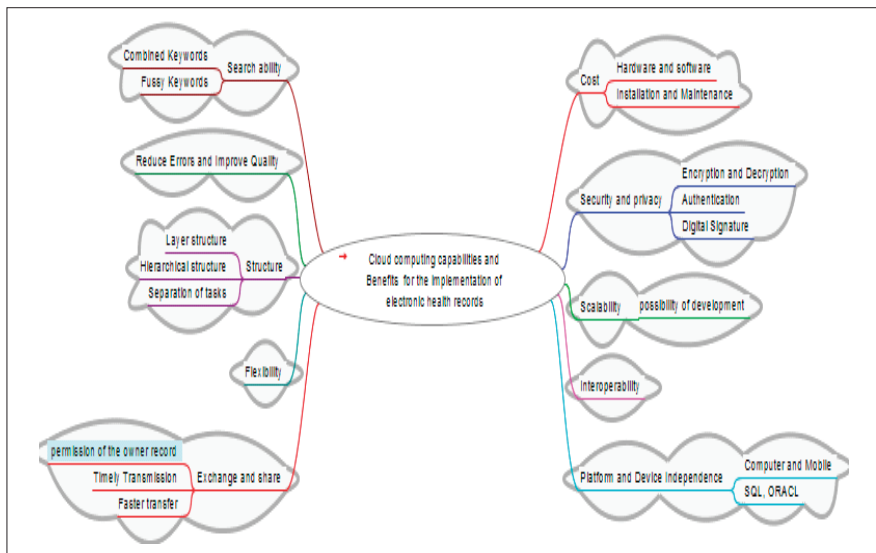

Figure 2. The main domains and subsets of the advantage and capabilities of cloud computing

platform and independence, search ability and exploration , reducing errors and improving the quality, structure, flexibility and sharing capabilities, in the implementation of EHR, it is recommended to use of it. One of the challenges of cloud computing is the lack of administrative support. In each setting, missing the public support will cause fear and doubt in the implementation of the work. The lack of skill, knowledge and expertise of users is another challenge for use of cloud computing. Staff training on new processes and tools, or recruitment of workers with new skills may be increasingly needed in this regard.

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