Deploying Cloud Computing to Implement Electronic Health Record in Indian Healthcare Settings

Article · August 2014

CITATIONS
13

READS
225

8 authors, including:

Ajit Kumar
Xavier Institute of Management, Bhubaneswar (XIMB)
52 PUBLICATIONS **173** CITATIONS
SEE PROFILE

Indrajit Bhattacharya
Quality Council of India, New Delhi, India
27 PUBLICATIONS **317** CITATIONS
SEE PROFILE

Jaijit Bhattacharya
Indian Institute of Technology Delhi
33 PUBLICATIONS **255** CITATIONS
SEE PROFILE

Anandhi Ramachandran
International Institute of Health Management Research, New Delhi
21 PUBLICATIONS **131** CITATIONS
SEE PROFILE

Scientific Online

OPEN JOURNAL OF MOBILE COMPUTING AND CLOUD COMPUTING
Volume 1, Number 1, August 2014

OPEN JOURNAL OF MOBILE COMPUTING AND CLOUD COMPUTING

Deploying Cloud Computing to Implement Electronic Health Record in Indian Healthcare Settings

Ajit Kumar[1]*, Indrajit Bhattacharya[2], Jaijit Bhattacharya[3], Anandhi Ramachandran[4], Sanjeev Maskara[5], Woon-Man Kung[6,7], Yao-Chin Wang[8,9], I-Jen Chiang[9,10]*

[1] *Institute of Cognitive Neuroscience, National Central University, Taoyuan, Taiwan*
[2] *Centre for Health Informatics of National Health Portal, National Institute of Health and Family Welfare, New Delhi, India*
[3] *Indian Institute of Technology, Delhi, India*
[4] *International Institute of Health Management Research, New Delhi, India*
[5] *The Practice PLC Amersham, Buckinghamshire, UK*
[6] *Department of Exercise and Health Promotion, College of Education, Chinese Culture University, Taipei, Taiwan*
[7] *Department of Neurosurgery, Lo-Hsu Foundation, Lotung Poh-Ai Hospital, Luodong, Yilan, Taiwan*
[8] *Department of Emergency, Taipei Hospital, Ministry of Health and Welfare, Taipei, Taiwan*
[9] *Graduate Institute of Biomedical Informatics, Taipei Medical University, Taipei, Taiwan*
[10] *Institute of Biomedical Engineering, National Taiwan University, Taipei, Taiwan*
*__Corresponding author__: ajitkumar@ncu.edu.tw; ijchaing@ntu.edu.tw

Abstract:

Background: In April 2013, Ministry of Health and Family Welfare (MoHFA) India released Electronic Health Record (EHR) standard to encourage electronic health information exchange among healthcare stakeholders. In addition, MoHFA expressed a need to find a suitable technology for EHR. Many technology solution providers have advocated cloud computing as a solution for realizing the EHR in India. Therefore, the aim of this study is to obtain insights into the desirability, feasibility, and concern to deploy cloud computing as a technology solution for EHR. **Methods:** A focus group discussion involving sixteen medical informatics experts was facilitated. The experts exchanged 76 emails using a group email address. The texts generated through emails were analyzed using grounded theory method. NVivo 10 was used for the coding of texts. **Results:** The textual analysis revealed three broad themes: (1) desirability to have superior attributes in cloud computing technology compared to the existing technologies; (2) concerns towards cloud computing to implement EHR; (3) solutions suggested in the current healthcare and ICT infrastructure of India. **Conclusions:** The results of this study suggest that the use of cloud computing for the EHR is likely to emerge in the future. However, given the current ICT infrastructure and healthcare system of India, several concerns were raised. Therefore, the superiority of cloud computing over other technologies needs to be assured, and stakeholder's concerns should be satisfactorily answered.

Keywords:
Electronic Health Record; Cloud Computing; Healthcare; Information and Communication Technology;

1. INTRODUCTION

Government of many countries including India has pushed healthcare stakeholders, such as doctors, hospitals, nurses, and insurance companies, to deploy various Information and Communication Technologies (ICT) for combating ever increasing healthcare cost and improving quality and accessibility of healthcare facilities [1–6]. ICT has shown tremendous success in banking, finance, insurance, telecommunication, aviation, and education. Likewise, ICT usage in the healthcare domain seems to be promising [7–11]. In recent years, many countries have deployed ICT to build a comprehensive electronic healthcare record for their citizen called Electronic Health Record (EHR). Many countries have gone even further by accepting EHR as the essential component of their country's healthcare system and wishing the maximum EHR adoption among stakeholders [3, 10, 12]. Some governments, like the USA, have offered incentives upon the EHR implementation and demonstration of its meaningful use. At the same time, the USA government has defined the regulations for paying penalties if the concerned stakeholders did not comply with the EHR regulatory guidelines. Therefore, the healthcare stakeholders have been left with no choices except adopting EHR and demonstrating its meaningful use [13]. The EHR can automate and streamline clinicians' workflow by integrating evidence-based medicine, decision support, quality management, and outcomes reporting [14–20]. The demographic details of patients, vital signs, problems, medications, past medical histories, immunizations, progress-notes, laboratory data, and radiology reports are some of the information included in the EHR [14]. Similar to other countries, the waves of EHR have reached India almost a decade ago; however, EHR implementation and meaningful use are still catching up [21–23]. The government of India has taken a number of initiatives to propose the standardization of healthcare information exchange that finally leads to building nationwide EHR. In 2003, Ministry of Communication and Information Technology, India recommended a framework for healthcare ICT infrastructure, including recommendations on guidelines, standards, and practices for Telemedicine. India has made a tremendous progress in Telemedicine [24, 25]. Furthermore, Ministry of Health and Family Welfare (MoHFW) sets up a task force in 2005 to look at the issues and standards related to EHR. In April 2013, MoHFW released EHR standard version 5 to encourage healthcare information exchange [26]. With the recommendation of EHR standard, the task force has expressed a necessity to find a suitable technology for EHR deployment amid an abundance of a variety of technologies. Besides Indian government initiatives, some private medical institutions have also slowly grasped the importance of EHR. However, they have mainly utilized the ICT for their administrative and fiscal revenue purposes [27]. In addition, healthcare stakeholders (Indian, as well as around the world) have raised several questions and concerns about choosing an appropriate ICT solution for their EHR from a plethora of available solutions, such as centralized, client-server, web-based, virtualized, and cloud computing [28].

We referred various medical and engineering literatures to understand healthcare stakeholders' questions or concern towards the available ICT solutions from the past to date. **Table 1** provides the summary of various ICT solutions available from 1960 to date. Column 1 of the table lists typical characteristics of different ICT systems, including hardware, platform, application, data storage, processing, communications network, logical layers, business, and economic model. Column 2 to 6 show chronological list of different ICT systems, including centralized, client-server, the Internet, virtualized, and cloud computing. The healthcare literature search reveals that healthcare stakeholders have deployed various technological solutions, such as centralized, client-server, the Internet, since the inception of information and communication technology [29].

As we can see in **Table 1**, in the early 1970s, the serious use of computers started using mainframe and time-shared computers to support healthcare by processing patients' information. In those systems, the

Table 1. Typical Characteristics of centralized, client-server, Internet, virtualized, and cloud computing.

Characteristics of the system	Computing system (Listed chronologically from left to right)				
	Centralized computing	**Client-server computing**	**Internet computing**	**Virtualized computing**	**Cloud computing**
Hardware	Mainframe	Personal computers; high performance computers	Personal computers; high performance computers	Personal computers; high performance computers	Infrastructure as a Service – personal computers, high performance computers
Platform	OS/360, OS/390, Z/OS	DOS, Unix, Linux, Windows server; Database server	Unix, Linux, Windows server; Internet Information Services server; Database server; Glassfish application server; Email Exchange Server	Unix, Linux, Windows server; Internet Information Services server; Database server; Glassfish application server; Email Exchange Server; VMware	Platform as a Service - Unix, Linux, Windows Server; Internet Information Services server; Database server; Glassfish application server; Email Exchange Server; VMware
Application	Applications run on the mainframe and an interface is made available to end-users	Applications generally run on thick clients personal computers	Web browser based applications that are downloaded as thin client and locally run on client personal computers	Runs on the server and the interface is made available to end-users	Software as a Service - runs on the server and the interface is made available to the end-user
Data storage	Data stored on the mainframe computer	Data stored on servers and accessed through client-server connectivity software	Data stored on the servers and accessed through thin client software or browser-based client software using personal computers	Data stored on the server and accessed through the browser or a thin client interface	Data stored on the server and accessed through the browser or thin client software
Processing	Minimal local processing	Process locally as well as at servers	Process locally (minimal preferred) as well as at servers	Minimal local processing	Minimal local processing is desired
Communications network	Personal network	Personal network	Internet, Virtual Private Network	Internet, Virtual Private Network	Internet, Virtual Private Network
Logical layers	One layer	Two layers	Multi-layers	Multi-layers with virtualization Layer	Multi-layers with virtualization layer
Business model	Organizations owns the system; high cost of the hardware and software	The organization owns the system; low cost of the hardware; perpetual license for operating systems and application software	Organizations own the system; low hardware cost; perpetual license for the operating system and application software	Organizations own the system; low hardware cost; perpetual license for the operating system and application software	Organizations rent the system – pay as you go and pay for what you use
Economic model	Optimized for efficiency due to the high cost	Optimized for agility due to low cost	Optimized for agility and efficiency	Optimized for agility and efficiency	Optimized for efficiency and agility due to increasing costs

healthcare records were centrally stored on mainframe computers [30]. Mainframe computers were very expensive to buy as well as maintain; therefore, few institutions could afford it. In 1980s, after the advent of low-cost minicomputers, healthcare stakeholders started using minicomputers to automate healthcare administrative processes, such as hospital and physician billing, commercial applications, and so on [30–32]. However, in the era of minicomputers, the medical records were stored in isolated silos, which were found to be an obstacle for the continuity of healthcare. To overcome the care continuity problem, some organizations developed standards and protocols to transmit health information within the institution.

Moreover, during the 1980s, the Internet began to grow in different corners of the world. National Science Foundation (NSF) USA was the pioneer to make the high-speed backbone network in the USA [30, 31]. The academic centers, including the medical establishment began to be connected to their backbone, and later this high-speed backbone network took a form of the Internet. After the introduction of World Wide Web, the rapid growth of the Internet took place in the late 1990s. Consequently, the records from silos of a single institution began to extend beyond institutions' boundary [30, 31]. The records beyond the particular institution have been identified, particularly useful for healthcare system; however, it requires interoperability of heterogeneous systems installed in medical institutions. The interoperability is possible if: (1) the records are stored based on the same standard; and (2) different healthcare applications are capable of retrieving it. Various ICT solutions have been proposed to achieve the goal of interoperability; however, the current scenario seems to be very confusing because, at every occasion, technology vendors come up with a new ICT solution and claim it to be superior to others [33].

Recently, IT vendors have offered the cloud computing solution for supporting healthcare. Cloud computing uses the Internet and remotely located centralized servers to support healthcare applications and databases. The cloud computing is built on the top of virtualized computing that makes servers, workstations, storage and other systems independent of the physical hardware by installing a Hypervisor on top of the hardware layer. The users can use healthcare applications without their installation and can access their data anywhere, at any time with mere access to the Internet and thin client software. Cloud computing allows a central and efficient management of storage, processing, memory, and bandwidth devices [34, 35]. EHR on cloud computing seems to address many healthcare challenges by maintaining a person's lifelong data to a centralized location with health information exchange capabilities [22, 36]. This approach might enable healthcare providers to manage patient records from any computer with access to the Internet [22, 37, 38].

In essence, cloud computing has created a hype among healthcare stakeholders, including hospitals, doctors, governments, and health insurance companies; therefore, cloud solution providers have upheld cloud computing as a promising solution for the healthcare [39]. However, little success of ICT in healthcare and vendors' marketing strategies (selling old wine into new bottles and labels) has created a room of permanent doubt among healthcare stakeholders for any new technological solution. In addition, as the cloud model depends on concepts of pooling, sharing, and outsourcing of hardware, software, and communication channel, the posting of EHR on a cloud platform further raises several dilemmas and concerns among stakeholders, such as legal, ethical, financial, security, privacy, security, and data ownership [33, 36, 40–47]. A need to assess cloud computing is felt prior to its deployment for EHR in Indian healthcare settings [36, 38, 45, 48–52]. Therefore, we conducted a study to obtain insights into the desirability, feasibility, and concerns to deploy cloud computing as a technological solution for EHR in Indian healthcare settings.

2. METHODS

This study was a qualitative study using a focus group discussion. In the focus group study design, the discussion is usually unstructured, open question, and answer style. The unstructured approach generates a sizeable deal of text, which is useful for studies to gain insights into the feasibility, desirability, and concerns about any new product or service [53]. As we intended to get insights into the possibility of deploying cloud computing in EHR; therefore, we chose to carry out this study using a focus group.

2.1 Participants

An expert group was selected, which consisted of 16 medical informaticians. Educational qualification, healthcare ICT experience, and designation were the main criteria to choose 16 medical informaticians. Out of 16 experts, four had a history of computer science education, whereas twelve had the background of medical science. They worked in different roles, such as a professor, director, chief executive officer, consultants, managing director, and healthcare researchers. In general, they had average 21.5+10 years of total work experience, and in particular; they had average 8± 5.5 years of healthcare ICT experience. The experts resided in different places of India and knew each other through the discussion forum only.

2.2 Data Gathering

We used a group email to facilitate the discussion. The topic of the discussion was centered on finding experts' expectations or concern pertaining to the deployment of cloud computing in EHR at the various hospitals and clinics in India. The group discussion was moderated to keep it aligned with the goal of the research. In addition, some questions were posed from time to time, in case, any significant aspect was thought to be missing. The group discussed the topics for a period of one month starting from 17 May to 5 June 2012. The views of the expert group were expressed through the exchange of 76 emails. The total number of word count, in those emails, was 10, 653 words.

2.3 Data Analysis

This study involves analysis of unstructured data, and NVivo is wonderful qualitative data analysis software [54, 55]. This tool is suitable for classifying, sorting, and arranging information. In addition, it can assist to analyze study materials, identify themes, glean insight, and develop meaningful, evidence-based conclusions. Therefore, we used NVivo tool to analyze the email-generated text. We converted all emails into the PDF files using a utility called NCapture that comes along with NVivo tool. We imported the text and analyzed it to find themes and sub-themes. The text was coded using grounded theory approach. Two independent researchers were asked to verify the accuracy of coding. A few minor modifications were made in coding based upon the advice of the independent researchers. The analysis of the coded text revealed three broad themes. A further analysis of these three themes revealed four, five, and three sub-themes respectively. The themes and sub-themes are shown in **Table 2**, in the Result section. In addition, we calculated the frequency of each sub-theme. Moreover, we tried to view the results from another perspective and framework as shown in **Figure 1**, in the Result section.

3. RESULTS

Table 2 shows the themes and sub-themes identified from the analysis. In addition, frequency shows the total number of experts, who expressed their desirability or concern towards sub-themes.

Table 2, which contains themes and sub-themes, can be summarized and seen from another perspective as illustrated in **Figure 1**. As shown in **Figure 1** that desirability, concern, and suggested solution can be

Table 2. Themes and Sub-themes

Serial number	Theme	Sub-theme	Frequency
1	Desirability to have superior attributes in cloud computing technology compared to be other existing technologies	Interface design	15
		Security	8
		Affordability	7
		Data management	6
2	Concerns towards cloud application deployment of EHR in Indian healthcare settings	Information and Communication Technology infrastructure of India	9
		Proof of cloud concept	7
		Customized report generation	5
		Readiness of Indian healthcare	5
		Trust building among the healthcare stakeholders	5
3	Solutions suggested at the given healthcare and ICT infrastructure of India	Hybrid computing	8
		Cloud computing	4
		Client server computing	4

respectively seen as enablers, barriers, and a balancing point at given healthcare and ICT infrastructure of India.

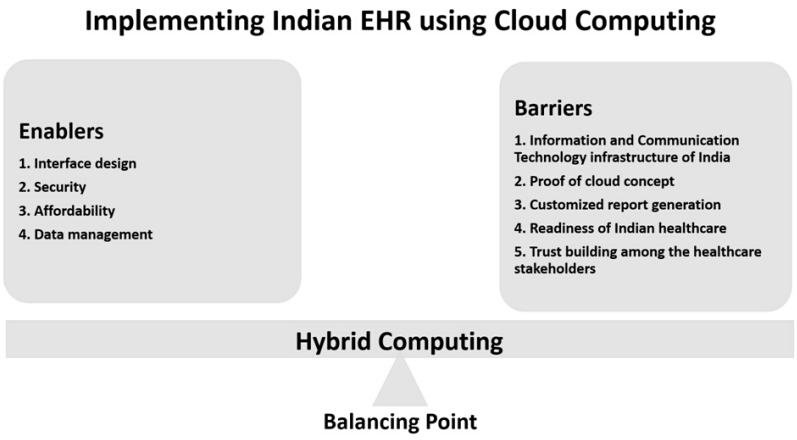

Figure 1. Enablers, barriers, and a balancing point for Indian EHR on cloud computing.

4. DISCUSSION

As shown in **Table 2** and **Figure 1**, this study derived three principal results: (1) desirability (or enablers) to have superior attributes in cloud computing based application compared to the existing technologies (2) concerns (barriers) towards the deployment of cloud technology for EHR and related applications in Indian healthcare settings (3) solutions suggested (a balancing point) at the given healthcare and ICT infrastructure. The results are further discussed as below.

4.1 Desirability to Have Superior Attributes in Cloud Computing Technology Compared to be Other Existing Technologies

The cloud computing might be worth deploying in India provided it proves to be a better solution than other available technologies in terms of usability, security, affordability and data management. As shown in **Table 2**, the experts believe that the features such as user experience, security, affordability and data managements are of paramount importance.

a) User experience

The user experience was found to be the most desired attribute category for healthcare applications, which might be due to past bitter experiences of healthcare ICT. As a user experience plays a vital role in the success, as well as the failure of healthcare ICT systems, it has been a hot topic of discussion in recent years at various national and international forums [56, 57].

b) Security

The provision of security was expressed as the second most desired attribute category. The expert group had serious concerns about security because stakeholder' EHR would exist at the cloud service provider's end; users would not own anything at their end. In addition, the cloud vendors would share their cloud site, with many users; therefore, natural security concern arises [58, 59].

c) Affordability

The affordability of EHR and related cloud applications was the third most discussed aspects. The experts were convinced about the cost advantage of cloud computing because consumers are not compulsorily required to purchase the hardware and software. Moreover, the end-user hardware and software requirement is minimal in the cloud framework [60].

d) Data management

The experts expressed to have some facilities provided by cloud applications that might keep the data separate to enable multiple database instances, one instance per each client, and so on. A provision of data encryption/decryption was also highly desired in a cloud computing environment. The experts suggested the Secure Sockets Layer (SSL) access configuration for cloud applications because, to their opinion, most of the data theft occurs during the transaction of data. Similar concern can be seen in MoHFW released EHR standard (version 5 in April 2013), which says that transmitting patient data electronically have a potential to increase patient risks. Therefore, data accessibility, reliability, and accuracy are critical success factors in obtaining the trust of stakeholders and for sustaining long-term data exchange on a large scale.

4.2 Concerns Towards Cloud Application's Deployment of EHR in Indian Healthcare Settings

The result of this study has highlighted some fundamental concerns of healthcare stakeholders if they wish to deploy cloud computing as a technology solution for EHR.

a) Information and Communication Technology infrastructure of India

The medical applications heavily rely on imaging data. The image transmission is a highly desirable

property in order to share electronic health record. The experts discussed the current Internet infrastructure in India, including the high-bandwidth requirement for image data and potential solutions to cut this high-bandwidth requirement. The expert group wished if cloud computing based application could provide some solutions that might solve the high-bandwidth requirements of image data. A few experts suggested some solutions, such as the use of Asynchronous JavaScript and XML (AJAX) that would facilitate minimum posting to the server, thereby would cut down the need for frequent refreshment and high Internet bandwidth.

b) Proof of cloud concept

The cloud computing is a relatively new concept. Only a few working examples exist in the Indian healthcare settings. India is still far behind from the minimally required cloud based infrastructure for EHR. The experts also raised sincere concerns over skill set's availability, support, coding, and operation of the cloud technology. The experts also wanted some proof of the cloud concept in terms of usability, responsiveness, efficiency, performance, and personalization if we wish to deploy cloud computing to implement EHR.

c) Customized report generation

The healthcare system is overly complex. Each patient, doctor, hospital is unique. Standardization of healthcare is undoubtedly required, but the importance of personalization, such as personalized reporting, cannot be ignored too. The expert group had reservations on the capability of cloud-based application that they could produce personalized reports because the cloud applications are primarily developed within the purview of general usage.

d) Readiness of Indian healthcare

Some experts believed that Indian healthcare is still churning up 1980's client-server based computing applications, and healthcare ICT in India has a long way to go before adopting a cloud computing.

e) Trust building among the healthcare stakeholders

Some experts raised a few concerns regarding subscription policy, hidden costs, and long-run cost because they have some unpleasant prior experience from other industries, such as telecommunication, banking, and insurance. In addition, there are no laws in India that can control the cloud computing deployment for EHR. India does not have regulations such as the Health Insurance Portability and Accountability Act (HIPAA) in the USA. ICT Act is the only law in India that governs ICT related matters, which is not abundant for governing EHR.

4.3 Suggested Solutions at the Given Healthcare and ICT Infrastructure

Expert group discussed quite a lot about the possible ICT solution to implement EHR at the given ICT infrastructure of India. In essence, it seemed that experts have ideally been in favor of cloud computing due to its remarkable features. However, they considered cloud computing in Indian healthcare contexts in a more pragmatic and holistic point of view. Therefore, they discussed various cloud computing models, including hybrid computing, cloud, and client server computing, to find if any cloud computing variant might be suitable in Indian healthcare settings.

a) Hybrid computing

The experts recommended that a hybrid model, somewhere between client-server and cloud, might

work in a given healthcare ICT condition in India. In the hybrid model, the remote installed applications would have a local copy of everything including the database. As the database would be locally stored, the users would feel more security and peace in their mind. The response of the hybrid model based ICT system would be fabulous. The system would be up-to-date because of the connection to the remote application and the data server. The data could be downloaded to the local computer based on availability, not based on demand. The updates and fixes would transparently occur in the background. The downtime of the server or slower Internet may not cause that many problems. The application would work well, save everything on the local machine and synchronize with the server when the connection is up. However, the expert group had some reservations on the hybrid cloud computing model from a financial viability perspective.

b) Cloud computing

Some experts felt an intense need for cloud computing. They argued that, in the past, ICT adoption by healthcare stakeholders has been not very encouraging because of inherent healthcare domain complexity. In fact, healthcare is considered as a complex adaptive system, which is nonlinear, dynamic, and composed of independent and intelligent agents with no single point of control [61]. To their opinion, the earlier ICT solutions could not cater the need of healthcare stakeholders. Now, cloud computing has come as a new solution, and other industries are happily deploying it. Some experts strongly argued to deploy cloud computing because, in their opinion, we already had been unsuccessful with the older computing technologies, and cloud computing is next available option.

c) Client-server computing

Some experts argued that the client-server computing based applications are the boon to handle healthcare complexity. According to him or her, healthcare is overly complex, and each patient, doctor, or hospital is unique. However, the cloud computing advocates the standardization of applications so that it can be installed and used by many. The standard is needed; however, we cannot ignore the importance of personalization in medical settings. For example, personalized reporting is an essential characteristic of healthcare application, and some expert had reservations that a cloud-based application might support personalized reports. In addition, currently, the use of ICT in the Indian healthcare system is more centered to billing-admission-revenue generation than the clinical use. EHR captures patients' record mainly for clinical purposes and for later use. Therefore, some of the experts did not feel even a necessity of EHR.

4.4 Limitation and Future Studies

We conducted only one focus group discussion involving 16 participants. This study was found to be quite useful to obtain insights into the feasibility, desirability, and concerns about the cloud computing deployment for EHR; however, the obtained results might not be that representative at the country level. The cloud computing deployment for EHR in Indian healthcare settings is a tremendously vast topic that involves a large number of dimensions, stakeholders, and sub-settings. One discussion cannot capture and explain the variability arising from different dimensions, stakeholders, and a variety of settings. Multiple group discussions, interviews, and direct observations might provide better insights into this topic.

5. CONCLUSIONS

In summary, this paper is the first step towards obtaining insights into the feasibility, desirability, and concerns to deploy cloud computing as a technology solution for EHR. The findings suggest that the use of cloud computing in EHR might be a possibility provided superiority of cloud computing is assured, and stakeholders' concerns are satisfactorily answered. To date, Indian healthcare has deployed mostly 1980's client-server technology for administrative and financial purposes. The uses of technology, such as cloud computing, for clinical purposes, are immediately available opportunities. However, the idea of leapfrogging from client-server to cloud computing has raised several questions pertaining to usability, security, affordability, and data-management capability. This study found that the healthcare stakeholders are concerned about full-fledged cloud computing deployment in the Indian healthcare given the current Internet bandwidth and power-supply facility in India. Rather, this study suggests going for a hybrid model – a mix of cloud and client-server computing.

6. COMPETING INTERESTS

The authors hereby declare that there were no competing interests.

ACKNOWLEDGMENTS

We are thankful to sixteen experts for their active participation and valuable inputs for this study. Special thanks to two anonymous reviewers whose comments were highly helpful in improving the paper.

References

[1] M. Malach and W. J. Baumol, "Opportunities for Cost Reduction of Medical Care: Part 3," *Journal of Community Health*, vol. 37, no. 4, pp. 888–896, 2012.

[2] E. Coiera, J. Aarts, and C. Kulikowski, "The dangerous decade," *Journal of the American Medical Informatics Association*, vol. 19, no. 1, pp. 2–5, 2012.

[3] A. Robertson, K. Cresswell, A. Takian, D. Petrakaki, S. Crowe, T. Cornford, N. Barber, A. Avery, B. Fernando, A. Jacklin, *et al.*, "Implementation and adoption of nationwide electronic health records in secondary care in England: qualitative analysis of interim results from a prospective national evaluation," *BMJ*, vol. 341, p. 4564, 2010.

[4] C. A. McGinn, M.-P. Gagnon, N. Shaw, C. Sicotte, L. Mathieu, Y. Leduc, S. Grenier, J. Duplantie, A. B. Abdeljelil, and F. Légaré, "Users perspectives of key factors to implementing electronic health records in Canada: a Delphi study," *BMC Med Inform Decis Mak*, vol. 12, no. 1, p. 105, 2012.

[5] I. Zejdlova, "Strategy to Support Improvement of Healthcare Quality," *Online Journal of Health and Allied Sciences*, vol. 11, no. 4, 2013.

[6] W. I. Yao-Chin, J. Bhattacharya, A. Ramachandran, S. Maskara, W.-M. Kung, I.-J. Chaing, and A. Kumar, "Usage of Cloud Technologies to Implement Electronic Health Record," in *The Second International Conference on Computing, Measurement, Control and Sensor Network*, 2014.

[7] E. H. Shortliffe and J. J. Cimino, *Biomedical Informatics Computer Applications in Health Care and Biomedicine*. Springer Science+Business Media, LLC, 2006.

[8] C. M. Christensen, R. Bohmer, and J. Kenagy, "Will disruptive innovations cure health care?," *Harv Bus Rev.*, vol. 78, no. 5, pp. 102–112, 99, 2000.

[9] Y. M. Chae, "Management issues in healthcare information technology," *Healthc Inform Res*, vol. 18, no. 2, pp. 85–87, 2012.

[10] A. K. Jha, D. Doolan, D. Grandt, T. Scott, and D. W. Bates, "The use of health information technology in seven nations," *International Journal of Medical Informatics*, vol. 77, no. 12, pp. 848–854, 2008.

[11] M. C. Christensen and D. Remler, "Information and Communications Technology in U.S. Health Care: Why Is Adoption So Slow and Is Slower Better?," *Journal of Health Politics, Policy and Law*, vol. 34, no. 6, pp. 1011–1034, 2009.

[12] B. Piotti and E. Macome, "Public healthcare in Mozambique: Strategic issues in the ICT development during managerial changes and public reforms," *International Journal of Medical iInformatics*, vol. 76, pp. S184–S195, 2007.

[13] F. Turner, "Use HITECH as directed: healthcare practitioners who want to take advantage of funds made available by ARRA must focus on the transition to EHR technology now," *Health Management Technology*, vol. 32, no. 10, pp. 24–25, 2011.

[14] M. Ramaiah, E. Subrahmanian, R. D. Sriram, and B. B. Lide, "Workflow and electronic health records in small medical practices,"

[15] R. C. Geibert, "Using diffusion of innovation concepts to enhance implementation of an electronic health record to support evidence-based practice," *Nurs Adm Q*, vol. 30, no. 3, pp. 203–210, 2006.

[16] J. A. Linder, J. L. Schnipper, and B. Middleton, "Method of electronic health record documentation and quality of primary care," *Journal of the American Medical Informatics Association*, vol. 19, no. 6, pp. 1019–1024, 2012.

[17] A. Jain and S. Hayden, "Using electronic health records to collect patient-specific performance measures and outcomes," in *AMIA... Annual Symposium proceedings/AMIA Symposium. AMIA Symposium*, pp. 1242–1243, 2007.

[18] J. A. Handler and J. G. Adams, "In response to: Method of electronic health record documentation and quality of primary care," *Journal of the American Medical Informatics Association*, 2012.

[19] P. Rosen, S. J. Spalding, M. J. Hannon, R. M. Boudreau, and C. K. Kwoh, "Parent satisfaction with the electronic medical record in an academic pediatric rheumatology practice," *Journal of Medical Internet Research*, vol. 13, no. 2, p. 40, 2011.

[20] A. Esquivel, D. F. Sittig, D. R. Murphy, and H. Singh, "Improving the Effectiveness of Electronic Health Record-Based Referral Processes," *BMC Medical Informatics and Decision Making*, vol. 12, no. 1, p. 107, 2012.

[21] S. P. Sood, S. N. Nwabueze, V. W. A. Mbarika, N. Prakash, S. Chatterjee, P. Ray, and S. Mishra, "Electronic Medical Records: A Review Comparing the Challenges in Developed and Developing Countries," in *Hawaii International Conference on System Sciences, Proceedings of the 41st Annual*, p. 248, IEEE, 2008.

[22] J. Haughton, "Look up: the right EHR may be in the cloud. Major advantages include interoperability and flexibility," *Health Management Technology*, vol. 32, no. 2, pp. 52–52, 2011.

[23] I. Bhattacharya, A. Ramachandran, and B. Jha, "Healthcare Analytics on the Cloud," *Online Journal of Health and Allied Sciences*, vol. 11, no. 1, 2012.

[24] D. Mohandass and J. Janet, "A Segmentation based Retrieval of Medical MRI Images in Telemedicine," *Journal of Scientific & Industrial Research*, vol. 72, no. 2, pp. 107–113, 2013.

[25] V. T. Bai and S. Srivatsa, "Design and implementation of mobile telecardiac system," *Journal of Scientific & Industrial Research*, vol. 67, pp. 1059–63, 2008.

[26] GOI, "Recommendations on Electronic Medical Records Standards in India," *MOHFW*, 2013.
[27] C. ZM, "Cloud Computing: An enabler of IT in Indian Healthcare Sector," 2010.
[28] B. Cesnik and M. R. Kidd, "History of health informatics: a global perspective," *Stud Health Technol Inform*, vol. 151, pp. 3–8, 2010.
[29] M. F. Collen, "Fifty years in medical informatics," *Yearb Med Inform*, vol. 45, pp. 174–179, 2006.
[30] E. H. Shortliffe, "Strategic action in health information technology: why the obvious has taken so long," *Health Affairs*, vol. 24, no. 5, pp. 1222–1233, 2005.
[31] E. H. Shortliffe and J. J. Cimino, *Biomedical informatics*. Springer, 2006.
[32] E. S. Berner, D. E. Detmer, and D. Simborg, "Will the wave finally break? A brief view of the adoption of electronic medical records in the United States," *Journal of the American Medical Informatics Association*, vol. 12, no. 1, pp. 3–7, 2005.
[33] "Technical and architectural issues in deploying electronic health records (EHRs) over the WWW," *Studies in Health Technology and Informatics*, vol. 143, pp. 93–98, 2009.
[34] R. Buyya, C. S. Yeo, S. Venugopal, J. Broberg, and I. Brandic, "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility," *Future Generation Computer Systems*, vol. 25, no. 6, pp. 599–616, 2009.
[35] P. Koch, "Benefits of cloud computing for PACS and archiving," *Radiology Management*, vol. 34, no. 2, pp. 16–9, 2011.
[36] S. P. Ahuja, S. Mani, and J. Zambrano, "A Survey of the State of Cloud Computing in Healthcare," *Network and Communication Technologies*, vol. 1, no. 2, p. p12, 2012.
[37] M. Poulymenopoulou, F. Malamateniou, and G. Vassilacopoulos, "E-EPR: A cloud-based architecture of an electronic emergency patient record," in *Proceedings of the 4th International Conference on PErvasive Technologies Related to Assistive Environments*, p. 35, ACM, 2011.
[38] M. Poulymenopoulou, F. Malamateniou, and G. Vassilacopoulos, "An access control framework for pervasive mobile healthcare systems utilizing cloud services," in *Wireless Mobile Communication and Healthcare*, pp. 380–385, Springer, 2012.
[39] J. Pechette, "Transforming health care through cloud computing," *Health Care Law Monthly*, vol. 2012, no. 5, pp. 2–12, 2012.
[40] E. J. Schweitzer, "Reconciliation of the cloud computing model with US federal electronic health record regulations," *Journal of the American Medical Informatics Association*, vol. 19, no. 2, pp. 161–165, 2012.
[41] J. DeGaspari, "Staying on your feet," *Healthcare Informatics*, vol. 28, no. 10, pp. 16–8, 2011.
[42] J. Conn, "Still at ground level. Security concerns hinder move into cloud services," *Modern Healthcare*, vol. 41, no. 32, pp. 32–33, 2011.
[43] K. Bennett, A. J. Bennett, and K. M. Griffiths, "Security considerations for e-mental health interventions," *Journal of Medical Internet Research*, vol. 12, no. 5, p. 61, 2010.
[44] G. Kelly and B. McKenzie, "Security, privacy, and confidentiality issues on the Internet," *Journal of Medical Internet Research*, vol. 4, no. 2, p. 12, 2002.
[45] P. K. Bollineni and K. Neupane, "Implications for adopting cloud computing in e-Health," 2011.
[46] D. F. Sittig and H. Singh, "Legal, ethical, and financial dilemmas in electronic health record adoption and use," *Pediatrics*, vol. 127, no. 4, pp. e1042–e1047, 2011.
[47] Y.-Y. Chen, J.-C. Lu, and J.-K. Jan, "A Secure EHR System Based on Hybrid Clouds," *Journal of Medical Systems*, vol. 36, no. 5, pp. 3375–3384, 2012.
[48] M. L. Braunstein, *Health Informatics in the Cloud*. Springer, 2012.
[49] Y. S. Shew, *Assessing malaysian healthcare professionals perception and intention in utilizing cloud computing medical record*. PhD thesis, UTAR, 2012.
[50] I. K. Azeemi, M. Lewis, and T. Tryfonas, "Migrating To The Cloud: Lessons And Limitations Of

Traditional IS Success Models," *Procedia Computer Science*, vol. 16, pp. 737–746, 2013.

[51] C. Pino and R. D. Salvo, "A Survey of Cloud Computing Architecture and Applications in Health," in *Proceedings of the 2nd International Conference on Computer Science and Electronics Engineering*, Atlantis Press, 2013.

[52] N. Kshetri, "Cloud Computing in Developing Economies: Drivers, Effects, and Policy Measures," *Computer*, vol. 43, no. 10, pp. 47–55, 2010.

[53] G. Marczyk, D. DeMatteo, and D. Festinger, "Essentials of research design and methodology.," 2005.

[54] P. Bazeley and K. Jackson, *Qualitative data analysis with NVivo*. Sage Publications Limited, 2013.

[55] E. Welsh, "Dealing with data: Using NVivo in the qualitative data analysis process," in *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, vol. 3, 2002.

[56] W. Albert and T. Tullis, *Measuring the user experience: collecting, analyzing, and presenting usability metrics*. Newnes, 2013.

[57] E. Karapanos, "User experience over time," in *Modeling Users' Experiences with Interactive Systems*, pp. 57–83, Springer, 2013.

[58] D. Zissis and D. Lekkas, "Addressing cloud computing security issues," *Future Generation Computer Systems*, vol. 28, no. 3, pp. 583–592, 2012.

[59] R. Zhang and L. Liu, "Security models and requirements for healthcare application clouds," in *Cloud Computing (CLOUD), 2010 IEEE 3rd International Conference on*, pp. 268–275, IEEE, 2010.

[60] G. B. Berriman, E. Deelman, G. Juve, M. Rynge, and J.-S. Vöckler, "The application of cloud computing to scientific workflows: a study of cost and performance," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, vol. 371, no. 1983, p. 20120066, 2013.

[61] "Health care as a complex adaptive system: implications for design and management," *Bridge-washington-national Academy of Engineering*, vol. 38, no. 1, p. 17, 2008.