THE IMPACT OF CLOUD COMPUTING ON THE TRANSFORMATION OF HEALTHCARE SYSTEM IN SOUTH AFRICA

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ABSTRACT

An increasing number of organisations around the world are making use of information and communications technology (ICT) for health (eHealth) to address healthcare challenges. This includes aggregating vast amounts of data from various sources to create evidence for policy and decision making. However, the eHealth initiative in South Africa is hindered by unreliable ICT platforms. This research study is designed to leverage eHealth and propose a conceptual cloud computing model to improve healthcare service delivery. The aim of this research study is to instigate new collaborative efforts for the creation of evidence value-based healthcare system. The findings attest that the sensitive nature of clinical data remains a challenge. Similarly, the South African government should resolve concerns on regulatory frameworks for proper governance of eHealth standards implementation, whilst accelerating healthcare improvements within the public health sector in particular.

Keywords— Information and communications technology, Cloud computing, Healthcare

1. INTRODUCTION

The following citation from the Department of Health (DoH) puts matters into perspective concerning healthcare system effectiveness in South Africa [6]: *"Although large sums of money have been used to procure health Information and Communications Technology (ICT) and Health Information Systems (HIS) in South Africa in the past, the ICT and HIS within the public health system is not meeting the requirements to support the business processes of the health system thus rendering the healthcare system incapable of adequately producing data and information for proactive management and for monitoring and evaluating the performance of the national health system. This results from the lack of an overarching technology policy framework and supporting regulations to inform ICT procurement and management processes"*.

Porter and Guth [18] also make similar observations in relation to the efforts to reform the German healthcare system by contending that, *"the future demographic shifts and innovations in medical technology threaten to further accelerate spending and destabilise the system"*. According to [18], nearly every government is now asking *"how can we design a healthcare system that produces better value for the money we spend"*.

Based on these observations by [18] in relation to the healthcare system reform in Germany, it could be argued that the healthcare system challenges are not confined only within the boundaries of the developing world. These interpretations of evidence also hold true as reiterated by [16] relative to the healthcare system reform in the United States (U.S.) in that: "*Despite many waves of debate and piecemeal reforms, the U.S. health care system remains largely the same as it was decades ago. We have seen no convincing approach to changing the unsustainable trajectory of the system, much less to offsetting the rising costs of an aging population and new medical advances"*.

As noted by [12], an inability to communicate and the lack of information technology (IT) standards undermine the ability of IT to enable value measurement and to restructure care delivery around the integrated care for medical conditions. These revelations conform to Porter's [17] strong belief that the fundamental issue in healthcare is not necessarily access, volume, convenience or cost estimation; but the value for patients.

2. NATIONAL E-HEALTH STRATEGY

The World Health Organisation defines eHealth as the use of ICT for health to treat patients, conduct research, and educate the health workforce, track diseases and monitor public health related activities [28].

The DoH alludes that this short definition of eHealth covers vast domains, which includes Electronic Health Records (EHRs) for sharing of patient data at the points of care [5]. It is worth mentioning that the South African Medical Research Council is at the centre of developments for eHealth to deliver on its new role as a World Health Organisation collaborating centre for the Family of International Classifications [25]. In addition, the Technical Advisory Committee of the National Health Council is responsible to provide technical oversight required to ensure proper implementation of eHealth strategy [5].

These initiatives in South Africa are in agreement with the fifty-eighth World Health Assembly resolution adopted in 2005, established an eHealth strategy for World Health Organisation member states. In a similar viewpoint, the DoH adopted an eHealth strategy for South Africa to lay solid requisite foundations for future integration and coordination of eHealth initiatives in the country [5]. It was noted that the implementation of the National Health Insurance (NHI) was intended to provide universal coverage through eHealth initiatives [8].

Basically, the DoH has embarked on strategies aimed at the primary prevention of non-communicable and chronic diseases through educating individuals, households and communities on the benefits of healthy lifestyles [6]. The programme involves the utilisation of community health workers through a re-engineered and integrated Primary Health Care system. This is a collective effort, which involves other departments such as the Department of Social Development as well as the Department of Trade and Industry [7]. These programmes started after 1994, whereby the information systems of the public health sector were overhauled to support the new Primary Health Care approach aimed at changing the South African healthcare landscape. These initiatives were later endorsed in the national parliament in 1997, by then, the Minister of Health Dr. N.C. Dlamini Zuma, in the newly democratic South African government of Dr. Nelson Mandela [4].

The NHI then becomes an integral part of a regenerated initiative underpinned by Primary Health Care in changing the face of care service delivery in South Africa [8]. This initiative is based on a R300 billion NHI project, regarded as one of the most complex and multi-disciplinary in nature ever undertaken by the South African Department of Health [22]. The suggestion by the South African National AIDS Council (SANAC) is that the South African government should increase the funding of public health services closer to 5% of GDP [26].

The importance of ICT towards the implementation of the NHI cannot be overemphasised. In a report, "The National Strategic Plan 2012/16 on Human Immunodeficiency Virus (HIV), and Tuberculosis (TB)", SANAC states that, *"The primary focus of Strategic Objective 3 (SO 3) is to achieve significant reduction in deaths and disability as a result of HIV and TB"*.

Through the adoption of eHealth strategy, ICT remains a critical enabling factor to achieve the universal access to affordable and good quality health outcomes, diagnosis, treatment and care, as an essential part of the SANAC's Strategic Objective 3 [26]. It is not surprising for the DoH to accentuate that globally, ICT has emerged as a critical enabling mechanism to develop a HIS, capable of strengthening healthcare system effectiveness [5]. Enthoven and Tollen [1] are also in agreement that the evidence based healthcare system can be supported by the state-of-the-art IT platforms. However, [12] contend that although IT can enable a new value-based approach to care delivery and measurement; it alone cannot fix a broken healthcare system.

As argued by [17] on the basis that part of the six fundamentals strategic agendas to reform healthcare delivery is to "Create an Enabling IT Platform". Correspondingly, [12] agrees with [17] and attests that the organisations should utilise IT to enable restructuring of care delivery and measuring results rather than treating it as a solution itself. Notable in this regard, [10] similarly conclude that cloud computing technologies provide a promising approach to address the IT needs of integrated care delivery structures in the future.

Furthermore, [2] quite pertinently states that cloud computing will greatly impact the organisations that are involved in a vast array of IT equipment, software, support, and services. As illustrated in figure 1, it is important to note that the healthcare service quality, accessibility, reliability and affordability should be sustainable throughout the care cycle of the healthcare system [17].

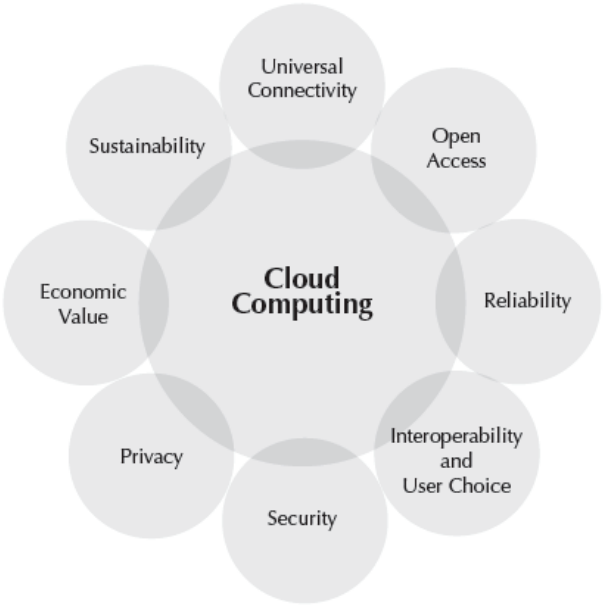

Figure 1. The 8 fundamental elements of cloud computing [2].

These noteworthy revelations are also supported by [9] due to the fact that cloud computing enables platforms of collaboration combined with rich abilities of communications and coordination. This includes opening up new and significantly more efficient business models. Frank and Moore [9] make an observation that cloud computing adoption models have a velocity, which has not been witnessed in technology space before. The emergence of cloud computing is observed as driving the need for better collaboration, coordination and interaction in the health sector [10].

3. OBJECTIVES OF THE STUDY

Preliminary investigations suggest that the healthcare system is not meeting the requirements to harness the vast amount of data to address multiple healthcare challenges in South Africa. As cloud computing looks set to scale up EHRs globally, in South Africa it is hindered by persistent reliance on using unreliable ICT platforms.

To achieve a collaborative and coordinated care that harnesses clinical data sharing, South Africa should find a proper balance between protecting personal health data from misuse and sharing data to accelerate healthcare improvements. This includes resolving concerns on regulatory frameworks for proper governance of eHealth standards implementation, whilst creating evidence value-based healthcare system.

The following list of formulated questions gives more insight into the problem statement:

a) What is cloud computing's real potential in the health sector?
b) How has the evolution of healthcare ICT infrastructure changed the nature of healthcare service delivery in South Africa compare to other developing countries?
c) What primary factors are inhibiting the use of cloud computing services within the South African healthcare environment?
d) What opportunities does cloud computing present to health sector for IT managers, and individuals?
e) What are the primary concerns for healthcare IT executives have about implementing emerging IT platforms especially one that may not be entirely familiar with including cloud computing solutions?
f) What are the challenges associated with acquiring and implementing large software applications, such as Electronic Medical Records (EMRs) and EHRs?
g) What are the main challenges facing the successful adoption and implementation of the national eHealth strategy within the healthcare environment in South Africa?
h) How has the lack of collaboration, coordination and interaction affected the implementation and adoption of the state-of-the-art ICT solutions within the healthcare environment in South Africa?

In order to address the research problem appropriately, the primary objective of the study is to identify key factors that are hindering the transformation of the healthcare system in South Africa. The objectives also take into account the new collaborative efforts for the creation of evidence value-based healthcare system. A key focus of a cloud-based open source computing platform is facilitating the flow of data from disparate sources into the clinical care process.

This will ensure that optimal treatments are offered to each individual patient at the point of care. Advances in cloud computing are starting to facilitate the development of platforms for effective data capture, creation, storage, search, sharing, modelling, transfer, analysis, visualisation, and manipulation of massive data.

4. CLOUD COMPUTING ADOPTION IN HEALTHCARE

The emergence of cloud computing in healthcare is increasingly gaining acceptance as an effective means of improving healthcare service delivery globally. According to [19], healthcare organisations are rapidly adopting cloud computing to enhance competitiveness within the health sector in China. This is part of the national health reform plan in line with the "Healthy China 2020" vision. Shen, Keskin and Yang [29] concur that cloud computing is being developed everywhere in China to different extents.

Bojanova and Samba [11] quite pertinently note that cloud computing is being adopted around the world by many countries through government programmes. This includes the U.S. Government's "Cloud Computing Mall" for government agencies, Japanese Government's "Kasumigaseki Cloud" and the U.K. Government's "G-Cloud" infrastructure project initiative. As a member of the BRICS nations (Brazil, Russia, India, China and South Africa), South Africa could stand to gain by tapping into collaborative best practices from other countries.

Through the implementation of the "National Development Plan: 2030 vision" on promoting health, the Presidency Republic of South African Government can also follow on the footsteps of other developing nations: Brazil, Russia, India and China. This insightful consideration could help South African government to leapfrog the leaders already gained vast experiences on cloud computing adoption within the healthcare environment in their respective countries. This includes the implementation of strategic partnerships to global health delivery system to reduce costs and lower the difficulty of enabling ICT infrastructure.

In the same way Marston *et al*. [23] also explain that to realise full potential of cloud computing services means removing the roadblocks to enabling IT-as-a- Service and overcoming the challenges of security, quality of experience and governance [23].

In order to resolve the identified challenges, healthcare organisations should collaborate with the world's top IT companies, international organisations and institutions that possess a great deal of expertise on eHealth related programmes. For that reason, it is important to note that the foreign based companies must familiarise themselves to the South African recommended eHealth interoperability standards in table 1 [15]. The use of interoperability standards is a core requirement to effectively integrate patient health information (PHI) from different medical systems.

As Rashid Al Masud [24] points out, in comparisons to locally-housed IT resources, cloud computing may improve security because Software as a Service (SaaS) providers are able to devote resources to solve security issues that many customers cannot afford. Cloud computing services are the enabling fabric of Health IT platforms [11], dramatically reducing the barriers to entry for developing economies. This includes transforming the cost base, agility and mobility of a well-developed HIS [11].

Table 1. Recommended standards for eHealth interoperability in South Africa [15].

Standard	Description
ISO/TS 2222O:2011	Identification of subjects of health care
ISO/TR 20514:2005	Electronic Health Record – Definition, Scope and Context
ISO 13606 (1- 4)	Electronic Health Record Communication (Part 1 - 4)
ISO 180308:2011	Requirements for an Electronic Health Record Architecture
ISO21549 (1- 8)	Patient Healthcard Data – (Part 1 - 8)
ISO 170090 (1- 3)	Public Key Infrastructure (Part 1 - 3)
ISO/TS 27527:2010	Provider Identifier Standard
HL7	Health Level Seven
DICOM	Digital Imaging and Communication in Medicine
HL7 CDA	Clinical Document Architecture
HL7/ASTM Standard	Continuity of Care Document (CCD)
ICD Coders	International Classification of Diseases Codes
SNOMED CT	Systematized Nomenclature of Medicine – Clinical Terms
LOINC	Logical Observation Identifiers Names and Codes
NAPPI	National Pharmaceutical Product Index
ICHI	International Classification of Health Intervention
CPT	Current Procedure Terminology
MIOS 5.0	SITA – Minimum Interoperability Standards for SA Govt. Systems

Porter's [16] suggestion that transforming the healthcare system requires a holistic and phased approach as opposed to attempting to resolve all issues in one stroke, is duly noted. The DoH supports Porter's [16] suggestion by contending that the eHealth strategy aims to support the medium-term priorities of the public health service delivery, whilst paving the way for future requirements [5].

This includes laying the requisite foundations for future integration and coordination of eHealth initiatives in the country. Figure 2 illustrates the execution of cloud computing principles to guarantee national and international compatibility, eHealth standards interoperability, open architecture, modularity and capability for flexible capacity upgrades.

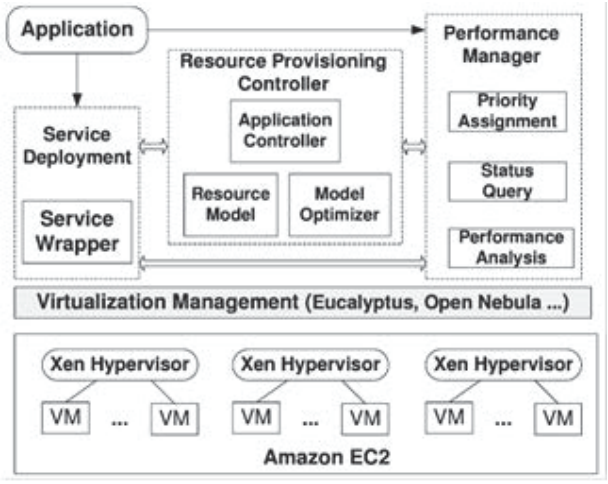

Figure 2. Cloud computing architecture for adaptive applications [21]

5. CLOUD COMPUTING CONCEPTUAL MODEL

The World Health Organisation put emphasis on the fact that developing HIS will depend upon how institutions function and interact, including ICT policy makers, in an effort to improve healthcare coverage, availability, dissemination and use of EHRs through the utilisation of computers, e-mail and internet access [27]. The DoH further reveals that the regulatory framework in South Africa is designed to place emphasis on the inter-linkages between quality assurances through regulation for the implementation of quality standards [7].

Of further significance, [14] also attest that a single organisation cannot provide all the technologies necessary to address healthcare system challenges. The argument is that interaction is needed between the medical schools and organisations, as well as between institutions and internet service providers, communication service providers and medical device developers as illustrated in figure 3.

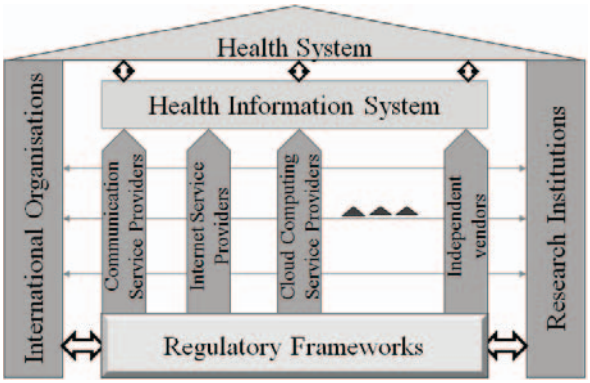

Figure 3. Proposed cloud computing model for the transformation of healthcare system in South Africa

The DoH agrees that eHealth is still facing many cavities in South Africa including the lack of clearly defined eHealth interoperability standards [5].

Other key concerns involve data integration as well as data security and privacy, broadband coverage and internet penetration, regulatory compliance standards, and the lack of competent professionals. While recognising the importance of instigating quality standards in the health sector, the World Health Organisation further acknowledges that there is a need to coordinate and align partners on an agreed framework for the improvement of healthcare system [27].

6. APPROACH TO RESEARCH DESIGN

To understand the dynamics associated with cloud computing adoption, [13] conducted interviews in 15 software organisations. The questionnaires were selected for an in-depth analysis based on a relatively progressive use of cloud computing and testing.

By the same token, [14] highlight that it is important to conduct interviews with the stakeholders concerned, to test the validity and completeness of the proposed model. In addition, Deloitte quite pertinently states that through analysis of the three stakeholder perspectives, it is possible to define an eHealth Architecture that identifies all the ICT components necessary to deliver eHealth Vision [3].

The cognitive behind such claims is that the eHealth architecture is structured into three segments that contain interrelated components necessary to delivery eHealth vision, highlighted as follows [3]:

a) The eHealth Solutions describe the systems and tools that consumers, care providers and health care managers will use to interact with the health system.
b) The eHealth Infrastructure describes the specific eHealth computing infrastructure components necessary to support the collection and sharing of structured and meaningful electronic information across the health system.
c) The eHealth Enablers describe the ICT components that must be in place to support the delivery of the overall eHealth strategy.

In this study, the participants consist of Managing Directors, Chief Technology Officers and Executives. The participant's roles were mapped according to the corresponding research subjects in table 2.

Table 2. Research subjects

Research Subjects	Participants Role on eHealth Initiatives	Description	Example
Health system in South Africa	Decision-makers	Strategic direction for eHealth (Department of Health, 2012:6)	National eHealth Steering Council
Health information system	Subject matter expects	Delivers HIS software (Mars and Seebregts, 2008:17)	Health ICT Service Provider
Cloud networking platforms	Key enablers	Enable connectivity (Shen *et al.*(2012)	Internet Service Providers
Cloud computing ecosystem	Key influencers	Enable utility computing (Winans and Brown, 2009:2)	Cloud Computing Service Providers
Enabling cloud computing ecosystem	Health IT innovators	Enhance ICT infrastructure performance (Calyam, 2011:2)	Technology Specialist Company

7. RESULTS

This section reviews responses from interviews conducted with respondents as per respective research subjects discussed in previous sections. The questionnaires were designed in such a manner so as to address a particular focus area, which is in agreement with proposed conceptual model in figure 3.

7.1. Research Subject 1: Healthcare System in South Africa

The collective viewpoint is that the eHealth strategy implementation and adoption is facing major stumbling blocks defined as challenges by the DoH within the South African context. Privacy and security is described as the biggest concern to the adoption of cloud computing within the health sector.

Therefore, this clear indicates that privacy and security are some of the critical areas that should be addressed and controlled for proper adoption of cloud computing within the South African healthcare environment.

South African government should advance regulatory policy frameworks in order to ensure effective interoperability standards to address key concerns surrounding privacy and security of sensitive medical data for clinical decision making.

7.2. Research Subject 2: Healthcare IT Service Providers

The insight gained is that the healthcare IT service providers have the capacity to delivery large-scale software platforms. However, the respondents are concerned about the key issues inhibiting the adoption of the state-of-the-art ICT platforms within the health sector in South Africa.

The major challenges highlighted include ICT infrastructure and high bandwidth costs, disparate systems and fragmentation of PHI systems.

On numerous occasions the respondents mentioned that there is a lack of governing principle on who owns the patient records. This includes lack of local standards adoption, policies which govern the EMRs, fundamental interoperability standards, and integration of dissimilar systems. If the identified issues are resolved and controlled, the respondents are of the opinion that cloud computing is a possible solution to improve healthcare service delivery. The respondents consider eHealth strategy document as the first step towards resolving the identified challenges.

7.3. Research Subject 3: Internet Service Provider

Overall, the respondents are of the view that the national broadband landscape has not transformed or changed the nature of healthcare service delivery in South Africa over the past decade.

The respondents argued that South Africa needs to adopt robust national eHealth policy standards and the commitment to execute within the agreed policy frameworks. There is a need for collaboration between the stakeholders to improve healthcare service delivery through ICT in South Africa. This includes a consolidated strategy around how the healthcare system is going to be implemented in South Africa.

To accelerate the adoption of cloud computing platforms, the implementation of strategic partnerships will help South African government to reduce costs and lower the difficulty of enabling ICT infrastructure. This includes developing a strategic vision on IT as an enabling platform for the creation of value-based healthcare system.

7.4. Research Subject 4: Cloud Computing Service Provider

The respondents were mainly concerned about the legislative frameworks governing the health sector. The respondents are of the view that the lack of coordinated regulatory framework in South Africa is the biggest challenge for the adoption of cloud computing. According to the respondents, the legislative frameworks and unwillingness for the companies to share information are some of the main issues hindering cloud computing adoption. This includes the sensitivity nature on PHI, which makes the organisation reluctant to move to the cloud computing platforms.

To resolve these challenges, it is necessary to achieve consensus between government, healthcare organisations and other key stakeholders to advance the development of eHealth initiate. Although the ICT has evolved in the private health sector, the respondents argued that the advanced ICT platforms are still lacking in the public health sector.

7.5. Research Subject 5: IT Specialist Company

The respondent mentioned that the organisations are now focusing more on the benefits offered by cloud computing and less on the challenges associated with ICT infrastructure. Furthermore, the respondent talks about enterprise mobility as one of the biggest benefits within the healthcare environment. This includes providing flexibility for health professionals and nurses to be more mobile across regions and in different parts of the world.

The respondent notes that cloud computing based applications are now available much easier and quicker. For example, the applications can be developed in India and be available in South Africa via cloud computing platforms. This clearly indicates that rapid advances in enabling ICT infrastructure can accelerate cloud computing adoption through partnerships with IT specialist companies.

8. CONCLUSION

The DoH describes eHealth as an integral part of the transformation and improvement of healthcare services in South Africa [5]. This includes enabling the delivery on the health sector's Negotiated Service Delivery Agreement for 2010-2014. In order to best overcome key factors that are hindering the transformation of the healthcare system, the DoH has put the programme of work that will lead eHealth strategy implementation. The DoH recognises that this programme of work should be underpinned by certain key principles at National and Provincial Departments of Health respectively. Finding competent data scientists to analyse healthcare data and extract value appear to be one of the major challenges across healthcare organisations.

Following the interpretation of the findings and supported arguments using existing literature review analysis, it can be concluded that the stated research objectives were achieved. Of further significance in this regard is the connection that existed between the results obtained and the literature review analysis. This noteworthy correlation was demonstrated by discussing the findings with respect to the research objectives.

The conclusive finding is that the HIS is not meeting the requirements capable of improving health system's effectiveness. Although cloud computing looks set to scale up EHRs globally, in South Africa it is hindered by persistent reliance on using unreliable ICT platforms. Therefore, it may seem counterintuitive for the South African government to implement cloud computing in the public health sector whereas the mandate to strengthen healthcare system effectiveness is not met.

The DoH quite pertinently admitted that the eHealth is still facing many cavities including the lack of clearly defined eHealth interoperability standards. Hence, South African government should advance regulatory policy frameworks in order to ensure effective interoperability standards to address key concerns surrounding privacy and security of sensitive medical data for clinical decision making. Furthermore, practitioners and researchers should consider investigating and accumulating information to determine the best possible ways of adopting cloud computing platforms within the South African healthcare environment.

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