Future Directions of Applying Healthcare Cloud for Home-based Chronic Disease Care

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***Abstract*— The care of chronic disease has become the main challenge for healthcare institutions around the world. To meet the growing needs of patients, moving the front desk of healthcare from hospital to home is essential. Recently, cloud computing has been applied to healthcare domain; however, adapting to and using this technology effectively for home-based care is still in its initial phase. We have proposed a conceptual hybrid cloud model for home-based chronic disease care, and have evaluated its future feasibility by a case study of diabetes care in Blekinge, Sweden. In this paper, we discuss some possible future opportunities and challenges to apply this cloud model with the huge population for home-based chronic diseases care. To apply this model in practice, a professional IT healthcare education team is needed for both healthcare providers and healthcare recipients. For home-based healthcare, a monitoring system with an automatic alarm to healthcare providers is also necessary in some cases. Also, how to record and integrate excises data through wearable devices in a cloud should be considered. Given the high demand, sharing medical images through the cloud should be another research focus.**

Keywords-future trends; hybrid cloud; chronic diseases; home-based care

I. INTRODUCTION

The care of chronic disease has become the main challenge for healthcare institutions around the world. According to a WHO report in 2014, almost 90% of deaths in Sweden are caused by chronic diseases [1]. As the incidence and prevalence of chronic diseases continue to increase, traditional hospital-based healthcare is less able to meet the requirements of patients. To meet the growing needs of patients, moving the front desk of healthcare from hospital to home is essential. Home-based healthcare could enable the care recipients to live independently at home. Healthcare providers could reach the patients based on their shared daily health data, and provide clinical suggestions. Also, for home-based healthcare, more people are encouraged to assist with the care, such as family members and other patients with similar symptoms.

The development of Information Communication Technology (ICT) has enabled people to enter a modern digital society. Our quality of life is promoted by the application of ICT in all fields. In the healthcare domain, by widely using personal computers, smartphones, and other self-monitoring devices, ICT has brought healthcare in a new era [2]. All of the ICT technologies could help improve the quality of home-based healthcare.

In recent years, cloud computing has been used to support healthcare. The obvious advantages of cloud computing, like big data storage, pay-as-go online software services, and powerful data analysis capacity make it a great benefit to apply cloud computing in home-based healthcare [3]. In our previous work, we have proposed a conceptual hybrid healthcare cloud model for home-based care. Moreover, we have tested the feasibility of the model by a case study of diabetes care in Blekinge, Sweden [4]. We believe that cloud-based solution is a future trend of healthcare technology. To prefect and realize our hybrid healthcare cloud in large-scale population, there are other technologies to be further explored.

This paper mainly discusses future opportunities and challenges of applying cloud model with the huge population for home-based chronic diseases care. Section 2 is a brief introduction of our research project, while in Section 3, we give a brief description on our Swedish case study. Section 4 lists some opportunities and challenges are discussed in Section 5. Conclusion and the suggestions of future work conclude the paper.

II. HEALTH IN HAND PROJECT

The Indo-Swedish R&D project Health in Hand – Transforming Healthcare Delivery is a project funded by VINNOVA (Reg.No.2013-04660) for three years. The main objective of the project is to establish long-term Indo-Swedish R&D collaboration around leading-edge applied health technology, with a focus on mobile health services, namely mHealth. mHealth technologies usually mean “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices [5]”. In this project, we mainly refer to “mobile services which inform, motivate and enable individuals to manage their own health information and knowledge sharing, as well as support communication and community building among both patient and caregiver communities [6]”. The project uses participatory design as a research approach, to focus on the local design of design methods, techniques, and tools that promote participatory design for mHealth development [7].

One of the aims of the project is to discover possible solutions to enhance collaboration around the complex systems which are the base for innovative mobile technologies in healthcare among different healthcare providers and

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between healthcare providers and recipients. In the final year of the project, the study is focusing on concerning up-scaling and commercialization of mHealth technologies in collaboration with industry and public sector [6]. In the beginning of the project, we tried to develop applications based on mHealth technologies. When we had our first Swedish case study, we found that there were already a number of mobile applications in the market, so we move our research focus to how to integrate these mobile applications into current healthcare system.

III. A CASE STUDY IN SWEDISH DIABETES CARE

In our previous work, we have studied on how to adapt cloud computing to healthcare domain and have proposed a conceptual hybrid cloud model for home-based chronic diseases. In this conceptual model, healthcare recipients using mHealth technologies for self-recording home-based healthcare data, and communicating with their healthcare providers, is one of the key elements. Within the scope of the project, we have conducted a two-step case study in diabetes care. The purpose of this case study was to improve the conceptual model and test its feasibility on one hand, and to explore some possible technical trends for up-scaling and commercialization of this model on the other hand [4]. The improved model is shown in Figure 1.

This model is a hybrid cloud model, which contains private clouds from the hospital and primary care centers, as well as public clouds for home-based self-management data. This model is based on that diabetes patients can measure their blood glucose and other parameters themselves at home via a few devices and upload the values to the app's public cloud automatically. The secure connected public cloud of the app not only stores the data, but also deals with the data with the help of powerful data processing capacity of cloud computing to monitor the threshold values and create different kinds of reports. The doctors at the hospital can access the public cloud if they have the authorization of their patients. Between the hospital's and primary care centers' private clouds, there is an internal journal system for sharing partly patients'' data sharing. All these ways of sharing data already existed in Blekinge, as well as other counties in Sweden. The improved communication between patients and primary care providers is the most pressing demand of the day.

This model visualizes the current data sharing of home-based diabetes care, as well as provide a cloud computing solution to enhance collaboration around the healthcare systems and moblie applications based on mobile technologies. For other types of chronic diseases, this model could also be used for data sharing. From our interviews with both healthcare providers and healthcare recipients, we found that it is feasible to apply this hybrid cloud in future home-based healthcare. For the model's up-scaling and commercialization, there remains future work to be further explored.

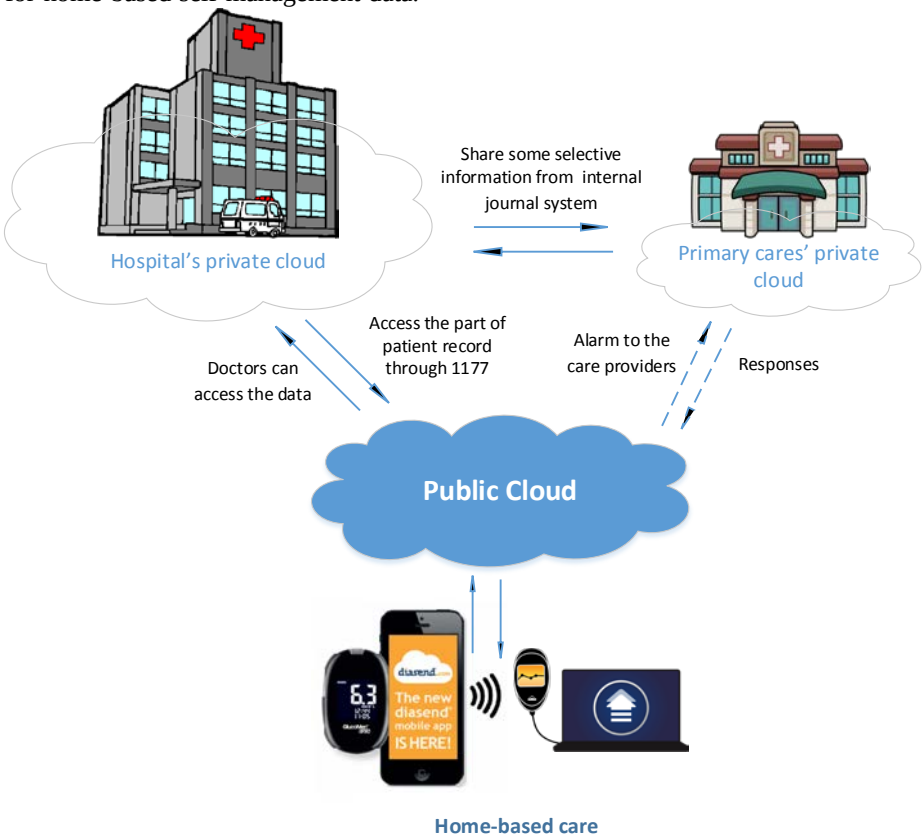

Figure 1. Conceptual hybrid cloud model [4]

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IV. FUTURE OPPORTUNITIES

A. Professional healthcare IT education

From our case study, we found that all eleven participants feel ICT technologies have developed very fast, and it is quite difficult for them to follow the steps of the development. The lack of IT knowledge sometimes reduces the enthusiasm of users to try new ICT technologies in healthcare. Especially with mobile technologies used for home-based healthcare, healthcare recipients thought it was healthcare providers' responsibility to teach them to use the mobile applications or self-recording devices. However, most of the healthcare providers thought they were not good at technology themselves. Although there are use guides from the service or device providers, the healthcare recipients still ask lots of technically related questions to their healthcare providers. From our case study, we were surprised find that healthcare providers are less interested in adopting new ICT technologies than healthcare recipients. The reason is that they felt their main work is diagnosis and treatment, and that using new technologies reduced their work efficiency in some way.

In this situation, building up a professional healthcare IT education team is of utmost importance. This education team should be built by people who have certificated knowledege in healthcare technology. It could be supported by government or set up as an independent commercial organization. The educational programs provided by this team should address both healthcare recipients and healthcare providers. For healthcare providers, training on their working systems and the communications between these systems could be offered frequently, like once a year. Since in chronic diseases care, self-management is a key factor [8], the education to help healthcare recipients to use different ICT technologies for self-management would be the main focus.

B. Mobile doctor

Another trend of home-based chronic diseases healthcare is the mobile doctor. The mobile doctor here refers to having a communication with a primary care doctor through a phone, tablet or computer. Healthcare recipients could receive primary care at any place of their convenience. In Sweden, there are two of this kind of services on the market, KRY [9] and Min Doktor [10]. The difference between these two services is that KRY provides a booked 15 minutes video meeting with doctors while Min Doktor provides the communication with the doctors with messages all day round. Both these two services are linked with personal ID; healthcare recipients must log in with their social security number. This will guarantee the healthcare recipients could receive the same benefits as they are visiting local primary healthcare centers.

Both these services are still in their beginning phases. In the future, we believe more and more chronic disease healthcare recipients will choose this type of remote primary care to communicate with their healthcare providers. How to promote and improve the quality of these mobile doctor services should be under discussion.

C. Real-time monitoring system

In Sweden, most patients with chronic diseases now contact more often with primary a healthcare center than with a hospital, which means primary healthcare centers take more responsibility for chronic diseases care. However, from our case study, we found that the communication between patients and primary healthcare centers is still based on regular mail and telephones.

As big data in the cloud brought a revolution in healthcare [11], a real-time monitoring system with alarm could be a possible mechanism for primary care. The calculated threshold values by the big data in the public cloud, together with healthcare providers in primary healthcare centers, can help the patients to set threshold values for their daily health parameters. When a patient's self-recording data is uploaded at home, and the values reach the threshold values, the data processing program in the public cloud can send an alarm to the responsible primary care center. As soon as the care providers see the alarms, they could contact the patients and give them some feedback. The design and development of this real-time monitoring system could be another future direction to apply a healthcare cloud for home-based chronic diseases care.

D. Wearable devices to record excise data

According to WHO, lack of physical activities is a significant risk factor for chronic diseases such as stroke, diabetes, and cancer. However, an estimated 23% of adults and 81% school-going adolescents are not active enough [12]. In most cases of chronic disease care, healthcare providers suggest their patients do daily physical excise as the main method to control their condition. With the widely use of wearable devices, it is possible for people to record their excise data[13]. Today most data recorded by the wearable devices is stored in device companies' servers. With the 5G network [14] and several sensors that are being introduced into the healthcare environment, and which provide even more healthcare data.

In the future, integrating this excise data with other home-based self-management data from both mobile applications and sensors will be an important trend.

E. Medical images sharing

The huge data storage capacity in the cloud makes it easier to store and process medical images. This will promote medical image sharing between healthcare providers and recipients. In Blekinge, Sweden, until now, there is no such kind of medical image sharing system, but the demands are keen according to our case study, especially for aged people who live independently. They want to bs able to take photos of wounds at home and send them to the healthcare providers in wound centers, which would be better than regular visiting. Moreover, the healthcare providers in wound centers also thought it could save time to treat the wounds.

A multi-functional medical image sharing mobile application could be a future research orientation. For example, how to pre-process the wound images before the healthcare providers review them, such as wound highlight, 3D visualization, are worthy of consideration.

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F. Games for health

Mobile games have a significant influence on people's physical activities, as illustrated by the success of Pokémon Go [15]. Games for health are not limited to serious games anymore. Designing an entertaining and fun digital game to encourage patients with chronic diseases to do more excises or an educational mobile game to help the healthcare recipients to get more knowledge of their diseases could be a new interest for both game and healthcare industry.

V. FUTURE CHALLENGES

Challenges to future development of healthcare cloud in home-based chronic diseases care also need to be carefully considered and addressed

A. User-friendly information system design

Most patients with chronic diseases are aged people. Thus the new information systems designed for home-based chronic diseases need to be user-friendly. In additional, smart tablets are easier to use for aged people than smartphones since the screen is bigger.

B. Data leakage of public cloud

In home-based healthcare, most self-recording data from home environment is stored in public cloud. Thus, it is a risk of data leakage. Access control and data security protection are always necessary for healthcare related data.

C. Reliability of third party healthcare services

There are a huge amount of healthcare mobile applications to support home-based chronic disease care, but not all of them are reliable. According to study on medical related mobile apps, less than half of the studied apps are reliable[16], which means if healthcare recipients use these unreliable apps, they may get wrong information and advice about their diseases. To overcome this challenge, the companies provided healthcare services, responsible government agencies and mobile app users should make efforts together.

VI. CONCLUSION AND FUTURE WORK

We found that our cloud model is feasible to be applied in home-based chronic disease care in the future. It will help to promote patient-centric healthcare in Sweden. In this paper, we mainly address the future trends of applying healthcare cloud for home-based chronic disease care. To upscale and commercialize the healthcare cloud, professional healthcare IT education, mobile doctors, real-time monitoring systems, wearable devices to record excise data, medical image sharing and games for health could be the main future directions. User-friendly design, data privacy and security, and reliability of services would be challenges to promote healthcare cloud development. In the future, we will put the focus on one or two above issues in our continued research.

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