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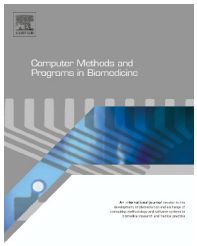

Empowering village doctors and enhancing rural healthcare using cloud computing in a rural area of mainland China

Che-Wei Lin[a], *Shabbir Syed Abdul*[b,c], *Daniel L. Clinciu*[b,d], *Jeremiah Scholl*[e], *Xiangdong Jin*[f], *Haifei Lu*[f], *Steve S. Chen*[f], *Usman Iqbal*[b], *Maxwell J. Heineck*[g], *Yu-Chuan Li*[b,h,*]

[a] *Graduate Institute of Medical Informatics, Taipei Medical University and Taipei Medical University Hospital, Taipei, Taiwan*
[b] *College of Medical Science and Technology, Graduate Institute of Biomedical Informatics, Taipei Medical University, Taipei, Taiwan*
[c] *Institute of Biomedical Informatics, National Yang Ming University, Taipei, Taiwan*
[d] *Institute of Translational Medicine, Taipei Medical University, Taipei, Taiwan*
[e] *Health Informatics Centre, Karolinska Institutet, Sweden*
[f] *Healthgrid Technology Inc., Beijing, China*
[g] *Institute of Industrial Management, King Fahd University, Dhahran, Saudi Arabia*
[h] *Department of Dermatology, Wanfang Hospital, Taipei, Taiwan*

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ABSTRACT

Background: China's healthcare system often struggles to meet the needs of its 900 million people living in rural areas due to major challenges in preventive medicine and management of chronic diseases. Here we address some of these challenges by equipping village doctors (ViDs) with Health Information Technology and developing an electronic health record (EHR) system which collects individual patient information electronically to aid with implementation of chronic disease management programs.

Methods: An EHR system based on a cloud-computing architecture was developed and deployed in Xilingol county of Inner Mongolia using various computing resources (hardware and software) to deliver services over the health network using Internet when available. The system supports the work at all levels of the healthcare system, including the work of ViDs in rural areas. An analysis done on 291,087 EHRs created from November 2008 to June 2011 evaluated the impact the EHR system has on preventive medicine and chronic disease management programs in rural China.

Results: From 2008 to 2011 health records were created for 291,087 (26.25%) from 1,108,951 total Xilingol residents with 10,240 cases of hypertension and 1152 cases of diabetes diagnosed and registered. Furthermore, 2945 hypertensive and 305 diabetic patients enrolled in

* *Corresponding author at*: College of Medical Science and Technology, Graduate Institute of Biomedical Informatics, Taipei Medical University, Taipei, Taiwan. Tel.: +886 2 2736 1661.
E-mail address: jack@tmu.edu.tw (Y.-C. Li).

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follow-up. Implementing the EHR system revealed a high rate of cholecystectomies leading to investigations and findings of drinking water contaminated with metals. Measures were taken to inform the population and clean drinking water was supplied.

Conclusions: The cloud-based EHR approach improved the care provision for ViDs in rural China and increased the efficiency of the healthcare system to monitor the health status of the population and to manage preventive care efforts. It also helped discover contaminated water in one of the project areas revealing further benefits if the system is expanded and improved.

1. Introduction

Over 68% of the population (900 million people) of China live in rural areas and its healthcare system often struggles to meet their needs [1–3]. Providing equitable access and timely care for rural populations is an important issue for healthcare reform [1,2] with long term management of chronic diseases being one of the major healthcare challenges in China [4]. Only 8.1% of the hypertensive population is aware of their condition and manage their blood pressure correctly [5].

One strategy that might help support these health reforms is to implement Health Information Technology (HIT) systems [6], such as an Electronic Health Record (EHR) system to systematically collect patient health data electronically through cloud computing. Cloud computing is the use of various computing resources (hardware and software) to deliver health services and patient data over the health network using Internet when available. Various studies have been conducted regarding the potential benefits for HIT to healthcare systems in developing countries [6–8].

However, Internet access in rural areas is often unavailable and further deprived by lack of local knowledge of keeping IT systems operational [9,10]. One solution is to set up a local vendor with knowledge and experience necessary to maintain the system on behalf of the healthcare organization [10].

In this study we present an alternative strategy based on implementing a system supplied by a cloud-computing vendor. A cloud-based Electronic Health Record (EHR) system was implemented in Xilingol county of Inner Mongolia to support work at all levels of the healthcare system, including work conducted in rural areas with a low level of infrastructure. The system's two goals for health reform are to (1) aid rural health workers with preventive medicine and public health efforts, and (2) to improve integration of care between different levels of the healthcare system. Thus, we address the following questions:

1. How can HIT improve the ability of ViDs to support preventive care and long term management of chronic diseases in rural areas?
2. What benefits has an EHR system in enhancing healthcare delivery to the rural population?
3. What strategic lessons does this system provide to improve the adoption of HIT systems in rural areas of developing countries?

2. Methods

2.1. Setting

The cloud-based EHR system was deployed in Xilingol county (population: 1,108,951; area: 211,866 km^2) of Inner Mongolia province in 2008.

2.1.1. Rural healthcare in China

The Chinese healthcare system is comprised of three levels of healthcare providers; city hospitals, county/town hospitals, and village health stations. All levels of the healthcare system are important for populations in rural areas since a patient may visit a city hospital to see a specialist for a complex health problem. However, the majority of primary healthcare work in rural areas is conducted at village health stations by certified health workers that have less training than medical doctors referred to as "barefoot doctors" [11,12]. They focus primarily on preventive issues such as health education, maternal and child healthcare, immunization and collection of disease information [12]. Over the years as the system has evolved, there are now different types of certified rural health workers with varying amounts of formal training and responsibilities.

Village doctors (ViDs) that have received 18 months of training and use a pay-for-service business model currently perform the majority of work related to delivering primary healthcare in rural areas.

2.1.2. Challenges with the village doctor system

Although the ViD system is considered a success on a cost-benefit basis, there are some challenges with the system. One challenge is the pay-for-service business model resulted in preventive medicine and public health work becoming a lower priority [11]. Recent reforms have changed the economic incentives for ViDs, providing them with a salary and bonus for performance instead of a pay-for-service model, resulting in a reduction of drug costs and unnecessary drug prescriptions [13,14].

Another challenge is related to health records. Because the ViDs live in the community in which they work and know all of their patients personally, they generally have not kept formal health records [14]. This creates challenges in integrating different levels of the healthcare system and makes it difficult for officials in obtaining the information needed to implement public health efforts and to manage chronic diseases, all important aspects of current health reform efforts in China [2,15].