Using a Cloud-based Electronic Health Record During Disaster Response: A Case Study in Fukushima, March 2011

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Abbreviations:
EHR: electronic health record
JMAT: Japan Medical Association Team
VPN: virtual private network
SWF: Small Web Format
TLS: transport layer security

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Abstract

Following the Great East Japan Earthquake on March 11, 2011, the Japan Medical Association deployed medical disaster teams to Shinchi-town (population: approximately 8,000), which is located 50 km north of the Fukushima Daiichi nuclear power plant. The mission of the medical disaster teams sent from Fukuoka, 1,400 km south of Fukushima, was to provide medical services and staff a temporary clinic for six weeks. Fear of radiation exposure restricted the use of large medical teams and local infrastructure. Therefore, small volunteer groups and a cloud-hosted, web-based electronic health record were implemented. The mission was successfully completed by the end of May 2011. Cloud-based electronic health records deployed using a "software as a service" model worked well during the response to the large-scale disaster.

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Introduction

The Great Eastern Japan Earthquake occurred in the Pacific Ocean off Japan's northeastern Sanriku coast at 2:46 PM (14:46 JST) on March 11, 2011, with a magnitude of 9.0.[1–3] There were 15,811 deaths, 4,035 missing persons, and 5,932 severely-injured people.[4] Additionally, the problematic handling of the Fukushima nuclear accident, particularly regarding delayed disclosure of information by the Japanese government and the Tokyo Electric Power Company, further complicated disaster response.[5] The government issued an evacuation order for people living within a 20-km radius of Fukushima Daiichi nuclear power plant on March 12th, while evacuation of areas outside this 20-km radius was delayed. Therefore, fear of the unknown led many people to flee Fukushima, reducing the labor force needed to assist with overall recovery in the region.[6,7]

Shinchi-town (population: approximately 8,000) is located 50 km north of the Fukushima Daiichi coastal area, at the north border of Fukushima Prefecture (Figure 1). The total number of fatalities in Shinchi-town was 109, and approximately 30% of the inhabitants were evacuated to shelters. Soon after the tsunami, a Japan Red Cross disaster medical team arrived in Shinchi and set up an emergency disaster clinic in the government office building. However, this medical team departed soon after the explosion at the Fukushima Daiichi Nuclear Power Plant on March 12th. There was no medical support remaining in Shinchi-town at this time. Approximately 10 days after the tsunami, one disaster medical team arrived from Tokyo and restarted disaster medical support activities such as shelter visits and a temporary emergency clinic. However, they had difficulties in sustaining their activity because of resource shortages.

In April, the Fukuoka Medical Association deployed Japan Medical Association Teams (JMATs) for long-term medical support. A JMAT is a disaster medical team organized by the Japan Medical Association, the largest physicians' union group, with the collaboration of volunteer health care professionals, and its mission is to conduct emergency humanitarian work such as medical and public heath support for people displaced by large-scale disasters.[2,3,8] Fukuoka is located in southwest Japan, more than 1,400 km from Fukushima (Figure 2).

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Figure 1. The Destroyed Train and Station at Shinchi-town, Fukushima

A cloud-based electronic health record (EHR) for the disaster response was introduced in Shinchi-town, Fukushima, which was severely affected by the triple disaster (earthquake, tsunami, and nuclear disaster) on March 11, 2011.

Report

Mission Plan and Objectives

Despite a rapid medical response, coordination and communication systems among the various disaster medical teams were lacking. As a result, sharing information obtained from patients and evacuees in the disaster area was inadequate among the disaster teams.[9,10] In order to address these issues, a browser-based communication tool and EHR system were deemed essential.[11–13] The system had to be available in a remote setting, and include sharing logs of daily activities, schedules, and other detailed information in the disaster area among the various teams.

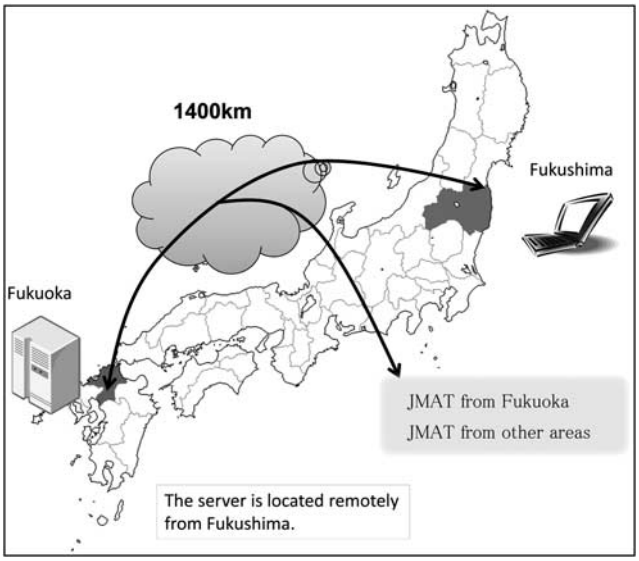
All JMAT members are volunteers, and they usually participate for a limited period (usually four to seven days). In the area around Fukushima there was also a risk of exposure to radiation. As a result, the short-term rotation of JMATs in many areas led to difficulties including:

1. Most medical records were written by hand, and the format varied. As a result, it took time for new teams to collect and utilize the updated information.
2. Sharing information between the shelters and the temporary emergency clinic was impossible. Many evacuees moved from one shelter to another, and duplication of medical records for the same patient often occurred. Evacuees repeatedly had to provide the same information when they used the disaster support services.
3. It was not easy for the disaster medical teams to reconfirm the details for patients seen by a previous team.
4. Even after the completion of JMAT activity, some patients needed medical follow-up. Sharing of information between the local medical staff and the JMAT was difficult.
5. The headquarters of the JMAT was located in a remote area, and could not oversee the frontline activity in the disaster area in a timely manner. The situation in the disaster area was fluctuating, and flexible approaches were required.

When the Fukuoka JMATs arrived on the scene, a cloud-based EHR was implemented. Himeno Hospital, in Fukuoka Prefecture, had created a web-based EHR in May of 2005 and this system was extended to support the disaster response effort.

In a traditional web-based system, information is constantly transferred to a server, and as a result, frequent data transmission between the server and client is essential. Given the vagaries of data transmission in the affected area, the system did not function well. To solve this issue, client-side software called OpenNetKarte

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Figure 2. The Distance from Fukuoka to Fukushima

(Institute of Medical Information Technology Co., Ltd, Hirokawa-town, Fukuoka, Japan) was developed using Adobe Flash technology (Adobe Systems Incorporated, San Jose, California, USA). This software enables sending SWF (Small Web Format) formatted data from the server to the client Web browser after log-in to the system. Data is processed locally during the browser session using Adobe Flash, and data transfer occurs only at the beginning and end of the session, to obtain and save the data. All devices using Adobe Flash work with this system regardless of the operating system, browser, or hardware platform. This is significant, because different types of computers are often used in a disaster response. The latest SWF files are downloaded during log-in, and the software is always updated to the latest version. The server-side Web services at Himeno Hospital support a variety of clients at several hospitals. For disaster response, a low bandwidth, local storage, and transfer approach using OpenNetKarte was found to be very effective.

The application for Shinchi-town was further customized to support shelter visits and temporary field clinic activity, eliminating less-critical clinical functions such as imaging and insurance calculations. The primary data entered into the EHR included: (1) patient demographic information such as age, date of birth, gender, and address; (2) a minimum data set of medical information (chief complaint, physical examination, diagnosis, and plan); (3) medication lists; (4) rehabilitation records; and (5) care plans for follow-up. New functions such as Web-based message boards and a scheduling calendar were added. All customization was completed within one week.

This mission, including the EHR implementation, was approved by the Shinchi-town city Mayor Norio Kato in April 2011. The research was reviewed by the ethical board of Himeno Hospital, Fukuoka, Japan.

Field Experience

Setting up the System—On April 15, 2011, the first Fukuoka JMAT was deployed to Shinchi-town. First, the team reviewed and scanned approximately 600 paper-based medical records, assigned an identifier to each individual, and loaded the records into the system. At the same time, medication supplies, which had not been managed optimally, were inventoried and linked to an electronic medication ordering system. In the first month after the disaster, prescriptions had been written by hand.

Activity at the Temporary Emergency Clinic—Asymmetric Digital Subscriber Line access to the Internet was available in the Shinchi-town government office building at that time, and provided sufficient bandwidth for the EHR. Locally purchased laptop computers were used. User IDs and passwords were assigned to Fukuoka JMAT members for the application and for VPN (Virtual Private Network) access. Current Japanese guidelines require VPN access for online medical records.[14]

Shelter Visits—There were six designated shelters in Shinchi-town, housing more than 1,000 evacuees. Regular shelter visits by health care workers were needed because there were many older people with chronic diseases.[15,16] Shelter visits were conducted every day by a team including a physician, nurse, pharmacist, and administrator (Figure 3). A portable Internet WiFi device in the field provided sufficient bandwidth for EHR use in shelters. Approximately 10-30 patients were seen during each shelter visit and in the temporary emergency clinic every day.

Scheduling and Handing Over the Mission—Each Fukuoka JMAT team worked for four days, and each week, two teams were thus required. From mid-April to the end of May, 20 JMATs participated in this mission. Scheduling and a formal method for handing over the responsibilities among these teams were needed. By using a calendar and pin-board system in the EHR, detailed scheduling information was easily shared, and coordination was facilitated. Additionally, the daily activity memo and hand off also was conducted smoothly using this system. Before field deployment, most members took a one-hour training course to learn the system.

Recovery and Retreat of the Fukuoka JMAT—By mid-May, most of the evacuees in shelters had moved to temporary housing, and the two local clinics restarted. As a result, the need for disaster medical support was reduced. After discussions with officials of Shinchi-town, Fukushima Prefecture, and local physicians, the mission was completed on May 31, 2011. All medical equipment and medications brought from outside were also returned to Fukuoka. The room in the government office building used as a temporary emergency clinic was returned to the government. In total, 552 patients were seen by the Fukuoka JMAT from April 15th to May 31st, 2011; all medical records had been written to a CD-ROM and given to appropriate officials in Shinchi-town.

The cost for the installation of the cloud-hosted EHR was approximately 1 million Japanese Yen (US $12,000), which included the travel cost for the staff and the purchase of the laptop computers/electronic devices. The server and software were provided at no cost by Himeno Hospital. This accounting does not include the cost of manpower to customize and develop the system. Fortunately, this was done by volunteers as part of the relief effort and did not require payment. Shinchi-town continued working towards disaster recovery from the earthquake, tsunami, and nuclear power plant incident with the cooperation of the local clinics.

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Figure 3. Accessing Medical Records During Shelter Visits by JMAT

Discussion

Fukuoka JMATs were involved with emergency humanitarian work for six weeks in Shinchi-town, Fukushima, after the Great East Japan Earthquake, with the support of an SaaS ("software as a service")/Cloud EHR. This system enabled the efficient deployment of medical disaster teams for medical/public health activities in the disaster-affected areas, as well as appropriate management of patient data. Due to the risk of radiation exposure in Fukushima, large-scale deployment of disaster medical teams was difficult.[5,17] This challenging situation was the first in the world involving deployment of a cloud-hosted EHR to a large-scale radiation disaster. The robustness of a low-bandwidth, low-cost, Internet-based EHR in the field during the acute response was demonstrated successfully.

In the Great East Japan Earthquake, computer servers in many government offices, business centers, and hospitals were destroyed, and data from the inhabitants, customers, and patients were lost.[16] As a result, a data management system using the "cloud" was very effective, similar to the experience of US Veterans Administration hospitals in the aftermath of Hurricane Katrina in Louisiana—no local records were available but cloud-hosted records were intact.[18]

An important success factor in applying this cloud-based emergency response and EHR system was that the system itself was readily available and designed to be rapidly extensible with little effort.

The probability of large-scale disasters is quite high in Japan, and preparation is important. Based on this experience, the following four points are proposed:

1. During peacetime, a nationwide cloud-based emergency communication and EHR for emergency humanitarian work should be established, and health care professionals who participate in relief work should have appropriate training.
2. Patient data should be pre-entered into a cloud-based system so that data are immediately available at the time of a disaster.
3. The vast majority of hospitals in Japan currently use an EHR. The medical information systems of hospitals should be linked in order to prepare for data sharing in future disasters.
4. For security, both a VPN and TLS (transport layer security) were used. However, in the future, TLS should be adequate, and existing regulations should be revised.

Although EHR systems are widely implemented in Japanese hospitals, they currently utilize closed networks within each hospital. An Internet-based EHR or cloud-based application has not been implemented in Japanese hospitals out of concern

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for privacy. The experience in Shinchi suggests that the benefits of such a system may outweigh the risks and that the security is adequate. Disaster planners in Japan should use these experiences to guide long-term planning for health care coordination and delivery.

Conclusion

A cloud-based electronic health record (EHR) for the disaster response was used successfully in Shinchi-town, Fukushima, which was severely affected by the triple disaster (earthquake, tsunami, and nuclear disaster) on March 11, 2011. Applying the cloud-based electronic health record will be beneficial for the future disaster preparedness.

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- Dr. Nagata had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
- Study concept and design: Takashi Nagata, Shinkichi Himeno.
- Acquisition, analysis and interpretation of data: Takashi Nagata, Shinkichi Himeno and Akihiro Himeno.
- Drafting of the manuscript: Takashi Nagata, John Halamka.
- Critical revision of the manuscript for important intellectual content: Takashi Nagata, Shinkichi Himeno, John Halamka.
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