Disaster-Tolerant Architecture of Regional Healthcare System with Special Reference to Great East Japan Earthquake Disaster

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Abstract: - In this article, a grand design for “disaster-tolerant” comprehensive regional healthcare IT system is described, which aims to provide the main structure for the healthcare system to be restored in Tohoku (north-east area of Japan) region where the Great East Japan Earthquake Disaster stroke. The design is composed of (1) cloud center which manages prefecture-wide healthcare information, (2) standard-based regional (several-cities-wide) healthcare information sharing systems, (3) wireless communication (town/village-wide) environment supporting collaborated care of daily life activities for the elderly, and (4) ASP/SaaS typed electronic medical record system for the clinics located at Pacific coastal areas. The regional healthcare cooperation systems, principally based on the above grand design, began to be constructed in Ishinomaki and Kesen-numa area from this August.

Key-Words: - East Japan, Earthquake Disaster, regional healthcare IT, electronic medical record, cloud center, ASP, SaaS

1 Introduction
The Great East Japan Earthquake Disaster, the most disastrous earthquake that has ever experienced in Japan after World War II with more than 15,000 people died, revealed the various types of vulnerability which current Japanese society has. One of them is the existing medical information system.

Immediately after the outbreak of the earthquake and tsunami, the communication infrastructure and transportation network were severely devastated and about 1400 medical institutions seriously damaged or destroyed (Fig.1). In this circumstance, disaster and emergency medical acute care was very harsh but after the period of imminent critical care, more intractable problems have occurred, which are related to the care of a number of elderly sufferers in the evacuation site who have a chronic disease. It became especially harder because most of medical records of them have been lost by great tsunami caused by the earthquake. As have been already reported in other disasters [1][2], the barrier to providing care was maintaining continuity of medications, due to inadequate information: inaccessibility to medical records and poor patient knowledge of their drugs.

It was thought that electronic health record (EHR) sharing the patient healthcare information of the region should have been realized.

Fig.1 Distribution of medical institutions which are seriously damaged or completely destroyed by Great East Japan Earthquake
The authors belong to the nation-wide organization for promotion of regional healthcare information collaboration of Japan, named “Regional healthcare and welfare information collaboration initiative (RHWI)”, so that, immediately after the Great East Japan Earthquake Disaster, we got started on participation in the reconstruction project of regional healthcare IT systems of the disaster area, that is, north-east area of Japan named “Tohoku”. In this paper, we describe the grand design of “disaster-tolerant” regional healthcare IT systems which we have developed for Tohoku healthcare reconstruction.

In making the grand design, we took into account the main two conditions which should be satisfied by the restored regional healthcare IT systems of the disaster area. One is the disaster-tolerance, especially against the tsunami. This would be realized by multi-site cluster or using cloud (ASP/SaaS) computing, the center of which is located in disaster-free site. The other is multiplicity of needs for healthcare IT. There are different goals of IT systems depending on the wideness of area where the healthcare information is shared. In order to satisfy these conditions, we have developed “the disaster-tolerant hierarchical health care IT systems”.

2 Problem Formulation
The essential conditions which the restored healthcare IT system for Tohoku region should satisfies are described in more detail.

2.1 Disaster-tolerance
The disaster-tolerance in the restored regional healthcare systems means that medical information or record of the patients should be stored in “disaster-free site” in addition to the original medical institution where the patients are treated. To realize this goal, medical record should be digitalized to be shared via the information network with a data center located at “disaster-free site”.

Moreover, patient medical record stored in “disaster-free site” should be standardized so as to be read out in vendor-independent way in case that disaster destroys the original one. In Japan, the Ministry of Health, Labor and Welfare (MHLW) established the standard storage structure of medical information called SS-MIX (Standardized Structured Medical Information Exchange) in 2006, which is the directory structure of the standardized patient information such as the laboratory test results or prescription history coded by HL7. The patient medical record in “disaster-free site” must follow SS-MIX format.

2.2 Multi-faceted challenges
The “disaster-tolerant” regional healthcare system is also expected to solve the various challenges which regional healthcare itself involves. Tohoku area has been long suffering from the problems of depopulation, rapid aging and shortage of number of physicians. The restored regional healthcare IT system for Tohoku area is expected to solve the challenges which the above situation caused. Thus the cooperation among medical institutions to realize the unified regional healthcare should be urgently required to solve the shortage of medical resource such as the number of physicians and medical institutions.

Other problem is isolation of many elderly sufferers who have chronic disease. Nursing care of elderly isolated people should be executed as efficiently as possible, by sharing their healthcare information among various healthcare professions; house call physician, home-visiting nurses/social workers and administrative personnel. This need is even more increased after the disaster because most of the elderly sufferers now live in temporary houses and became more isolated than before the disaster.

Hereafter, we describe the challenges along the hierarchies of width of regional area where healthcare should be taken place.

2.2.1 Prefecture-wide regional healthcare
The prefecture-wide regional healthcare is defined as “the third medical zone” healthcare by MHLW. In this area, the medical care of specific disease which needs prefecture-wide cooperation among the advanced acute care, convalescent care, and maintenance period treatment, which is called “critical pathway of regional medical cooperation”.

Another challenge which should be dealt with is the efficient management of the prefecture-wide emergency care system.

2.2.2 2nd medical zone-wide regional healthcare
“The second medical zone” defined by MHLW means the healthcare area which consists of several cities, towns, and villages, being able to execute self-consistent ordinary medical care with efficient hospitalization capacity, excluding the specific advanced medical care. The main challenge of healthcare in this area is extensive cooperation of regional hospitals and clinics for sharing regional patient medical records for joint and consistent care.

2.2.3 Daily life area healthcare
Daily life area means that of town or village comparable to the school district of elemental or
middle school. The healthcare challenges in daily-life area are mainly related to the home healthcare of elderly isolated people, where collaboration among the house call physician, nursing care worker, and community administrator should be realized. Another challenge is disease management of chronic disease at home such as diabetes and hypertension by using self-monitoring device.

3 Problem Solution
To solve the above-mentioned challenges, we developed the ‘disaster-tolerant’ multi-hierarchical regional healthcare IT system which has “the three layered system with four essential functions.

3.1 Comprehensive daily life area care IT system
The comprehensive nursing care IT system which combines the house call physician, nursing care worker and community administrator to enable sharing the healthcare information of the elderly isolated people is designed. To daily monitor their physiological state, we develop the wireless mobile sensor system which transmits the monitoring data to the data center either of 2nd medical zone or prefecture area.

This system is also used for the daily disease management of patient with diabetes or hypotension. Collected data will comprise the life-long healthcare record, which is called PHR (personal health record).

3.2 Disaster-tolerant ASP/SaaS EMR system for clinic at coast area
The clinics located at the coast area, some of which were destroyed by tsunami and now being restored, should implement the electronic medical record (EMR) system. But EHR system is not that of stand-alone type with in-house server which would be taken away by tsunami. Instead, ASP/SaaS type EMR which its software/data is located in cloud center at disaster-free site within prefecture area, in order to realize “disaster-tolerant” EMR.

3.3 Regional Healthcare Cooperation System with Patient Medical Information Sharing at 2nd Medical Zone
In the 2nd medical zone, the extensive patient medical information sharing among hospitals and clinics is to be implemented. The clinic can access the hospital medical data of the patient whom the clinic refers to that hospital and vice versa or acute and convalescent hospital can share the patient data.

This should be realized along the IHE-XDS (cross enterprise data sharing)architecture. But current XDS system is essentially distributed system, where the patient medical data is stored in each original medical institution, and, whenever patient data is inquired, the virtually integrated patient healthcare record is compiled to provide. But this architecture is vulnerable to disaster, if it destroys one of the cooperated hospitals, all the information that hospital has will be eventually lost. Thus we design the patient information sharing system with central database which physically stores the data.

3.4 Cloud center for managing the prefecture-wide healthcare
The regional healthcare cooperation IT system for 2nd medical zone and comprehensive nursing care IT system in daily life area are the two essential components of the restored Tohoku healthcare IT system. But for the prefecture-wide healthcare cooperation, medical information center should be implemented at the prefecture-level. This center also takes a role of cloud center which manages the ASP/SaaS EMR systems or personal health record of regional inhabitants.

Fig.2 Comprehensive regional healthcare IT system with three layer and four systems
4 Discussion
Thus our grand design consists of three layered regional healthcare IT systems which are (1) the central IT systems that manage prefecture-level healthcare information, (2) regional healthcare cooperation IT system, (3) daily life area comprehensive healthcare and nursing IT system. The four systems consist of additional ASP/SaaS EMR system for clinic along the Pacific coast other than the above three layer systems (Fig.2).

This grand design has been transformed in detailed specification documents and the implementation has been started this August for two “2nd medical zones” of Ishinomaki and Kesen-numa area with the financial aid for reconstruction of disaster-affected region of Great East Japan Earthquake by Ministry of Internal Affairs and Communications.

The remaining problem is how to unify the disaster-tolerant regional healthcare structure and international IHE standard architecture of XDS.

We are developing the unified architecture satisfying both criteria.

5 Conclusion
We have developed Three-layer regional healthcare IT systems with four essential functions. This grand design is now being utilized to restore the Tohoku healthcare.

References: