

Miyagi Medical and Welfare Information Network: A Backup System for Patient Clinical Information after the Great East Japan Earthquake and Tsunami

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On March 11, 2011, the Great East Japan Earthquake and ensuing tsunami that hit the northeastern coastal region of Japan caused about 18,000 casualties and destroyed numerous buildings. Additionally, many medical facilities were damaged and patient medical records lost. In order to maintain patient clinical information, a prefectural medical network system, the Miyagi Medical and Welfare Information Network (MMWIN), began providing backup data storage services in 2013 for hospitals, clinics, pharmacies, and other care facilities as a precaution for upcoming disasters. This system also facilitates the sharing of clinical information trans-institutionally as long as patients provide consent for this. In the present study, we examined the development of the MMWIN and its efficiency during the 5 years from its launch, and identified general problems to maintain such a backup system. At the end of 2018, the system contained backup data from more than 11 million patients with more than 420 million data items; more than 900 facilities were MMWIN users, and the number of patients consenting to sharing their clinical information reached 90,000. The use of the system has become widespread and the accumulating data should be utilized for research in the future. Maintaining a balance between income and cost is critical to make this project independent from local government subsidies.

Keywords: backup; clinical information; data sharing; disaster; electronic health records

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Introduction

On March 11, 2011, the Great East Japan Earthquake (GEJE) hit the northeastern coastal region of Japan and generated a devastating tsunami, leading to an unprecedented disaster with 15,897 deaths and 2,534 missing persons as of December 10, 2018 (National Police Agency 2018). As well as houses and buildings, many medical facilities including hospitals and clinics were destroyed, resulting in loss of medical records, whether on paper or servers (Ishigaki et al. 2013; Tanihara et al. 2013; Kuroda et al. 2013; Tomio and Sato 2014; Ishii et al. 2016; Egawa et al. 2017; Sakuma et al. 2018). Ishinomaki City Hospital, which was also completely destroyed and lost its information system servers during the tsunami, was able to retrieve its medical records from Yamagata City Hospital because they had a mutual backup exchange agreement (Egawa et al. 2017). As a result of this, backup systems of electronic medical records started to prevail in Japan.

Miyagi Prefecture, located in the northeastern part of

Japan with a population of about 2.3 million, was one of the areas most damaged by the GEJE, with 9,547 deaths and 1,220 missing persons (National Police Agency 2018). In 2013, a project to develop a network system between hospitals, clinics, pharmacies, and care facilities, known as the Miyagi Medical and Welfare Information Network (MMWIN), was launched. The system enables medical facilities not only to save patient clinical data but also to share information among medical staff members trans-institutionally. The government provided funding to the network throughout the prefecture. In the present study, we examined the development of the MMWIN during the 5 years from its launch in 2013 and identified general problems to maintain such a backup system.

Methods and Results

Development of the system of MMWIN

Health information exchange (i.e., exchange of patient information across healthcare providers electronically) is challenging, as problems often arise regarding interoperability between different ven-

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dor products. In Japan, the Ministry of Health, Labor and Welfare established the standard storage structure of medical information known as SS-MIX (Standardized Structured Medical Information Exchange) in 2006 and revised it as version 2 (SS-MIX2) in 2012. This provides the directory structure of standardized patient information (e.g., disease name, laboratory test results, prescription history) using an international standard, Health Level 7 (HL7), and enables data from medical record systems developed by different vendors to be stored in a similar format according to the folder structure (Fig. 1) (Kimura et al. 2011). The backup system in the MMWIN is based on the SS-MIX2. In order to save clinical information in the MMWIN storage, each facility needs to install an application that transfers patient clinical data from the hospital information system (or other information systems available in clinics, pharmacies, or nursing care homes) to SS-MIX2-format XML/HL7 files, and the gateway server that uploads the XML/HL7 files to the MMWIN center storage server. In fact, the MMWIN contained clinical information from a total of 672 facilities with 53 different vendor systems on December 31, 2018. To see patients' clinical data, the browser-based viewer application Human Bridge (Fujitsu, Shiodome, Japan) is required in users' personal computers.

The architecture of the MMWIN system is shown in Fig. 2. The main center system of the MMWIN is composed of a backup storage, a portal server to manage patients' ID registration information, the gateway that receives clinical data from facilities and stores them into the storage, and viewer applications. Computers in facilities are connected with the center sever system of the MMWIN via a virtual private network. To unify the disaster-tolerant regional health-care structure, all clinical data extracted from each facility are stored into the SS-MIX2 storage, which ensures a common format among facilities. The information system of each facility outputs a clinical register with local patient IDs at each facility in SS-MIX2 format. These data are transferred to the gateway in the center via the gateway server. The gateway in the center receives the files and stores them into the SS-MIX2 folder corresponding to each facility on the

SS-MIX2 storage. In addition, it registers index information into the index database to find and search stored files speedily. In pharmacies, the medical receipt computer cannot create files in SS-MIX2 format. Thus, instead of SS-MIX2, it outputs the file in the standard format NSIPS (New Standard Interface of Pharmacy-system Specifications) of Japan Pharmaceutical Association. When the gateway in the pharmacy transfers NSIPS files to the gateway server in the center, this gateway will convert the NSIPS files into SS-MIX2 files. As well as SS-MIX2 files, it also stores files in SS-MIX2 and register index database. In order to refer to clinical data of a particular patient in the MMWIN system, it is necessary for the patient to have a MMWIN common ID, and to link the local patient ID at each facility with the MMWIN common ID. Furthermore, permission is required to view clinical data by information disclosure through Human Bridge. If information disclosure for a patient's clinical data is permitted, Human Bridge fetches the clinical data from the SS-MIX2 storage with the local ID linked to the MMWIN common ID, and provides it to the user. A screen shot of the Human Bridge is shown in Fig. 3. Besides Human Bridge, there are several viewers, such as the pharmacy, perinatal care departments, and ophthalmology systems, which can be started via the portal system. These viewers can also fetch data from the SS-MIX2 storage and display clinical data according to a use or purpose. To avoid the loss of clinical data gathered from facilities, SS-MIX2 files and the index database are copied in a backup center located in a far distant place. As of March 2019, 672 facilities have uploaded and referred to clinical data among 958 facilities, while the remaining 286 have only refer to the data without uploading.

MMWIN Subsystems

To increase the level of satisfaction of end-users, the following subsystems were introduced: ophthalmology, perinatal care, document sharing, telemedicine, and image sharing. The ophthalmology system enables ophthalmologists to share specific data such as images of the retina, intraocular pressure, and visual fields. Using the perina-

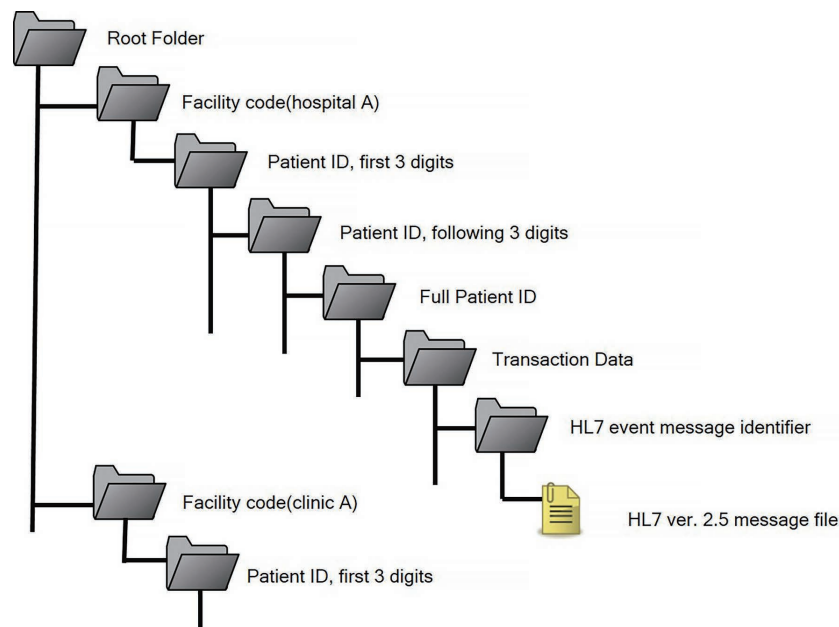


Fig. 1. Structured Medical Information eXchange (SS-MIX).

SS-MIX has a hierarchical tree structure. Medical records are stored in accordance with this rule.

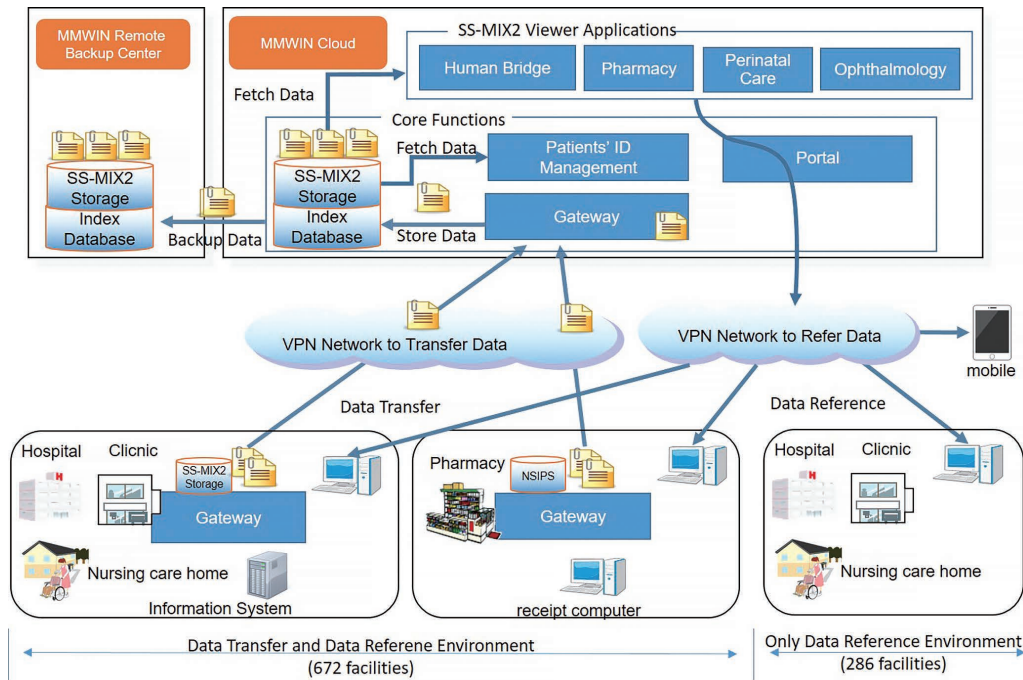


Fig. 2. Scheme of the Miyagi Medical and Welfare Information Network (MMWIN).

To save clinical information in the SS-MIX2 Storage of the MMWIN Cloud, medical facilities upload XML/HL7 files through the SS-MIX2 Gateway. Pharmacies send clinical information through the NSIPS Gateway. During the data transmission, index information is also saved in the Index Database. To access patient information, facilities need to use the viewer application Human Bridge. Patients participating in the MMWIN have MMWIN IDs, which are linked to their IDs used in local facilities.

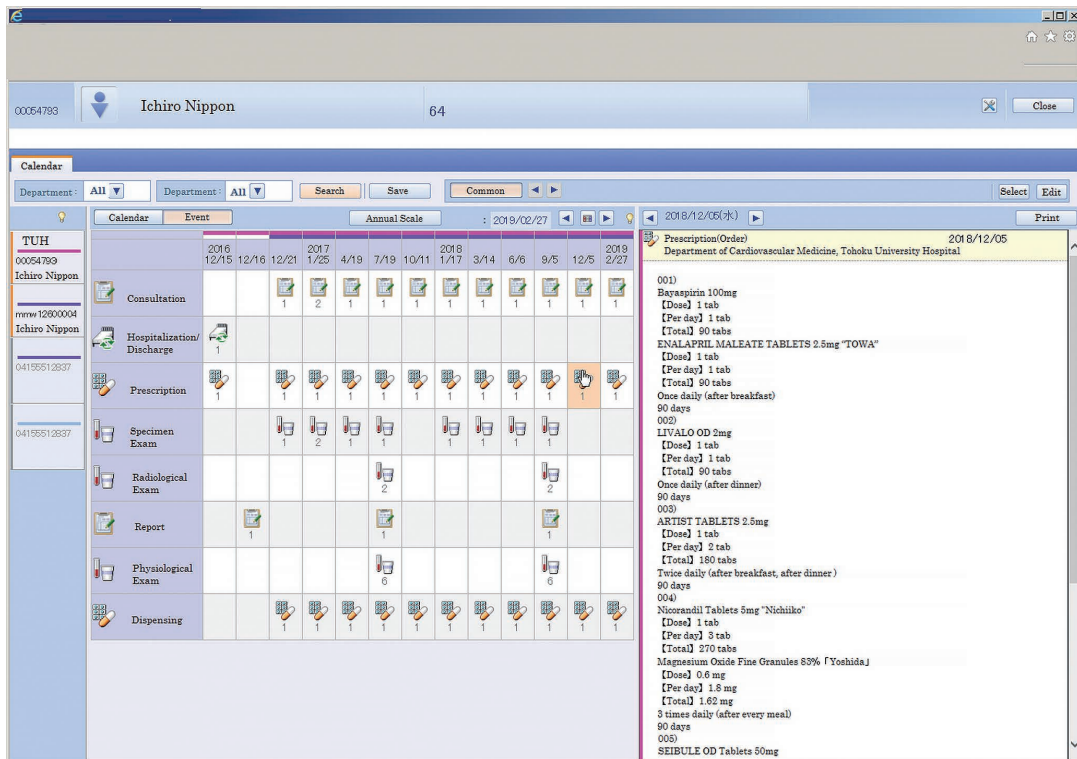


Fig. 3. Screenshot of the Miyagi Medical and Welfare Information Network (MMWIN) main viewer.

Users can access specific information by selecting icons on the left hand-side that represent care and drugs by date. This figure shows prescription data for a specific patient on December 5, 2018.

tal care system, obstetricians in the hospital where expectant mothers deliver can use the pregnancy-related information collected in clinics. The services using these subsystems gradually expanded to large hospitals and clinics throughout Miyagi Prefecture. The document sharing system allows medical staff members to upload documents that are not supported by hospital information systems. For example, hemodialysis records (Fig. 4) are needed not only by nephrologists but also any medical staff caring for patients with routine hemodialysis. Moreover, processes using fax are planned to be replaced by this document sharing system. Telemedicine and communication services such as teleconference services and a secure mail system are important, especially between university hospitals and rural areas and

islands, where these systems are useful as remote diagnostic and medical support systems of the health network. Finally, as most users require sharing imaging data, this system allows users to make images such as computer tomography and magnetic resonance available to different hospitals. In addition, doctors can send images to other hospitals, and the images can be also available on mobile devices, which enables doctors to diagnose remotely based on patients' transferred images.

Current status of MMWIN

As of December 31, 2018, the number of facilities that had joined the MMWIN was 958 (Fig. 5 and Table 1). The number of

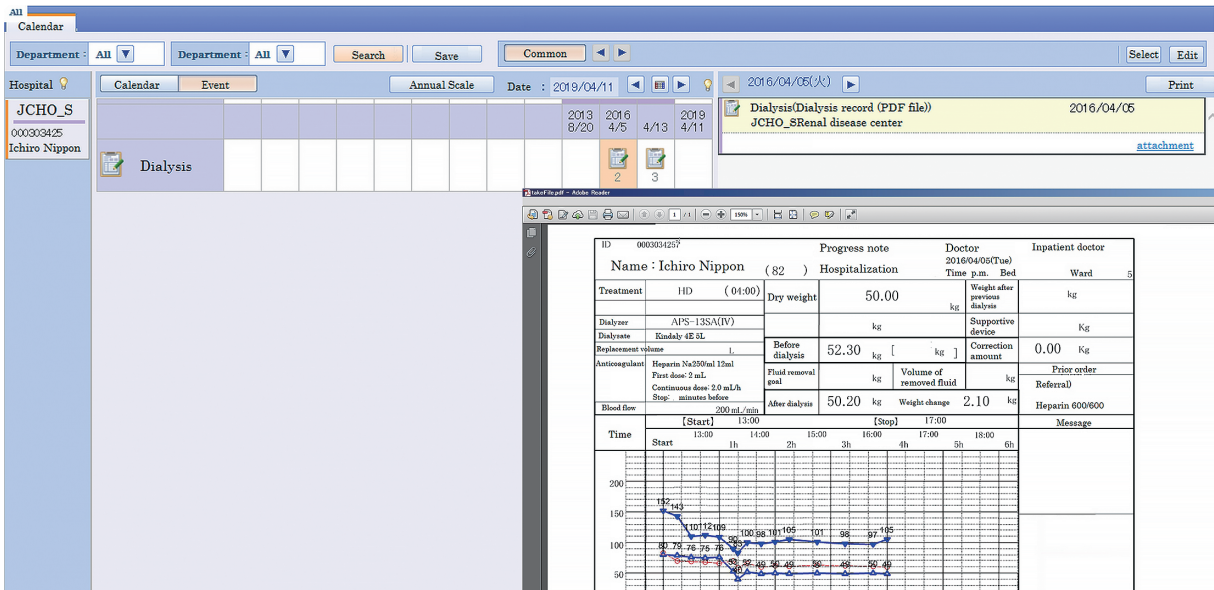


Fig. 4. Screenshot of hemodialysis record on the Miyagi Medical and Welfare Information Network (MMWIN) main viewer. Users can access dialysis records in a similar way to how they access other information.

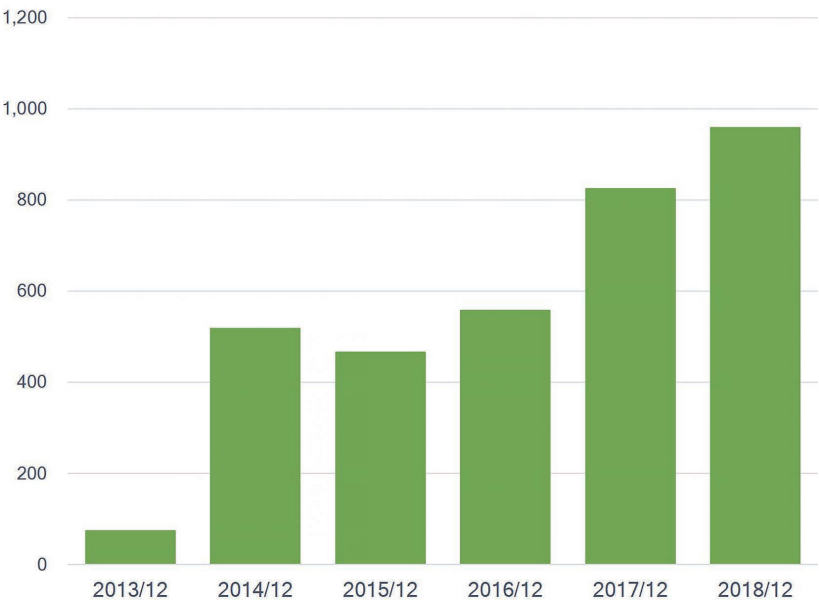


Fig. 5. Number of participating facilities. The number of participating facilities has gradually increased (958 facilities as of December 31, 2018).

Table 1. Number and ratio of facilities participating in the Miyagi Medical and Welfare Information Network (MMWIN) in Miyagi Prefecture.

	Participating	All facilities	Ratio
Hospitals	84	139	60.4%
Medical clinics	246	1,396	17.6%
Pharmacies	395	1,113	35.3%
Care homes	231	1,522	15.1%
Others	3	-	N.A.
Total	959	4,170	22.9%

N.A., not available.

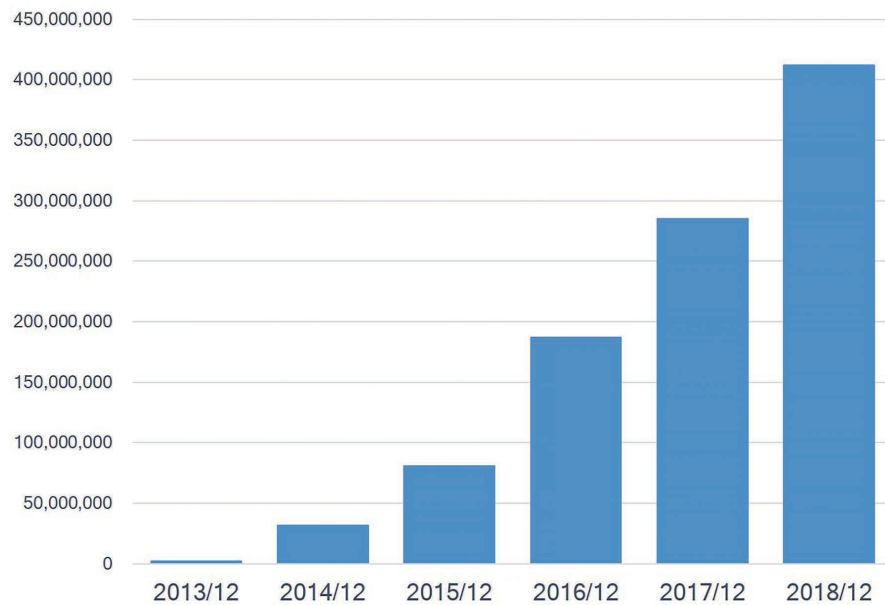


Fig. 6. Number of backup data items.
The number of backup data items has increased every year (405,554,783 items as of December 31, 2018).

participating hospitals was 84, which accounts for 60.4% of hospitals located in Miyagi Prefecture. The number of participating pharmacies, clinics, and care facilities was 395 (35.3% in Miyagi Prefecture), 246 (17.6%), and 229 (15.0%), respectively. In addition, a checkup facility and a city hall also joined in 2018. All backed up clinical data, including patients' basic information, disease names, blood tests, and prescription list, reached more than 420 million data items from 11 million patients (Fig. 6).

The MMWIN system was initially designed for the backup of patient data in the event of a disaster. Clinicians and medical staff members can share patient clinical information as long as patients provide consent allowing designated facilities to share their information. MMWIN staff members in collaboration with several hospitals and clinics registered patients who provided consent for MMWIN

data sharing. The number of consenting patients had reached 90,000 at the end of 2018 (Fig. 7).

The budget to develop the MMWIN system was provided by the government in 2013 for 5 years. Additionally, a usage fee has been collected from participating facilities. To maintain this project, the balance between costs and income should be improved by decreasing maintenance costs and increasing participating facilities and other additional services for patients involving charges.

Discussion

The present report describes the backup system for clinical data uploaded from hospitals, clinics, pharmacies, and nursing facilities in Miyagi Prefecture developed after the GEJE, which is also used for sharing patient informa-

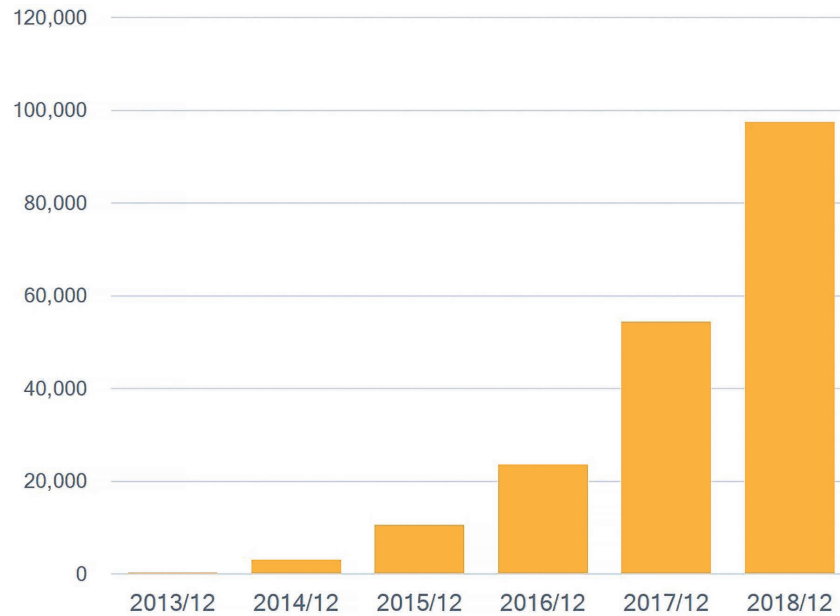


Fig. 7. Number of patients who consent to data sharing.

The number of patients consenting to data sharing has increased every year (95,790 as of December 31, 2018).

tion among medical facilities according to patients' consent. This project has several strong points in terms of safety for medical staff and patients. First, the stored clinical information can be available during disasters, when hospitals are expected to continue providing high quality care to patients. Therefore, developing business continuity plans is pivotal for each hospital. The remote backup of data from hospital information systems is considered a key factor in business continuity plans (Kuroda et al. 2013). During past disasters such as the GEJE and Hurricane Katrina, several studies pointed out that medical records were crucial to care for patients, and the loss of such records may leave patients untreated or worsen various diseases (Brown et al. 2007; Ogawa et al. 2012). In addition, an effective and prompt response under these circumstances requires real-time information to assess needs and available resources based on ordinary data collected on usual days, which are necessary for the prediction of demands in disasters. Thus, "disaster-tolerance" in the restored regional healthcare systems implies that medical information and patient records should be stored in "disaster-free sites" in addition to the original medical institution where patients are treated.

Second, the MMWIN allows medical and care facilities to share patient information trans-institutionally despite the fact that the MMWIN contains information from 584 facilities with 43 different vendor systems. Health information exchange is an important approach to share patient data among medical facilities in an electronic way, leading to extensive cooperation of regional hospitals and clinics for joint and consistent care. Rural areas in Miyagi Prefecture have been suffering from problems such as depopulation, rapid aging, and shortage of physicians, similar to other rural or remote areas in Japan; therefore, the regional

healthcare IT network system is expected to solve the health issues derived from the situation in these areas. In addition, the MMWIN system is available not only for doctors but also for nurses, physical therapists, nutritionists, and care workers, resulting in a multidisciplinary information sharing system. Thus, information items of interest are set for each worker caring for a particular patient. Health information exchange can therefore help to overcome health data fragmentation and create opportunities for joint care.

Third, as shown in Fig. 7, the use of our system has become widespread among patients. The number of patients who gave consent to share their information was only about 4,000 in the first 3 years but increased tremendously to over 90,000 at the end of 2018. Several studies pointed out that the main barriers to implement health information exchange were user resistance, lack of return on investment, and concern about security policy (Adler-Milstein et al. 2013, 2016; Kruse et al. 2014; Rudin et al. 2014; Eden et al. 2016).

Lastly, in the future, the MMWIN is expected to leverage the collected clinical data for research use. For example, the Tohoku Medical Megabank Project (TMM) led by Tohoku University started two prospective cohort studies: a population-based adult cohort study with 80,000 participants, and a birth and three-generation cohort study with 70,000 participants, including fetuses and their parents, siblings, grandparents, and extended family members (Kuriyama et al. 2016). The two cohort studies contribute to an integrated biobank of biospecimens, genome, and omics data. Most of the participants currently have normal health but may develop diseases in the future. Combining clinical data from the MMWIN with genome data from the TMM will help to establish a substantial basis for the devel-

opment of personalized healthcare and medicine.

Several limitations of the present system need to be mentioned. Mainly, the MMWIN is maintained by subsidies from the local government. Thus, the first priority is to obtain financial independency, as pointed out in many other similar projects (Kruse et al. 2014; Eden et al. 2016). Increasing usage fees from facilities and decreasing costs for maintenance is crucial. Fortunately, the number of participating facilities and their usage of several subsystems for further additional fees has been increasing. In addition, the phase of the MMWIN will move from development, requiring a tremendous budget, to maintenance, with a minimum cost.

In conclusion, we have developed a backup system for clinical data that can be used in disaster situations, which also allows medical and care facilities to share patient information. The number of participating facilities, backup data, and patients providing consent for sharing information has steadily increased, and the use of the system has become widespread, improving patient care in terms of quality, economy, and efficiency.

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Conflict of Interest

The authors declare no conflict of interest.

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