Project on Information-support Solution in Emergency Medical Service

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Recent years have seen reports of incidents in which patients die during emergency patient transfer before reaching hospital to be treated. Further, there are an increasing number of cases to be addressed where ambulances are on site for longer than 30 minutes in search for a hospital with a capacity to receive patients, and this number is predicted to grow further. These are becoming social problems. This paper explains the development of an emergency medical system in Japan and issues regarding the information system in emergency medical services. It also describes some of the projects at Fujitsu that address these issues, including the information-sharing system for an emergency medical service that allows for data-sharing between paramedics and hospital staff to minimize the patient transfer time. Another project at Fujitsu is a system to support emergency medical services for elderly patients, which draws on regional health information exchange (HIE) systems to select an appropriate destination hospital and facilitate preparations for timely acceptance.

1. Introduction

Recent years have seen reports in which patients die during emergency patient transfer before reaching hospital to be treated because of a delay in finding a medical institution with a capacity to receive patients, and this is becoming a social problem. The number of ambulances get called out has increased by more than 30% from 10 years ago, and this number keeps increasing every year. For the last few years, more than 50% of those who used the ambulance service were elderly patients. In view of the rapidly aging population in Japan, this figure is likely to grow.

According to a forecast up to 2014 made by the Fire and Disaster Management Agency (FDMA), the number of ambulance callouts will increase while the gross national population will dramatically decrease by 2024 (**Figure 1**). Therefore, there is an urgent need to deal with this demand for emergency medical services.

There have been many initiatives to leverage information and communications technology (ICT) effectively in paramedic activities. As the latest development, Fujitsu and other manufacturers are offering information-sharing solutions which allow on-site paramedics to communicate with medical institutions via a mobile network and share real-time information about the patient's conditions and acceptance status of emergency patients in the hospital, using smart devices fitted in the ambulances.[1)–4)]

Based on this, this paper addresses the present circumstances and challenges in relation to the emergency medical services today. It also describes the present states of ICT deployment in emergency medical services, and explains Fujitsu's endeavor to find solutions to the issues. Further, the paper introduces a system to support emergency medical services for elderly patients, developed mainly at the initiative of the Medical Association in response to the growing need for the sharing of patient data to leverage regional health information exchange (HIE) systems when transferring elderly patients.

2. Present circumstances and challenges of emergency medical services

Japanese emergency medical services are available "at anytime, anywhere, to anyone."

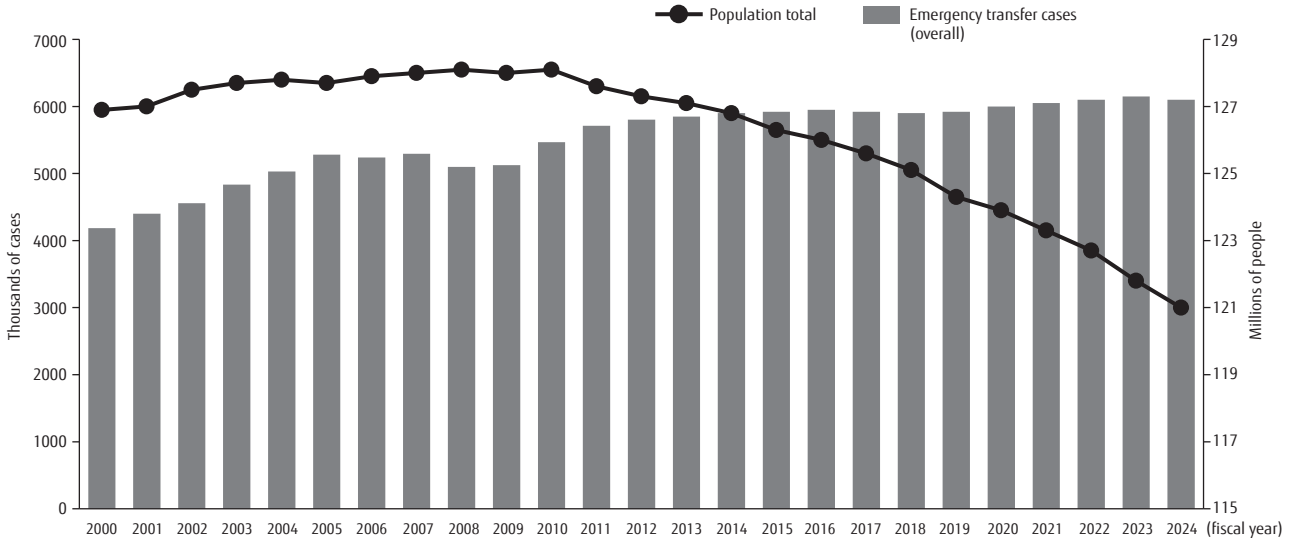


Figure 1
Emergency service deployment, present statuses and future predictions.

The beginning of that is an ordinance "Defining the emergency hospital" which was enacted in 1964.

Based on this, hospitals and clinics have announced they can be used as emergency medical facilities with approval from the prefecture. In 1977, the emergency medical services were further institutionalized into a three-tier structure with initial, secondary and tertiary emergency medical care facilities.[note 1)]

Meanwhile, aiming to improve medical care before and at the time of transferring patients, a new legislation "the Emergency Life-saving Technicians Act" was passed in 1991 that allowed paramedics to administer emergency treatment during transfer before the patient reached hospital (Prehospital Emergency Care). Today, the scope of treatment these paramedics are allowed to conduct under medical supervision has expanded, including administering cardiac arrest patients with defibrillation, intubation and injection (adrenaline jabs), leading to significant improvements in healthcare.[5)]

note 1) Initial emergency medical care treats patients whose illness or injury is relatively mild, and who may be able to return home without aid. Secondary emergency medical services deal with patients who suffer from an illness or injury that may not be fatal, but who need to be admitted to hospital for treatment. Tertiary care is reserved for seriously ill or injured patients who require immediate medical attention for their survival.

While paramedics qualify to perform high-level pre-hospital care as just mentioned, they are not allowed to administer emergency medical care without a physician's specific instructions. This has given rise to the need for medical control (MC) to ensure that the paramedic's pre-hospital care is of a sufficient medical quality. MC entails preparing an emergency medical care operation protocol; giving education and training based on the protocol; having a physician offer instructions, orders and advice; and carrying out a post-operation evaluation. MC is becoming increasingly important as the paramedics deal with a wider range of treatments.

In 2002, the FDMA and the Ministry of Health, Labour and Welfare (MHLW) issued "a notice to prefectures regarding efforts to establish a Medical Control Council"[6)] informing them of the decision to establish MC Councils at the prefectural and community levels.

The prefectural MC Councils consist of the prefecture's primary fire department, public health department, and regional medical association, and others and they are responsible for liaising with community MC systems and giving instructions and advice based on reports by community MC Councils. The community MC Councils consist of major emergency medical institutions such as Emergency Medical Centers as well as local council and fire departments, and they provide support for liaising with the fire brigade and medical

institutions involved in pre-hospital care, preparing operation protocols and manuals, securing post-operation evaluation systems, and training EMTs.

Since paramedics' pre-hospital care requires MC systems to be in place as a prerequisite, local fire departments are also proactive in setting up and developing MC Councils.

The 2008 amendment to the Fire Service Act provided that prefectures were allowed "to prepare their own operational standards regarding patient transportation and hospital acceptance" in order to realize speedy, effective emergency medical services based on local needs at the prefectural level.

This amendment was intended not only to reduce the time emergency vehicles are on the road, but also to ensure that patients could be brought to medical institutions with the right capacity and equipment to treat them. The standards include medical institution charts that reflect the local circumstances of the prefectures to ensure medical treatment can be given to patients appropriately according to their conditions, as well as observation protocols for paramedics and rules for identifying alternative institutions for patient admission in case there is a difficulty in finding one immediately. Cases are always reviewed in order to improve the standards. **Figure 2** shows the legal and structural developments of emergency medical systems in Japan.

3. Issues at the frontline of emergency medical services

Despite all the efforts being made as stated above, the demand for emergency medical services continues to increase every year, and the time required for patient transportation is also increasing. Fundamentally, this is attributed to the shortage of emergency medical facilities and unequal distribution of specialized physicians. With this in mind, we will describe the challenges pertaining to the liaison between fire departments and medical institutions.

1) Increase in number of patients transferred

In 2013, 5.34 million people were transferred to hospitals by ambulances in Japan, which is the highest number so far.[7] Approximately 50% of them had mild conditions, and 50% were accounted for by elderly patients. Data for the ten-year period up to 2012 show that the numbers of children and young adults with mild conditions who were transported by ambulances is remaining stable, whereas the number of elderly patients is on the increase even for those with mild and more-than-mild conditions. Considering the advance in population aging, this tendency will continue (**Figure 3**).

2) Decrease in number of medical institutions

According to the Health Statistics issued by the Organisation for Economic Co-operation and Development (OECD), the number of physicians per 1000 people in Japan was 2.29 in 2012, well below the

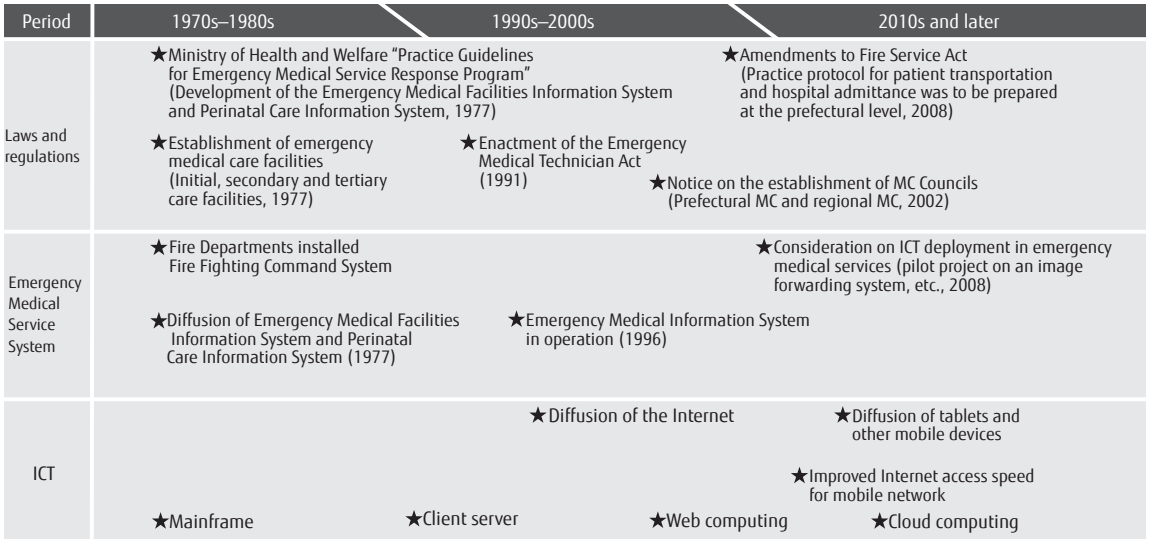


Figure 2
Legal and structural development of emergency medical care systems in Japan.

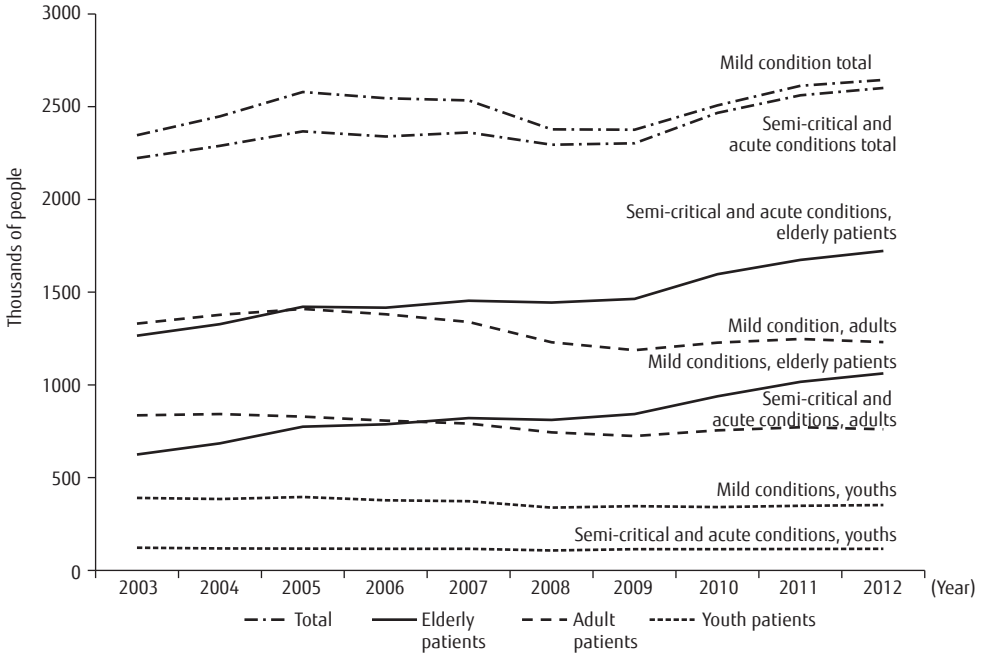


Figure 3
Statistics on transportation for mild/semi-critical/acute patients by age group.

average of 3.58 in member states.[8)]

The number of secondary emergency medical facilities is also constantly declining throughout the country, going from 4132 in 1996 to 3053 in 2008, a decrease of 26.2%.[9)] Furthermore, the maximum number of medical students to be admitted in a year became restricted in 1984. In 2004, a new clinical training system started, allowing medical students to choose their locations for on-site training. These changes resulted in trainee physicians concentrating in urban hospitals, and not many of them return to their hometowns after the training period, exacerbating the shortage of physicians in rural regions. In view of this situation, the MHLW is pursuing some measures to increase the student quota at medical schools and to improve working conditions for female physicians, as there have been more of them in recent years.

4. Present circumstances and challenges of ICT deployment in emergency medical services

In this section, we will explain the procedures of emergency patient transportation, and describe the present circumstances and challenges in relation to the systems that aid emergency medical services.

1) Emergency patient transportation process

Figure 4 depicts the task flow of patient transportation from an emergency call to dispatch of an ambulance and its return to the station, together with the main tasks of paramedics and the systems they utilize.

Upon receiving an emergency call, the operator at a General Fire Department confirms the patient's current location and physical conditions, and then issues a request for an ambulance at the respective fire brigade. The information obtained from the emergency call is all the operator can pass on to the paramedics. Once the ambulance is at the site, the paramedics consult the person who made the call and others involved to verify the patient's identity and to gain more details of the situation and the patient's condition. If the patients are capable of communication, the paramedics also speak to them. The paramedics check the condition and determine the level of urgency of the patient, to select the optimal medical institutions as transport destination. In the selection, being the closest hospital from the dispatch location is given priority. Via a phone call, after offering information and the symptoms of the patient, paramedics issue an acceptance request to a selected medical institution. As for the medical institutions, they

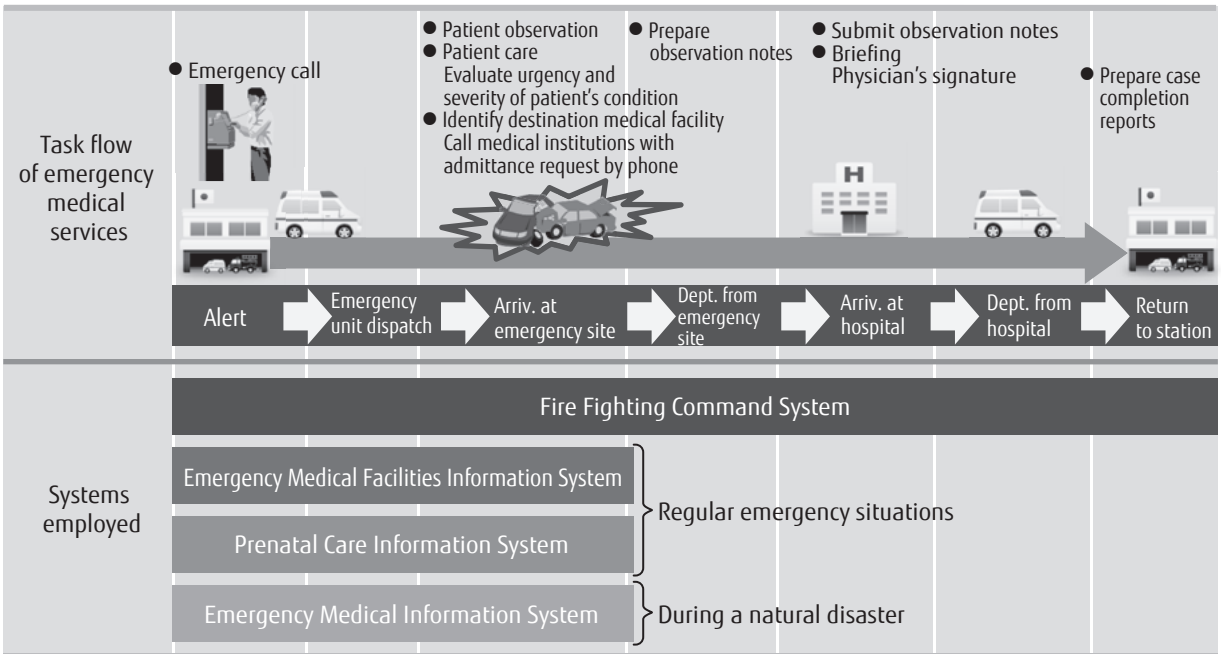


Figure 4
Task flow of emergency medical services and employed systems.

can only obtain information about the patient during the call made by the paramedics, where they must make a decision on whether it is possible to take in the patient. The paramedics will brief the physician in charge as they arrive at the medical institution, and hand them an observation note (activity record) that contains information about the patient regarding their symptoms, conditions and major complaints, to which the physician adds an account of treatment, and then signs and returns it to the paramedics. The paramedics return to the station, and prepare a report on the completion of the case, which concludes their task of patient transportation.

2) Systems utilized in emergency medical services

Most prefectures employ the following arrangements: Fire Fighting Command System, Emergency Medical Facilities Information System, Perinatal Care Information System[note 2)], Emergency Medical Information System (EMIS) and Medical Information System. Each system is explained in **Table 1**. We will explain the Fire Fighting Command System and Emergency Medical Facilities Information System as these are the most often utilized ones in emergency patient transportation.

The Fire Fighting Command System determines the location of the incident (natural disaster) on a map based on the name and address of the caller (phone contract holder) automatically identified from the phone number (landline or mobile phone) from which the emergency call is made. It makes an arrangement for appropriate emergency vehicles to be dispatched, and executes a series of processes to have the emergency vehicles deployed from the fire station in charge, while also providing the necessary support for rescue activities in general. The system also supports the preparation of reports after the brigade returns to the station and the processing of data on each case for statistical reports.

The Emergency Medical Information System began operating in 1977 at the implementation of the Practice Guidelines for Emergency Medical Service Response Program issued by the Ministry of Health and Welfare. With the diffusion of personal computers and

note 2) Perinatal women (from 22 weeks into pregnancy to up to 6 days after delivery) and newborn babies are vulnerable around this period of pre- and post-pregnancy. Therefore, it is important to have a coordinated comprehensive care system, which spans obstetrics to pediatrics, in place in case of emergency. The Perinatal Care Information System caters for such patients in perinatal conditions.

Table 1
Major systems of emergency medical information.

System name	Users	Administrator	Description
Fire Fighting Command System	Fire department	–	The system gives support to regional community fire brigades and others with regards to a series of tasks pertaining to emergency medical services, from the emergency call to dispatch order and case closing report (case record).
Emergency Medical Facilities Information System	Fire department	Medical institution	Medical institutions update the hospital capacity information daily. Paramedics refer to this information while on emergency deployment to identify a destination hospital. Installed in 43 prefectures[10]
Perinatal Care Information System	Fire department	Medical institution (obstetrics/ pediatrics)	Medical institutions (perinatal facilities) update the hospital capacity information daily. Paramedics refer to this information while on emergency deployment to identify a destination hospital. Installed by 45 prefectures[10]
Emergency Medical Information System	Fire department Medical institution Government	Medical institution Fire department Government	Disaster-response medical care information is shared across prefectural borders in case of a natural disaster, conveying operational statuses of the hospitals in affected areas, to gather and provide comprehensive information in relation to smooth provision of medical care and rescue efforts in such areas. Installed in all prefectures[11]
Medical Information System	Residents	Medical institution Government	Residents can access information on medical institutions through searching by practice and address using the Internet or their mobile phones. Some prefectures provide a 24-hour telephone operator system.

mobile phones that can be connected to the Internet, the system is installed in most prefectures today. The fire departments are supplied with information regarding medical institutions through the system, in terms of their current capacities for each clinical department and bed availabilities. The capacity information is updated regularly by the medical institutions every day. The fire departments can access the data in order to determine the hospital to which they will transport patients.

3) Issues with Emergency Medical Information System

The most time-consuming tasks in the transportation of emergency patients are those performed in the period from the arrival of the paramedic team at the site until they reach a hospital. The national average of this period is 30.4 minutes for 2012, an increase of 35.1% in comparison with the figure for 2002.[12]

In 2006, there was an incident in which a pregnant woman eventually died due to a delay in emergency transportation. As a result of this incident, the FDMA conducted a survey on pregnant/perinatal patient transportation and found that, in emergency transportation, there was an increase in the number of patients being refused by many hospitals. This finding prompted further investigations at 757 fire departments in all prefectures to examine their recognition of the importance of having a liaison between fire departments and medical institutions in emergency patient transportation.

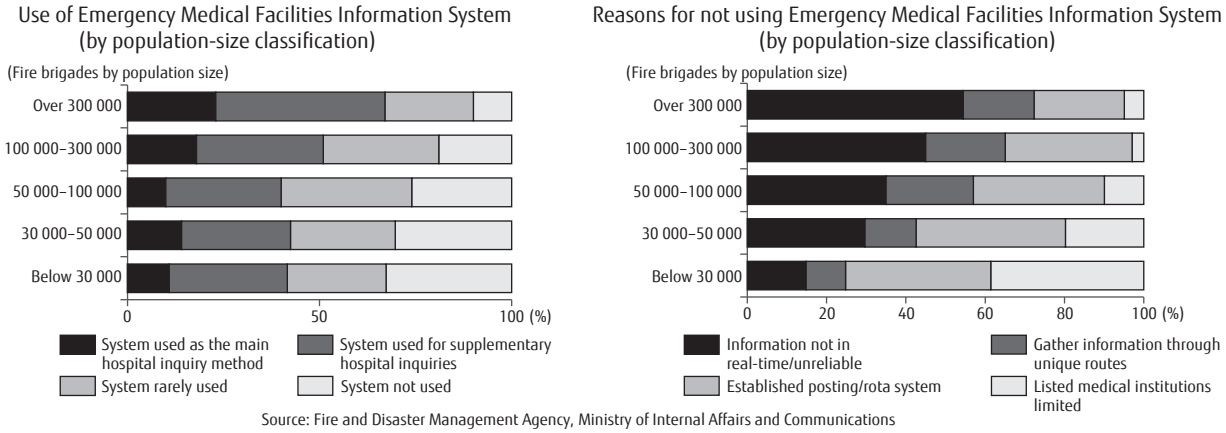
As a result, it proved that a half of them either seldom or never used the Emergency Medical Information System (**Figure 5**).

Even in urban areas, where there is generally believed to be a higher level of system utilization, those that were underusing the system accounted for 30% of fire departments despite a higher incidence of ambulance callouts and more medical institutions that deal with emergency cases. The underlying reason for this is that, despite the need for reliable, real-time information on accessibility, only 10% or so of the medical institutions kept an eye on the real-time capacity information.[13]

This is a factor that contributes to increasing the transportation time and creates difficulties in identifying appropriate destination medical institutions. These issues regarding the system and its operation reflect the fact that many fire departments regarded the "real-time aspect" and the "certainty of medical institutions' admittance acceptance" as important factors in using the system.

5. Projects on emergency medical services at Fujitsu

It is crucial to have close collaboration between paramedics and medical institutions in order to immediately identify an appropriate medical institution according to the patient's conditions for the best treatment, and ICT has the potential to improve such



Source: Fire and Disaster Management Agency, Ministry of Internal Affairs and Communications
"2007 Conference on Promoting the Enhancement of Skills in Pre-hospital Care; report"

Figure 5
Current usage of Emergency Medical Facilities Information System (national).

collaboration.

We will describe some systems Fujitsu offers, including the system of real-time information-sharing for paramedics to verify reliable capacity information, and the Information-support Solution that facilitates appropriate medical attendance.

5.1 Case 1: Hospital reference information to be shared among paramedics through the Fire Fighting Command System

1) Outline

Fujitsu delivered to Sendai City Fire Bureau a comprehensive system for fire service communications in 1991. In 2010, Fujitsu developed the Byoinshokai Support System (BSS; *byoinshokai* means "hospital reference" in Japanese) that incorporated smartphones and put it in operation as part of the system. Like other municipalities, Sendai City was experiencing an increasing number of emergency call cases, and the transportation time was longer than the previous 10 years by 6 minutes. The city needed to improve both the way to identify destination hospitals and the transportation efficiency.

2) System structure

As part of social infrastructure, the Fire Fighting Command System operates completely independently. Therefore, BSS links up with the system via a gateway (a device to relay the connections between different networks and systems). Each client accesses the BSS server via the Internet, and the data are encrypted through a Virtual Private Network (VPN).

3) Operation of BSS

Paramedics use smartphones as terminals to look up medical institutions. If they find a certain institution has indicated its non-availability, the paramedics upload this piece of information onto the BSS server using the smartphone. This information can be viewed by other paramedics, and thus it helps them to reduce the time lost in making inquiry calls to the same medical institution, leading to a shorter transportation time.

BSS allows users to select and view the relevant emergency case and its details (address, time of incident occurrence, etc.) from a list of emergency cases sent from the Fire Fighting Command System. An added handwritten note feature that comes with tablet devices enhances the communication in place of conventional radio communication sent by the system operators, lowering the risk of some of the conveyed information being overlooked.

The use of smartphones makes the process flow seamless, as paramedics can select a medical institution from the list, call them straightaway, and enter the results of the communication after the conversation. The information on the contacted medical institutions (contact date and time, and inquiry results) is submitted to the Fire Brigade Deployment System, and the data may be used to prepare reports.

It generally takes three minutes to make one inquiry to a medical institution. BSS helps to reduce the number of inquiries to be made, and thus makes patient transportation more time-effective. Furthermore,

the use of a data network, as opposed to phone lines, made BSS a viable system in the event of the Great East Japan Earthquake in 2011, when phone lines immediately became usable only in a limited capacity. It must be noted, however, that BSS was also unusable in certain areas, according to some reports.

4) Future development

BSS helps to enhance efficiency in identifying destination hospitals by allowing paramedics to share information and avoid making unfruitful hospital inquiries. An additional feature is currently under consideration that would make it possible to share information with several medical institutions simultaneously, conveying precise information about the patients' symptoms and conditions.

5.2 Case 2: Use of tablet devices to share information between paramedics and medical institutions

1) Outline

The Sunto District (Eastern Shizuoka area) of Shizuoka Prefecture is experiencing difficulties in maintaining the secondary emergency medical care rota system due to a decline in the number of secondary emergency medical facilities and physician shortages as well as an uneven distribution of specialist doctors. Discussions were held at the initiative of three medical associations of Numazu, Mishima and Gotenba with participation by representatives of secondary emergency medical facilities, local authorities and fire departments. They subsequently initiated a pilot operation of a wide-area secondary emergency medical care system that covered the entire area under the purview of the three medical associations.

As the area expanded, it became more time-consuming to select destination hospitals for emergency transportations and patient transfers during the nighttime and weekends. To address this challenge, the three medical associations and Fujitsu developed the Eastern Shizuoka Emergency Medical Information Matching System (ESMAT) and started operating it in 2013.

2) System structure

ESMAT facilitates communications between paramedics and medical institutions via a cloud-based server, using tablet devices as clients. These tablet devices have been fitted in all 29 ambulances stationed within the 4 cities and 3 towns in the Sunto District, as well as at 18 secondary emergency medical facilities, where they can also access the system using personal computers. The network uses Secure Sockets Layer (SSL) encryption.

3) Operation of ESMAT

ESMAT makes it easier to share real-time information not only between paramedics, in order to determine the availability of hospitals that can accept patients of hospitals that can accept patients, but also with medical institutions to obtain various types of information. This includes patients' sex, age and other personal data as well as information on their physical conditions. The information can be transmitted to several medical institutions simultaneously. This will help the medical facilities to make decisions on admittance without delay, and prepare for the arrival of the patient and swift administration of medical care. The system is also equipped with a feature to output the observation notes, containing the information about the patient that was entered during the course of primary stages of emergency services, helping reduce the paramedics' workload. It also comes with functionalities to aggregate the case data and generate graphs, or prepare CSV (comma-separated values) output, of the information on the numbers of emergency cases and patients transported, sorted by date and/or the fire department or medical institution involved. Because the user can easily comprehend the system operation statuses, the system can be utilized for long-term, effective evaluation of the ways to deploy systems and for reviewing the patient transportation practice protocol.

4) Future development

Since its launch in 2013, ESMAT has been under review to examine the need for additional features and operational methods based on user feedback.[14] Requests from paramedics include a simpler method of data entry to allow them to prioritize patient care on site, and data utility so that they can use the recorded data not only for preparing the observation notes in the emergency vehicles, but also back in the office when they prepare case completion reports and other forms, including one for the national statistical annual report on emergency cases.

The medical institutions are requesting a function that allows them to share information on patients' medical history and medication/allergy data, which are important for making a decision on patient admittance.

5.3 Case 3: Connecting HIE network and emergency transport support system

1) Outline

The challenges facing the emergency medical services stated above are equally significant at various medical facilities, where they also suffer from physician/specialist shortages.

With the population aging moving into full swing, the national medical system is also transforming, dividing the medical route up into a course of stages (from acute, quasi acute, recuperation, rehabilitation to home care) and other functions such as regular clinic and secondary emergency medical care. The conventional medical care that revolved around hospitals is now moving toward more HIE networks. In this shift, it is vital to have collaboration with the emergency medical care (services) for elderly people. As an example of constructing such a system, we present a project of a system to support emergency medical services for elderly people (*Tobiume* Net) which was jointly developed by the Fukuoka Prefecture Medical Association and Fujitsu.

2) Operation of *Tobiume* Net

Fujitsu developed a "system to support emergency medical services for elderly people" at the initiative of the Fukuoka Prefecture Medical Association. This system provides paramedics with various types of information in an emergency situation. The information includes local residents' personal health records (PHR: comprehensive healthcare data of elderly citizens covering a range of data from regular check-up results to home-care information, registered with the consent of the patients and their physicians of regular clinics) and Face Sheet (patients' personal information such as sex, age, occupation and home address) (**Figure 6**).

The database contains information that is

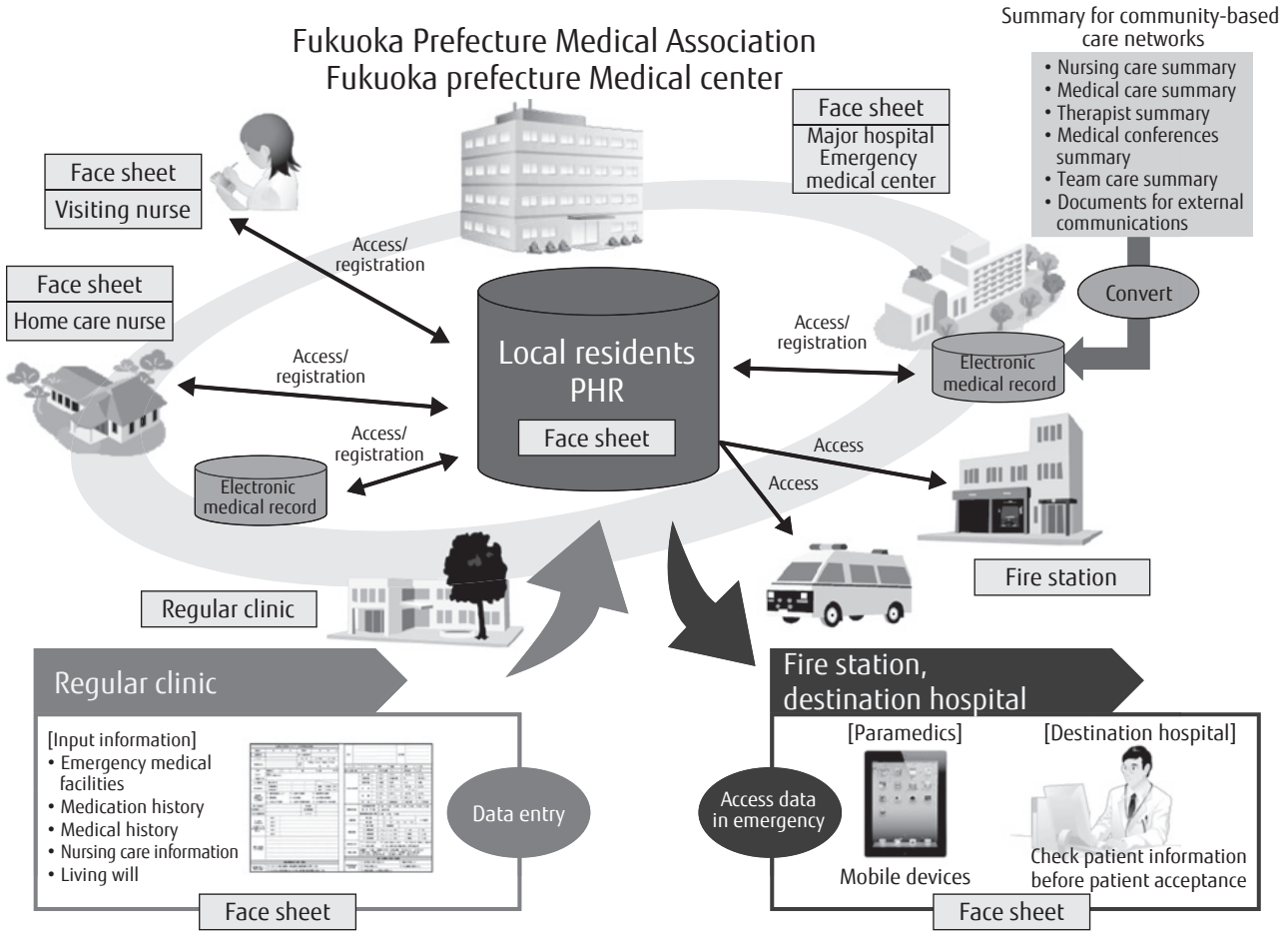


Figure 6
Geriatric emergency medical service support system (Tobiume Net).

necessary for emergency patient transportation and care, including the patients' basic data as well as their preferred medical institutions, diagnoses, allergies and medications. It is being leveraged in the primary care of emergency services and helping to reduce response time.

3) Future development

Currently, the system is deployed in two areas in Fukuoka Prefecture (Kasuya Town and the ward of Wakamatsu), and it is planned to be rolled out to the entire prefecture.

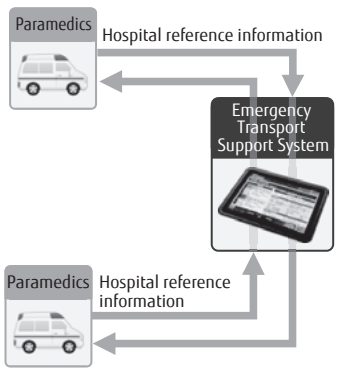
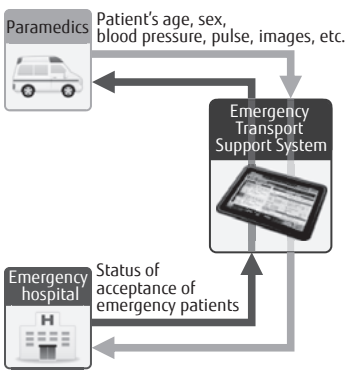
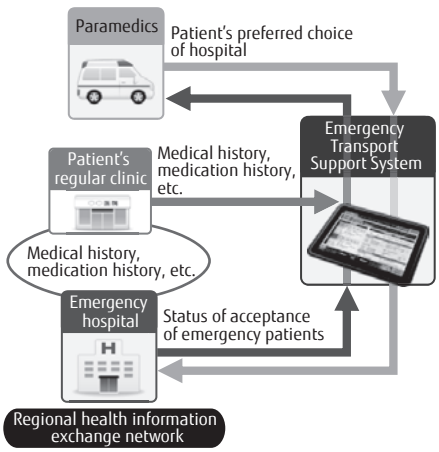
Table 2 summarizes the operational concepts of the three cases described above.

6. Conclusion

Emergency medical services have improved to the extent that paramedics are now able to obtain various types of information through a seamless liaison between the Fire Fighting Command System and HIE network. This has made it possible to shorten the patient transportation time, and provide information about the patients in terms of their preferred choice of medical institutions, medical history, allergy and other data. These cases underpin the idea that ICT deployment will help lead to faster identification of destination hospitals, facilitating the best treatment for patients based on their conditions.

Based on its expertise and know-how gained through the development of fire services and healthcare solutions, Fujitsu will continue striving to realize a society equipped with a dedicated emergency medical care network that gives people piece of mind.

Table 2
Operational concept of information-support solution in emergency medical service.

Cases	Case 1: BSS	Case 2: ESMAT	Case 3: *Tobiume* Net
Features	Information-sharing among paramedics	Information-sharing between paramedics and emergency hospitals	Information-sharing between paramedics, emergency hospitals and regular clinics
Users	Paramedics	Paramedics, emergency hospitals	Paramedics, emergency hospitals, regular clinics
Aims	Reduces unfruitful inquiry calls	• Shares information about patients' symptoms and vital signs, and improves the information's accuracy • Supports the hospitals with their capacity judgement responses and patient acceptance preparations	• Speedy decision on the destination hospital by obtaining information about the patient's preferred choice of medical institution • Appropriate decision on the destination hospital by obtaining information about the patient's medical history, allergies and medications, facilitating smooth patient acceptance
Shared information	• Hospital reference information (acceptance capacity information) • Acceptance statistics by hospitals	• Patient information (age, sex, vital signs, images, etc.) • Capacity information from hospitals	• Patient information (name, age, address, contact details, etc.) • Patient's preferred choice of medical institution • Patient's medical data (medical history, allergies, medications, etc.)
Operation image			

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Mr. Ishibai is currently engaged in planning and development of emergency medical services' peripheral systems.