Future Challenges in Fujitsu's Healthcare Business—Activities of Next-Generation Healthcare Innovation Center—

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Since the mid-1970s, Fujitsu has been at the forefront of information and communications technology (ICT) in the field of medical care. Being the first in Japan to develop and launch package solutions for medical care providers, Fujitsu has always moved in step with customer needs and expectations. A major paradigm shift is taking place today in tandem with remarkable advances in medical technology and ICT against the background of a super-aging society and a changing disease structure. The degree of health information sharing is expanding along with advances in networking, and an era is approaching in which healthcare information for the entirety of an individual's life is available through the network. This paper describes Fujitsu's efforts to date and its present situation in the field of medical care and introduces activities and specific examples of technology development at the Next-Generation Healthcare Innovation Center, which was established to bring about a society in which people can lead long and healthy lives.

1. Introduction

The application of information and communications technology (ICT) in the field of medical care has traditionally focused on the use of information technology by healthcare providers. Today, however, major changes are beginning to take place due to new approaches driven by advances in medical care technologies and ICT and to the launch of network systems in tandem with the shift from hospital-based to region-based total medical care.

This paper describes the transitions that have taken place in medical care ICT over time and changes that are occurring in the present and presents the approaches of the Next-Generation Healthcare Innovation Center.

2. Transitions and trends in medical care ICT

In Japan, the use of ICT in the field of medical care began in the mid-1970s, and since then, four generations of change have taken place, each lasting about ten years. The 1st generation was marked by the introduction of department systems, the 2nd generation by the introduction of order-entry systems, the 3rd generation by the introduction of electronic medical record (EMR) systems, and the 4th generation by the introduction of regional health information exchange (HIE) networks (**Figure 1**). The expansion of ICT in the field of medical care has also been promoted as a matter of national policy—since the government announced its e-Japan strategy in January 2001, the application of ICT has continuously been ranked as a priority policy in Japan. Fujitsu has been providing ICT solutions and services that support the widespread use of medical care information from the very beginning and has come to acquire the largest share of this massive market in Japan.

During this period of expansion, a variety of technological changes have occurred, such as the migration from legacy systems using mainframes to open systems, the explosive growth of the Internet and other networks, the use of cloud computing, and the spread of smart devices. In addition, such technical innovation continues in the present with no end in sight, as reflected by big data analysis technology, high performance computing (HPC), grid computing, the Internet of Things (IoT) using sensor technology, and the Internet of Everything (IoE) using smart devices,

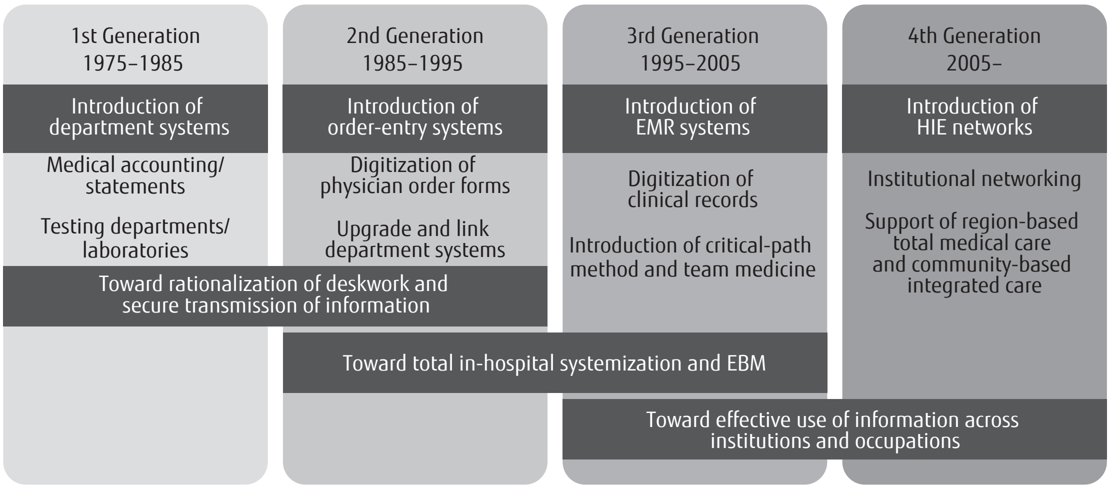


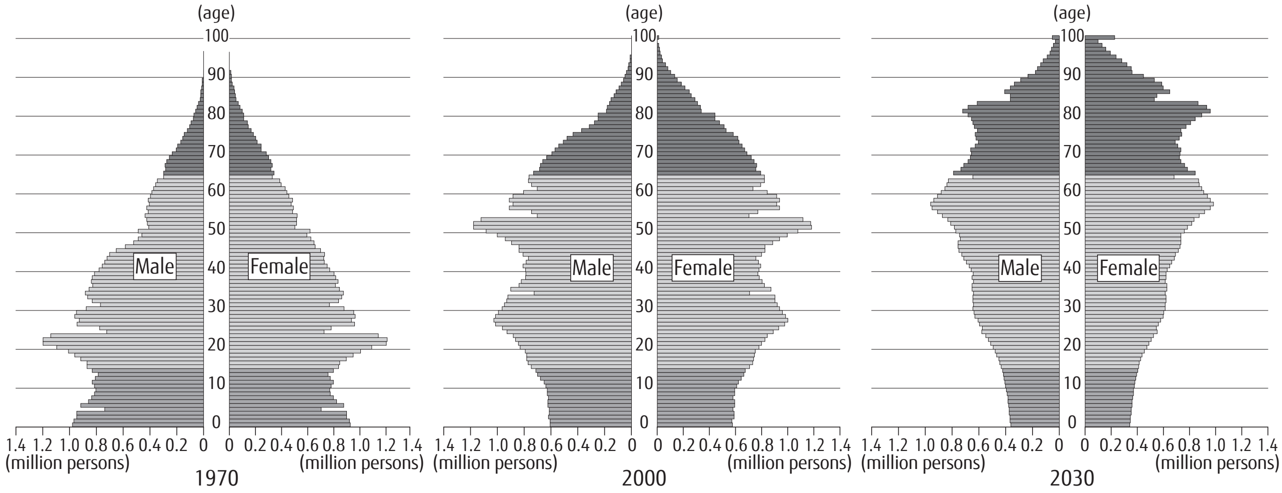
Figure 1
Transitions in healthcare ICT.

wearable devices, and augmented reality (AR). These revolutionary changes have been occurring at a rapid pace. For example, the processing ability of today's smartphones now exceeds that of supercomputers used ten years ago.

Changes are likewise taking place in the medical care environment. There are many factors behind these changes, such as the increasing diversity of medical care against a backdrop of hospital functional specialization and community-based integrated care, the aging population and low birth rate, and advances in medical care technology. All of these factors are generating a need for improved provision of medical care and reasonable healthcare charges set on a national basis.

While the problem of an aging population due to a low birth rate cannot be treated as an isolated problem since it is actually a side effect of economic growth, it is changing the shape of Japan's population pyramid from its present gourd shape to a paper-lantern shape (**Figure 2**). The National Institute of Population and Social Security Research[1),2)] forecasts that Japan's elderly population (65 years of age and older) will exceed 30% of the total population by 2020 and that the annual number of deaths will exceed 1.5 million, about twice the number of births. It also forecasts that the elderly population will be about 37 million in 2030, that the working-age population (18 to 64 years of age) will be about 67 million (about 60% of the total population), and that the average life expectancy will be 81.95 years for men and 88.68 years for women. Furthermore, as Japan becomes the first country in the world to confront a super-aging society, its disease structure will likely change, reflecting an increase in malignant neoplasm, heart disease, cerebrovascular disease, diabetes, and other medical conditions that mainly affect the aged. Japan's response to the super-aging society will be watched closely by other countries in similar situations.

Remarkable advances have taken place in medical care technology, especially over the last ten years. In the area of biotechnology, the results of the Human Genome Project (HGP) have been particularly profound. Since June 2000, when sequencing of the human genome was declared complete in a joint announcement by United States President Bill Clinton and British Prime Minister Tony Blair (final version released in April 2003), technical innovations in DNA sequencers have contributed greatly to shortening the sequencing period at a rate exceeding Moore's Law and to reducing costs,[3)] thereby making clinical applications a reality. This accelerated pace of research and development in biotechnology has had multifaceted effects, including application of results to personalized medicine, preventive medicine, and drug discovery. Attention is also coming to be focused on the practical implementation of regenerative medicine as typified by the use of induced pluripotent stem (iPS) cells, the application of robotic technologies such as in robotic surgery, the use of 3D printers, and the development of next-generation



“Population Pyramid” (Statistics Bureau, Ministry of Internal Affairs and Communications)
Prepared from data at http://www.stat.go.jp/data/kokusei/2010/kouhou/useful/u01_z24.htm

Figure 2
Change in Japan’s population pyramid.

medicine including anti-aging treatments.

3. Fujitsu’s healthcare business system: from life innovation to future medical care

Taking into account the trends in medical care described above, Fujitsu established the Life Innovation Office in its Healthcare & Educational Systems Unit in January 2013 with the aim of achieving an ICT environment as envisioned in the Life Science Growth Strategy of the Japan Revitalization Strategy announced by the government in 2012. Now a Life Innovation Division is supporting the construction of various types of ICT systems. This effort is based on a policy of “achieving world-leading medical care technologies and services and extending healthy life expectancy while developing medical care, pharmaceutical products, and medical equipment as a strategic industry and pillar of Japan economic revitalization,”[4] as set forth by the government in new health and medical care strategies. The Life Innovation Division is involved, in particular, in the creation of biobanks that integrate omics information (comprehensive biomolecular data including genome information) and medical-checkup and clinical information and in the development of translational research platforms to support academia in applying omics information to basic research and the development of pharmaceutical products and medical equipment. Furthermore, with the aim of using this information in medical and pharmaceutical collaborations and clinical applications, the Life Innovation Division is pushing forward the development of ICT systems that reflect today’s paradigm shift in medical care through activities closely correlated with the Japan Agency for Medical Research and Development (AMED), which was launched in 2015 as the core of the Japanese National Institutes of Health (NIH). Details on these government strategies and the Life Innovation Division can be found in the article titled “New Solutions Using ICT in Clinical Trials and Clinical Research” in this special issue.

At Fujitsu, the Healthcare & Educational Systems Unit is focused on developing ICT solutions in the “present” field of healthcare, the Life Innovation Division is intent on fostering innovation for “near-future” applications, and the Next-Generation Healthcare Innovation Center (described below) has its eyes fixed on the “future.” These three entities form a three-pronged organization that provides total support for healthcare in the present, near future, and future.

4. Activities of the Next-Generation Healthcare Innovation Center

The Next-Generation Healthcare Innovation Center was established in December 2013 with the following objectives:

- Investigate the use of ICT in extending the nation's healthy life expectancy, promoting good health, preventing disease exacerbation, achieving early detection of disease, creating new drugs, and providing personalized medicine and develop new businesses closely linked to on-site needs in collaboration with leading research institutions.
- Integrate and accelerate research and development functions for new technologies with the aim of expanding diagnostic services and the medical equipment business. Promote tie-ups and collaborations with outside organizations such as university medical faculties, research institutions, pharmaceutical companies, institutions conducting clinical trials, and medical equipment vendors.

The Next-Generation Healthcare Innovation Center has the following five missions based on the above objectives:

1) Cultivate business for next-generation medical care information systems to be created as national projects (such as the Center of Innovation Science and Technology based Radical Innovation and Entrepreneurship Program (COI STREAM) launched by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).
2) Create medical information big data business (covering both healthy people and patients) that integrates biobanks storing genome information and health information based on cohort research and EMR clinical data.
3) Plan and promote simulation activities related to drug discovery, biological body functions, and so on.
4) Promote compound design services as a business toward IT-Soyaku (in silico drug design).
5) Expand EMR and other healthcare-related technologies globally.

For more information on mission 3), please see the articles in this special issue titled "Developing Biomedical Simulations for Next-generation Healthcare" and "Project on Bio-IT for Next-generation Healthcare," which address biological simulations and Bio-IT, respectively. For more information on mission 5), please see the article titled "European Union's Growth Strategy for Healthcare," which addresses current conditions in the EU.

Here, we explain the ideas behind the envisioned system, which is illustrated in **Figure 3**. This system will be based, first and foremost, on the premise that the consent of the individual—the ultimate source of healthcare information—must be obtained, all pertinent regulations must be observed, and ample security measures must be implemented.

HIE networks (shown in the lower portion of Figure 3) are now being introduced as a network infrastructure enabling a variety of medical care entities in a region to make mutual use of each other's medical care information. These entities include care-giving facilities, individuals themselves, rehabilitation centers, core hospitals, advanced treatment hospitals, medical clinics, pharmacies, checkup centers, and testing centers. In addition, an integrated information usage infrastructure will be established on top of each HIE network by introducing an electronic health record (EHR) system as a mechanism for consolidating information (patient registry) and by implementing a personal health record (PHR) service linked to the EHR system to enable individuals to proactively manage their healthcare information with the aim of maintaining and enhancing their health.

Furthermore, this infrastructure will be expanded into a "new information usage infrastructure" for multifaceted use of data by anonymizing personal data in the EHRs and by optimizing applications in accordance with the services that are linked. Access to this information will be expanded from regional institutions to academia such as university research institutions, to companies providing pharmaceutical products and medical equipment, and to government institutions.

The plan is to merge the results of the "long-term technology development" described below with this new information usage infrastructure and thereby achieve a next-generation EMR system and more effective usage of medical information.

5. Examples of long-term technology development

This section introduces specific examples of long-term technology development based on the total system concept presented in the previous section.

5.1 Clinical decision support system

The clinical decision support system (CDSS) has

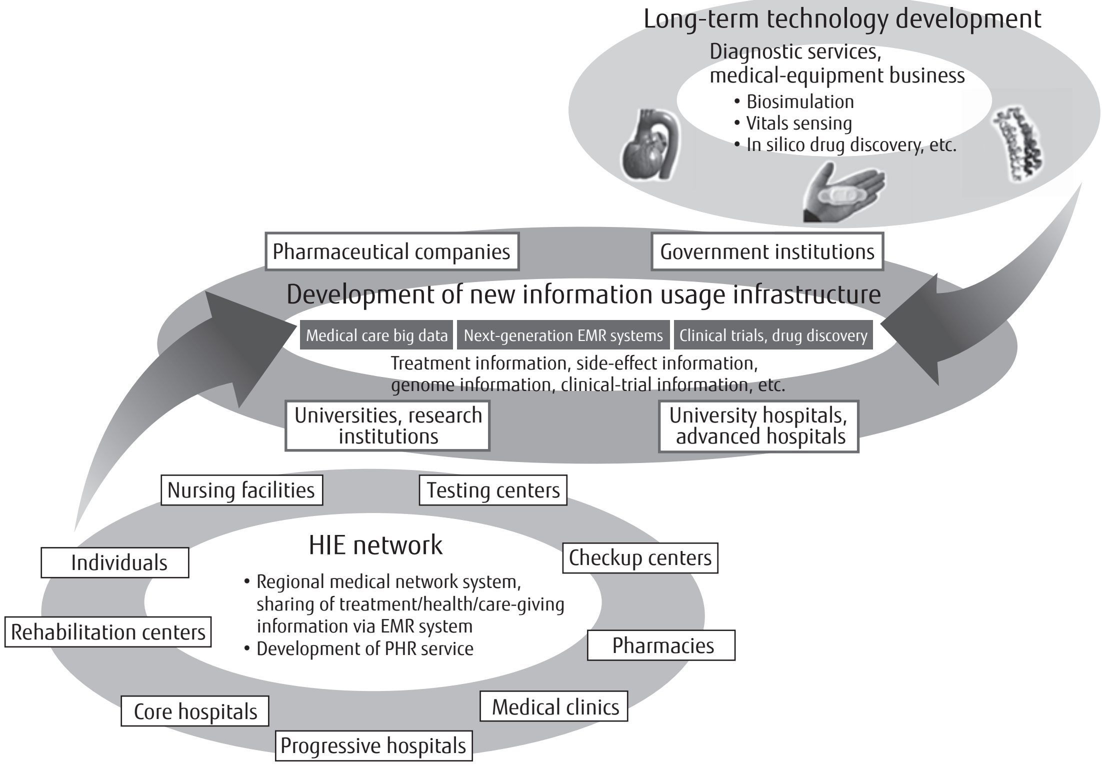


Figure 3
Current state and future image of ICT in the healthcare field.

found widespread use throughout the world. In Japan as well, computerized provider order entry (CPOE) and the EMR function, which make up part of CDSS, incorporate a check function to raise the level of safety in medical care with respect to maximum dose (upper limit of the amount of drug to be administered to prevent risk as indicated by pharmacopeia), contraindications for co-administration, etc. A CDSS generally consists of three functional levels and content as described below.

1) Functional levels

Level 1: Pattern matching and similar case retrieval

Functions of the type described above are implemented on this functional level in CDSS. Typical of these functions are checks on drug-related items such as contraindications for co-administration and on the insurance diseases name as well as support for clinical decision-making by simple pattern matching based on correlation with a national master database. This level can also be used to implement a function for presenting similar patient cases for reference purposes through dynamic matching of test results across patients. There has also been some functional expansion in recent years. For example, there is a function for presenting the risk of genetic disease for reference purposes using information on single nucleotide polymorphisms (SNPs), which represent variation in the genome sequence of a biological species caused by the mutation of a single nucleotide at a frequency of 1% or greater in that species. Another new function called "genomically driven CDSS" provides support for the personalized administration of drugs tailored to the constitution of individual patients.

Level 2: Rule base (decision tree)

This functional level registers and applies decision-support rules in a flowchart format more complex than that of level 1. These decision-support rules are known as a rule base (or decision tree). There have been cases of constructing a mutually supportive environment for multiple users by enabling the distribution of rule bases over the Internet.

Level 3: Hypothesis deduction support

This functional level introduces hypothesis deduction (a technique that establishes a hypothesis through induction and then tests that hypothesis by combining deduction and induction) so that the system can present the user with support information such as predictions based on previously accumulated information. The use of big data analysis technology and artificial intelligence technology has also been seen in recent implementations of this functional level.

2) Content

"Content" supports the three functional levels described above and specifically refers to open data as well as guidelines for academic societies, government institutions, etc. on referencing a national master database by pattern matching and on using the rule-base and hypothesis-deduction functions.

There are many cases in which the CDSS introduced in this section is implemented as a cloud service that provides linkage among the EMR/order-entry system, the HIE system, and more recently, the public health management system including disease management. There are also cases of using CDSS for educational purposes targeting medical students and doctors in clinical training. Fujitsu is collaborating with a number of universities and medical institutions in the research and development of CDSS functions and content as one element of the next-generation EMR system.

5.2 Activities toward PHR

In parallel with the development of solutions and services supporting on-site medical care centered about next-generation EMR, Fujitsu is also developing services toward the provision of a PHR system and a personal life record (PLR) system. The former will enable individuals to take the initiative in managing their healthcare information to maintain and enhance their health while the latter will enable individuals to proactively use information covering their entire lives. Furthermore, instead of having to prepare and incorporate new data on individual patients, the plan is to enable these new services to use data that are currently being used in HIE networks while taking the need for safety and security into account.

Up to now, the target users of the solutions and services that Fujitsu has been providing have been mainly healthcare providers and individuals who are sick, but from here on, services that expand into PHR and PLR will be able to provide comprehensive healthcare support for individuals who are healthy as well.

As reflected by the examples described above, the Next-Generation Healthcare Innovation Center will promote innovative activities including research and development toward the provision of practical applications while keeping in mind the correlation among the following three items:

- Use of ICT in areas more closely related to clinical needs than in the past.
- Development of next-generation EMR that revolutionizes the present EMR system.
- Use of information centered about the individual.

6. Conclusion

In this paper, we described the activities at the Next-Generation Healthcare Innovation Center that was established to deal with new challenges in Fujitsu's healthcare business. Looking to the future, we can expect a variety of ICT-based initiatives in the healthcare field to become increasingly sophisticated and accelerated in conjunction with the activities of the AMED and the introduction of The Social Security and Tax Number System or medical care ID. Expectations are high for the early creation of a future society in which everyone in Japan can live a long and healthy life.

Going forward, Fujitsu is committed to using ICT to support safety and security in the healthcare field, to help the nation's people lead an enriching and healthy life, and to contribute to the realization of a peaceful global community.

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