Healthcare R&D in Fujitsu Laboratories Group in U.S. and Europe

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Fujitsu Laboratories of America, Inc. and Fujitsu Laboratories of Europe Ltd. have been doing R&D on healthcare. We investigated what should be done in this area as an information and communications technology (ICT) company, and found out two important areas: improving medical systems and promoting preventive medical care. Both of these could be done very efficiently by utilizing ICT. To improve medical systems, we introduced the new notion of Q-Score, which represents the quality of each provision of healthcare, in order to evaluate them. Also, with respect to preventive medical care, we are conducting investigations on how to measure biodata such as blood pressure, pulse rate, or weight. There is a need to do this in various aspects of life without inconveniencing those who are having their data measured. We would like to have a method where people can be given advice based on such biodata as a way to promote health management. Moreover, such advice could be made dynamic, incorporating real-time contextual elements such as environmental data and health status. We report an overview of the current status of our activities in this paper.

1. Introduction

Fujitsu Laboratories of America, Inc. (FLA) and Fujitsu Laboratories of Europe Ltd. (FLE) embarked on R&D on healthcare in 2009.
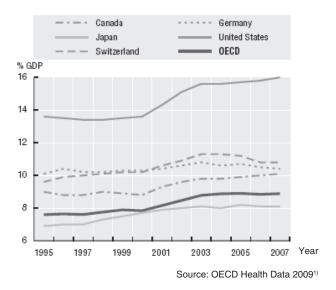
One major challenge of healthcare is to control the steep rise in medical expenses. This paper reports on our approach and the state of R&D regarding how to address this challenge and realize a society where everybody can live a healthy life. The next section gives an overview of the R&D, and that is followed by a description of our proposals for the improvement and streamlining of medical care systems and the development of a remote monitoring system required for promoting preventive medical care.
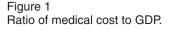
2. Overview of R&D

The significant increase in medical costs is posing a global problem mainly in advanced nations including the U.S. and the U.K. as well as Japan (**Figure 1**). While there are country-specific circumstances and characteristics, the main reasons are believed to generally

Source: OECD Health Data 2009[1]

Figure 1
Ratio of medical cost to GDP.

FUJITSU Sci. Tech. J., Vol. 48, No. 2, pp. 135–142 (April 2012)

135

include lifestyle changes, aging and increases in advanced medical care expenses.

Urgent measures to address this problem are called for, and various nations are working to develop them in view of their own systems and circumstances. One example is the healthcare reform bill signed by U.S. President Barack Obama.

Since 2009, we have been studying what should be done to contribute to this reform, and we have come to the conclusion that there are two major requirements:
1) Supporting improved and streamlined medical care systems
2) Supporting preventive medical care

2.1 Improved and streamlined medical care systems

We aim to have improved and streamlined medical care systems by making use of information and communications technology (ICT) and as a result reducing medical care costs. Specific methods include computerizing medical records to provide electronic medical records (EMRs), making mutual use of EMRs between hospitals, and integrating EMRs with the patient management systems of individual hospitals, and this is being realized through a cohort of Health Information Systems (HIEs). Some of these measures have already been commercialized.

Fujitsu Laboratories is going one step further and studying ways to make medical care more useful to patients and also reducing medical care costs by improving the quality of medical care. This research, which has been conducted mainly by FLE, is intended to accomplish these purposes by introducing a notion called Q-Score to represent the quality of medical care provision based on health outcomes.

2.2 Preventive medical care

The improvement and streamlining of medical care systems mainly concerns the fields of medical care. On the other hand, preventive

medical care is something that occurs before medical treatment is required, and is intended to help individuals stay healthy by managing their health conditions. It is an area commonly called wellness.

Recently, more and more people have come to suffer from lifestyle-related diseases such as high blood pressure and diabetes. Before their condition progresses to a stage requiring medical treatment, these people can have their health managed in their daily life without being inconvenienced so that they can be given appropriate advice. In this way, we have attempted to reduce the number of patients and medical care costs while maintaining people's living standards.

In this paper, we describe FLE's approach to quantifying the quality of medical care provision by introducing the notion of Q-Score,[2] and approach to health management by dynamic, context-ware advice generation, and FLA's approach to health maintenance management by remote monitoring.[3]

3. Improvement and streamlining of medical care systems by introducing Q-Score

FLE has been working on a system called Healthcare Outcomes Monitoring sErvice (HOME) for auditing and managing medical care provision in hospitals and local communities. HOME has three purposes:
1) To allow medical care provision to be evaluated
2) To improve the quality of healthcare-related treatment
3) To allow efficient auditing of healthcare-related treatment

HOME focuses on managing information for the key persons concerned and the quality and criteria of its evaluation as a means of encouraging improvement. It is scalable and intended to cover major places where medical care systems operate in a human-centric manner.
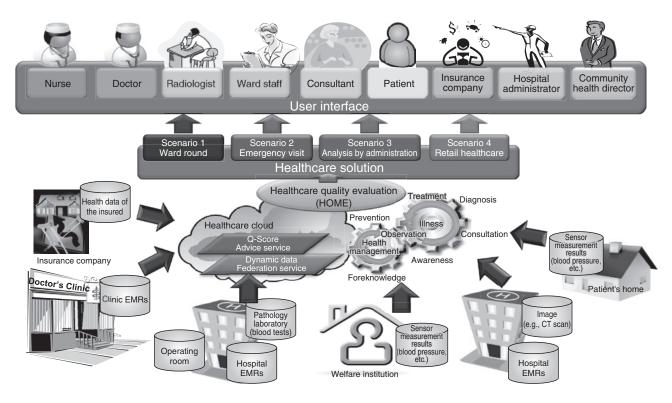
Figure 2
Concept of Healthcare Outcomes Monitoring sErvice (HOME).

Figure 2 shows the overall concept of HOME.

The main purpose of this technology is to evaluate medical care provision by assessing the quality of treatment in the individual aspects of medical practice. The intention is that it will also facilitate the assessment of compliance with evidence-based guidelines for healthcare provision. We refer to the quality of treatment in the individual aspects of medical practice as Q-Score, and it is obtained by analyzing patients' data that are managed by various medical institutions.

FLE developed a mechanism for calculating Q-Score, which is the main concept of HOME, and it is calculated based on the health outcomes for a particular medical practice and represents the degree to which it has been achieved; it specifies how well medical care has been provided. Q-Score would indicate the loopholes or loose points in the medical care provisioning from person to population (i.e., from area-wide to region-wide to country-wide). This also allows any omissions in

medical care systems to be identified.

We expect HOME to provide the following benefits and improve quality management.

1) The government and medical institutions can promote evidence-based medical care by evaluating the quality of such care.

2) Medical institutions can request remuneration for high-quality medical practice. The government can reduce the costs resulting from low-quality medical practice such as inaccurate diagnosis and inappropriate treatment.

3) Individuals (especially those with chronic diseases) can manage their health and lifestyle options.

In order to narrow down HOME that was based on analyzing streams of patients' clinical data, the HOME Virtual Managers (VMs) solution emerged to support operations and decision-making and enable users to extract meaningful information. It is based on a need to provide the different players in a health system

with the necessary information to prevent ill health, to improve the quality of care to the individual or disease group and the quality of services provided to a population. In this way, it can improve the efficiency, and therefore the productivity, of the overall health system.

FLE is working on HOME Virtual Manager for Individuals (VMI), to modify and generate real-time personalized advice taking into account an individual's changing situation. This is further elaborated on in the following section.

4. Preventive medical care

Preventing diseases and ill health could save tens of thousands of lives each year[4] and improving control is one of the most effective ways to prevent chronic conditions[5,6] such as heart disease, diabetes, or strokes. Since lifestyle interventions could modify people's risk factors,[7] their awareness about their personal risk factors that can be raised through remote monitoring and imparting knowledge about the available lifestyle options is fundamental to self-management. It is imperative to educate individuals about their health and it is important to obtain self-supported outcomes. A total of 75% of the risk of type II diabetes[note] is attributable to obesity, which is preventable through self-awareness and self-management[8] (i.e., by changing lifestyles). Moreover, 80% of all cardiovascular diseases are considered to be preventable by reducing risk factors like smoking and an unhealthy diet.[9] According to the World Health Organisation (WHO) at least 80% of all cases of heart disease, stroke and diabetes are preventable,[10] requiring remote monitoring and lifestyle changes.

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note)   It is preventable whilst Type-I diabetes is not preventable. The cells do not respond correctly to the insulin. It is caused due to unhealthy lifestyle. It can be treated/ prevented through lifestyle changes (i.e. healthy eating, exercise, etc.)

4.1 Health management by remote monitoring system

To promote preventive medical care, we believe a system is necessary in which people's biodata (such as blood pressure, pulse rate and blood sugar) are acquired and accumulated for an extended period of time in their normal life. Then, important information is taken from that data and fed back to them. **Figure 3** shows a conceptual diagram of this system.

As shown on the left side of the figure, biodata are collected in various aspects of an individual's life such as at hospital or home or during outdoor activities. The data are stored in a cloud environment by an appropriate means. The collected data are used to offer various services that help the individual stay healthy. Examples are shown on the right side of the figure.

As the first step to achieving preventive medical care, FLA has developed a remote monitoring system capable of gathering biodata including blood pressure, heart rate and saturated oxygen concentration of the blood (SpO2) for an extended period of time.

For the development, we have given thought to:
- Non-invasiveness
- Simultaneous gathering of multiple pieces of biodata

In biodata gathering, being non-invasive means not causing discomfort or inconvenience to those who are having their biodata measured. For example, measuring SpO2 usually involves mounting a clip-shaped instrument onto a person's fingertip. However, this prevents them from moving or acting normally while measurements are being taken. To solve this problem, we have prototyped a sensor in the form of a ring as an alternative. This sensor allows people to do simple operations such as typing (whether or not this ring sensor can be used for SpO2 measurement as part of medical practice still needs consideration).
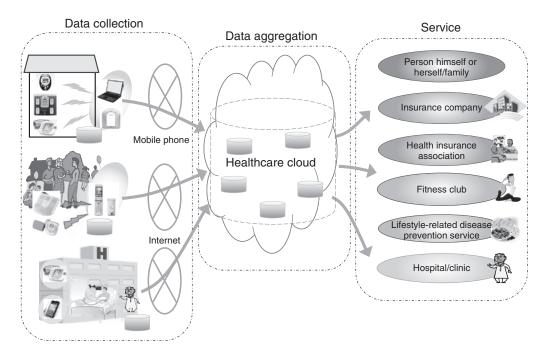
Figure 3
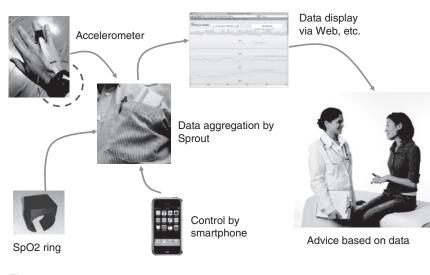System image of preventive medical care.

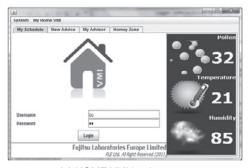Figure 4
Diagram of remote monitoring system.

Being able to simultaneously gather multiple pieces of biodata refers to being able to measure blood pressure, heart rate and accelerometer data, for example, at the same time. A single piece of biodata alone may not be enough to accurately recognize the conditions of the person undergoing the clinical trial. For example, when the heart rate and blood pressure have exceeded the normal ranges, the person can be estimated to be "running" if the accelerometer data have also increased. Making this estimation is difficult without the accelerometer data.

An outline of the remote monitoring system we have developed is depicted in **Figure 4**. The

FUJITSU Sci. Tech. J., Vol. 48, No. 2 (April 2012)

139

ring-shaped object in the middle-left side of the figure is the SpO2 measuring instrument. The white square box on the breast is called Sprout; it is a device that temporarily stores multiple pieces of data that have been gathered and it is capable of simple data processing as well. This Sprout itself does not have any input/output (I/O) and is controlled remotely by a smartphone or such like. The biodata stored in the Sprout are transferred to a PC or server via WiFi or other means, and they are then displayed on a screen. The idea is to provide a system in which users are given appropriate advice in response to the results of analysis based on the data obtained.
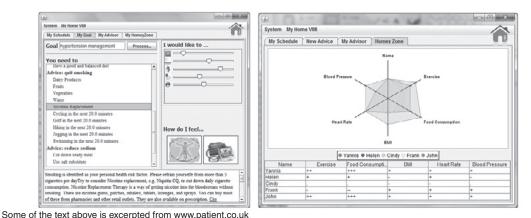
The biodata collection system has been completed and at present biodata are being gathered mainly from employees of FLA and Fujitsu's affiliated companies in North America.

4.2 Health management by dynamic, context-ware advice generation system

In order to achieve preventive medical care and wellness, we believe that it is imperative to help the individuals make better decisions more quickly and more easily, and to help them implement such decisions. FLE has developed a dynamic, context-ware advice generation system called HOME VMI to modify and generate real-time personalized advice taking into account an individual's changing situation. **Figure 5** depicts some screenshots of this system. Figure 5 (a) shows the HOME VMI log-in screen. Once users are logged in, the system displays real-time environmental data including pollen count, temperature, and humidity. Figure 5 (b) is HOME VMI's main application screen where individuals can break down their goals into

(a) HOME VMI log-in screen

Some of the text above is excerpted from www.patient.co.uk

(b) HOME VMI's main application screen

(c) Homey community zone screen

Figure 5
Screenshots of HOME VMI.

various feasible actions or activities; moreover they can change those actions according to their preferences. Figure 5 (c) is the Homey community zone screen where individuals can see how well their friends or families are doing in terms of staying healthy; here they can compare and compete.

We developed a taskforce of healthcare stakeholders including clinicians, doctors, and nurses in collaboration with Brunel Healthcare Associates (BHA, Brunel University UK) in order to determine the real requirements. Based on these real requirements and feedback from Fujitsu UK and Ireland, and Fujitsu Global Business Group, we prototyped HOME VMI (R1.0) by implementing two use use cases (UCs).

- UC-1: Autonomous advice revision with sensing data

For UC-1, FLA's technology (Sprout, as mentioned in an earlier section) was used for capturing the sensing data and sending it as an input to the system on the basis of which advice was revised.

- UC-2: Dynamic advice revision

For UC-2, an interface with respect to the human anatomy was developed so as to capture input directly from the user, based on which advice is revised.

The system can be used to support operations and decision making about an individual's lifestyle. It can provide cost savings by reducing the number of times individuals need to revisit their care facilities for advice when their situation changes, thus providing recommendations that allow individuals to make informed decisions. It also aims to incorporate social media by enabling people to access peer communities to share best practices and offer mutual support. It implements a feedback loop and can be used for proactive wellbeing and self-management.

5. Conclusion

This paper has outlined the R&D activities

on healthcare conducted in the American and European laboratories of Fujitsu Laboratories. Healthcare is a very important theme and we think that making use of ICT to implement health management and improve medical care systems without lowering the living standards of people is a significant contribution to society.

In addition to promoting the research themes described in this paper, we intend to listen sincerely to and understand the opinions and requests of medical workers, system designers and managers, and users. We will then work on the necessary research themes in a timely manner by using an appropriate system.

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FUJITSU Sci. Tech. J., Vol. 48, No. 2 (April 2012)

141

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142

FUJITSU Sci. Tech. J., Vol. 48, No. 2 (April 2012)