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## **Relationships among ICT, ageing, and health expenditures in Japan: An economic evaluation**

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### **Abstract**

The paper examines the relationship among Information and Communication Technology (ICT), ageing, and health expenditures in Japan. For this, primary data has been collected from an extensive mail survey that was carried in Nishiaizu Town, Fukushima prefecture, Japan from 2002 to 2010. 9 years panel data is used to empirically identify the determinants of health expenditure in relation to ageing and telehealth use. Also, the effects are analyzed by comparison of medical expenditures between users and non-users of telehealth. Their receipts from those stored in the town office are examined too. The receipts of National Health Insurance of each month are kept at the town office. The paper uses mainly the following data, as: (i) name of resident, (ii) date of birth, (iii) either regular outpatient treatment or hospitalized patient treatment, (iv) name(s) of major disease(s), (v) date of initial treatment, (vi) number of days spent for treatment, and (vii) score (amount) of medical expenditure. Besides, other variables such as the availability of chronic disease among the participants, types of chronic diseases such as heart disease, high blood pressure, diabetes, and strokes, living alone or with family and employment status have also considered for the analysis. Using these variables, a rigorous econometric model is estimated. The estimation model is panel data analysis with the one-way fixed effect model with only time effect. A user dummy variable is added as an explanatory variable, which enables to estimate whether there is difference between users and non-users in medical expenditures of each disease of ageing. Based on the data obtained, the objectives of the estimation consists of the following three questions: (i) whether there is difference in medical expenditures among users and non-users of telehealth use; and (ii) how medical expenditures related to chronic diseases were different among two groups, user and non-user. (iii) how the use of telehealth can reduce medical expenditures of ageing.

**Key words:** health expenditure, economic evaluation, panel data, Japan, telemedicine

### **1. Introduction**

Within the high and rising level of ageing and healthcare expenditures in Japan it becomes an essential issue for policy makers to reduce overall health related cost. Yet relatively little attention has been given to the empirical analysis to check the factors that can minimize aggregate healthcare expenditures. Besides, the medical expenditures for elderly citizens are

rising sharply. To address these issues, the paper aims to analyze the role of telehealth on ageing and health expenditures in Japan.

Increasing medical costs and shortages of medical doctors in rural areas are issues that urgently need to be addressed in healthcare around the world (Akematsu, Y., Nitta, S., Morita, K., Tsuji, M., 2013). Medical expenditure in Japan has been steadily increasing, and in FY 2012 it amounted to JPY 35.1 trillion (US\$ 4,387 billion) with more than half (51.7%) of that being spent on the care of patients over the age of 65. In 2012, 24.2% of the Japanese population was over the age of 65, and this is expected to increase in the near future. Furthermore, the number of outpatient days in Japan is the largest among the OECD member countries at 13.4 days per person per year, compared with 4.0 (US), 5.9 (UK), 7.8 (Germany), and 6.9 (France) days per person per year (OECD Health Data). It is imperative to reduce the number of treatment days as well as medical expenditure in Japan.

To cope with the serious healthcare situation in Japan, local governments have begun implementing telecare or e-Health, which allow the local government to remotely monitor the health of elderly residents at home by transmitting health-related data, such as blood pressure, blood oxygen level, and ECG, to medical institutions via telecommunications networks. Telecare is thus expected to improve users' health, as demonstrated at previous studies [Akematsu Y., and Tsuji M., 2009, 2012; and Nubetaki K., Akematsu Y., and Tsuji M].

The present study was conducted in Nishi-aizu, a town located in Fukushima Prefecture, Japan, and we attempt to demonstrate that telecare use reduces not only medical expenditure but also days of treatment. Besides, we attempt to determine how ageing user can be benefitted by using the system. A rigorous panel data analysis is conducted.

The present research is conducted in March 2012 to obtain two basic data for statistical analysis such as receipt data for 272 telecare users (treatment group) and 247 non-users (control group) for the period 2007 to 2010 and their responses of questionnaire were collected. This data included individuals who were included in our previous studies of the period 2002 to 2006; therefore, data for 90 telecare users and 118 non-users for the period 2002 to 2010 (9 years panel data) were used in this study.

## **2. Telecare system in Nishi-aizu**

### *2.1 Background of telehealth*

Nishi-aizu Town is located in the Northwest corner of Fukushima Prefecture, and is been an important point of transit to reach Niigata Prefecture and Aizu-wakamatsu, a nearby major city. The center of town is in a basin but the main area is surrounded by mountains, which cover 86% of the prefecture's area. The climate is severe in winter and summer, with lots of snow. The population is about 8,000; there are 3,000 households, and the percentage of the elderly ( $\geq 65$  years) was 42.0% in 2012. The main industry is agriculture, and rice is the main product.

As stated earlier, severe winter, especially heavy snow causes elderly people to lack physical exercise. In addition, due to a traditional diet of salty and protein-poor food, the town's death rate was 1.7 times higher than the national average during 1983-87, partly due to high rates of stomach cancer. The number of bedridden elderly people suffering from

osteoporosis or arthritis is higher than the national average. In order to cope with these situations, the town office took initiative to establish a “total care system,” which is referred to as the “Challenge to 100 Years Old,” by unifying health, medical and welfare services. As a part of this project, e-Health was introduced in 1993.

In the town, there are three public clinics, named Nishi-aizu, Murooka and Shingo, which are operated by the National Insurance System, and two private clinics. The total number of medical doctors is four. One full-time physician is employed in the Murooka clinic, while the Shingo clinic has a part-time doctor dispatched from the other two clinics. There are private doctors, a surgeon and a neurologist, but both are more than 70 years old.

## *2.2 Implementation of e-Health*

In order to prevent chronic diseases such as cerebral infarction and stroke, the town office introduced e-Health in 1994 which is Japan's longest-running e-Health. 300 peripheral devices called “*Urara*,” manufactured by Nasa Corporation, were provided to residents who have symptoms of the above diseases. Each terminal is connected a host computer via PSTN (Public Switched Telephone Network), and health-related data of users, such as blood pressure, pulse, ECG, blood oxygen, weight and temperature are transmitted to a host computer. In 1996 and 1997, an additional 50 terminals each were purchased. These terminals use the CATV network for transmitting data. All costs of operating the system are paid by the town. In 2010, new peripheral device called “*Sauri*,” was introduced in accordance with the network renovation of CATV for optical fiber. Currently all network were transformed to optical fiber.

The section in charge of e-Health is the town office’s Department of Health and Welfare, which consists of seven public health nurses which represents a much larger ratio than in other towns. They check the above health data transmitted by users and if these nurses observe unusual data, they ask medical doctors in clinics to see the patient in question. The health data of each user are summarized in a “Monthly Report,” which is sent to a physician in charge. After a public health nurse adds their comments, the report is sent to the user. When the user sees a doctor, he/she is asked to bring the report with him/her.

e-Health is being operated as a part of the town’s “Project for Promoting Total Care,” and its essence lies in the close collaboration of health, medical and welfare activities. One important example of this collaboration are “Regional Care Meetings,” which consist of doctors, nurses, public health nurses, staff of the town office, helpers of elderly people, and living advisers. The total number of participants in each meeting is over 20. Problems and treatments regarding a particular user, such as medical examinations, health advice, and care are discussed in detail. The health data of e-Health plays a role in this meeting. In Nishi-aizu Town, many such examples of exchanging information on residents can be found in the town office.

In addition, the town office organizes users’ meetings five times a year in order to enhance motivation to use e-Health, and users exchange their experiences with using the system. These activities promote usage of the system. The introduction of e-Health is not the sole factor promoting regional healthcare; rather, it should establish a framework for the system to assist all related sections and personnel.

### 3. Method of analysis

#### 3.1 Sample selection:

Here two kinds of data for analysis, namely receipt data and responses of questionnaire are explained. In our previous study, the receipt data of 199 users and 209 non-users collected between 2002 and 2006 was obtained from the National Health Insurance. The receipts for each month are kept at the Nishi-aizu town office, and include a range of information. In the current study, the following data was used: (i) name of patient, (ii) birth date, (iii) regular outpatient treatment or hospitalized patient treatment, (iv) name(s) of major disease(s), (v) date of initial treatment, (vi) number of days of treatment needed, and (vii) “point” of medical treatment (one point is equivalent to JPY 10).

We next collected receipt data for the years 2007 to 2010. To ensure that the patients included in the previous studies were also included in the current study, we first checked whether they responded to the questionnaire survey (in case of death, etc.); about half of the respondents had not responded, which resulted in a lack of samples. We therefore selected 565 new respondents from among the telecare users. The questionnaire used in this study was the same as that used in our previous studies. The questionnaire asks about characteristics such as sex, age, and the individuals’ use of the telecare system, which is data not included in the receipt data. Non-users were selected by stratified sampling from the list of subscribers to the National Health Insurance, which amounted to 1035 non-users. The respondents are summarized in Table 1, which shows that 272 users and 247 non-users were selected as valid respondents for this study; 91 users and 118 non-users were included in both the previous study and the current study. We then collected their data mentioned above.

Table 1: Respondents to mail questionnaire

	No. of residents sent questionnaire	No. of valid respondents
		(No. of valid respondents between 2002 and 2009)
Users	565	272 (91)
Non-users	1035	247 (118)
Total	1600	519 (209)

The percentage of sex of users and non-users is shown in Table 2. The percentage of males (59.1%) is higher than that of female (40.9%).

Table 2: Gender (Users and non-users)

	Users	Non-users	Total
Male	51	72	123
Female	39	46	85
Total	90	118	208

The average ages of users and non-users are shown in Table 3. The average ages of the two groups are similar, but they are naturally higher than in the previous research, since the last survey was five years ago.

Table 4 summarizes the number of years of individual telecare use. Users that had used the telecare system for more than 10 years accounted for 25.6% of the total number of users, which is the largest percentage, and this makes examining the long-term effect of the system possible.

Table 3: Average age of respondents

	N	Average age
Users	90	75.67
Non-users	118	75.76

The number of respondents who replied that they did not use the telecare system accounted for 30% of the respondents, which was larger than expected. It is possible that they responded that they did not use the system, even though they had a telecare device in their homes.

Table 4: Years using telecare

	N
1–3 years	8
3–5 years	8
5–7 years	11
7–10 years	13
>10 years	23
Do not use	27
Total	90

### 3.2 Methodology

Using the selected variables, a rigorous econometric model is estimated. The estimation model is panel data analysis with the one-way fixed effect model with only time effect. A user dummy variable is added as an explanatory variable, which enables to estimate whether there is difference between users and non-users in medical expenditures of each disease of ageing. Based on the data obtained, the objectives of the estimation consists of the following three questions: (i) whether there is difference in medical expenditures among users and non-users of telehealth use; and (ii) how medical expenditures related to chronic diseases were different among two groups, user and non-user. (iii) how the use of telehealth can reduce medical expenditures of ageing. The estimation model corresponding to estimation (1) is expressed in the following equation (Tsuji, M, Abu, S. T., and Kinai, Y., 2015):

$$\begin{aligned}
y_{it} &= \alpha + X_{it}\beta + \sum_j^{12} \{disease_{it}^j(\gamma^j + User_t\delta^j)\} + u_{it} \\
u_{it} &= \lambda_t + v_{it}
\end{aligned} \tag{1}$$

where  $y_{it}$  denotes the medical expenditures of all disease of  $i$ -th subject at year  $t$ ,  $X_{it}$  residents' characteristics such as sex, age, education, employment (dummy variable), the number of family living together, and income.  $disease_{it}^j$  is a dummy variable which takes 1 if  $i$ -th resident have treated  $j$ -th disease in year  $t$ , and takes 0 otherwise.  $User_i$  represents a user dummy variable. We utilized the panel data analysis with the one-way fixed effect model where  $\lambda_t$  denotes a year dummy variable, because the rule of calculating medical expenditures in the National Health Insurance was usually changed every two years. In addition, the individual effect, or dummy variables might cause serious multicollinearity with each characteristic, and accordingly only the time effect is considered. The difference in medical expenditures due to each disease between users and non-users can be identified by the coefficient of  $\delta^j$ , which can be referred to as the cross effects. If coefficient  $\delta^j$  is negatively (positively) significant, users' total medical expenditures affected by the  $j$ -th disease is statistically smaller (larger) than those of non-user. In sum,  $\delta^j$  answers question (i).

## 4. Results of Estimation

### 4.1 Result of Estimation (1): All diseases

The result of estimation (1) of all diseases is shown in Table 6. The detailed results on the variables of individual characteristics such as age, employment, the number of family living together, having chronic diseases, telehealth users, treated diseases, and usage duration are summarized as follows. Among them, age ( $p < 0.05$ ), employment ( $p < 0.01$ ), chronic disease ( $p < 0.01$ ), user ( $p < 0.10$ ), treated diseases such as heart diseases ( $p < 0.01$ ), high blood pressure ( $p < 0.01$ ), diabetes ( $p < 0.01$ ), strokes ( $p < 0.01$ ), cancer ( $p < 0.01$ ), gastropathy ( $p < 0.01$ ), arthritis ( $p < 0.01$ ), and others diseases ( $p < 0.01$ ) are found to be significant. The detail can be explained as follows:

- Medical expenditures increase around JPY 431.81 (US\$ 4.0) comparing to our previous studies (Tsuji, M, Abu, S. T., and Kinai, Y., 2015) as (JPY2,223.7 (US\$22.24) per year when they become one year older. It is natural that the older they become the larger medical expenditures. The result provides recommendations for policy makers that how the cost of ageing can be reduced.
- Medical expenditures are lower those who have employment status than those not working by approximately JPY9664.03 (US\$90.00) per year. This is because working people might be healthier. However, because whether being sick or not could affect their working condition, this variable has to be treated as an endogenous. This problem should be taken care in the future study.
- The person having chronic diseases can increase the health expenditures as much as JPY 9463.10 (US\$ 85.02). This is because the person who bears chronic disease requires routine check-up and add extra cost to the total health related cost expenditure in Japan.

Individual diseases are taken as dummy variables in equation (1), and they take 1 if the particular disease was treated, while take 0 otherwise. Thus, medical expenditures related to these variables can be interpreted as a part of total medical expenditures. According to Table 7, the proportion of each disease in the total medical expenditures is summarized as

follows: heart diseases (20%); cancer (17%); diabetes (16%); and high blood pressure (10%). The shares of these diseases show higher ratios among diseases. In particular, the share of total expenditures related to four chronic diseases including heart diseases, high blood pressure, diabetes, and strokes is accounted for nearly 60% of total medical expenditures. This indicates that the reduction of expenditures of these diseases is indispensable for the reduction of total medical expenditures.

Table 6: Result of Estimation (All Diseases)

Variables	Coefficient	Std. Err.	z-value	P-value	
Age	431.8195	202.8601	2.13	0.033	**
Employment	-9664.0300	3200.5340	-3.02	0.003	***
Number of family members	288.9004	1006.9410	0.29	0.774	
Chronic disease	9463.1030	3018.8010	3.13	0.002	***
User	-8680.6470	4938.1770	-1.76	0.079	*
Heart diseases	14415.1800	4732.7530	3.05	0.002	***
High blood pressure	11051.1500	2735.5090	4.04	0.000	***
Diabetes	15411.9800	4083.0670	3.77	0.000	***
Strokes	14305.2600	6158.3130	2.32	0.020	***
Respiratory diseases	6051.8280	3835.9770	1.58	0.115	
Cancer	26211.6400	4733.3800	5.54	0.000	***
Gastropathy	16873.7700	3435.6970	4.91	0.000	***
Lumbago, Arthritis	13771.5400	3483.2550	3.95	0.000	***
Ophthalmic diseases	1991.9850	3017.0780	0.66	0.509	
Kidney diseases	3111.8300	7495.0690	0.42	0.678	
Anal diseases	-18284.6000	13074.2300	-1.40	0.162	
Others	12683.1500	2378.0180	5.33	0.000	***
Usage duration	641.0288	598.0537	1.07	0.284	
_cons	-23422.0100	14354.5700	-1.63	0.103	*
Number of obs		1542			
Number of groups		204			
R-sq: within		0.1133			
between		0.3187			
overall		0.1831			

Note: \*\*\*, \*\*, and \* indicate the significance level of 1, 5 and 10%, respectively.

#### 4.2 Results of estimation (2): Chronic diseases

This section attempts two types of estimation for each disease; with full sample and selected samples. The former indicates that the analysis covers all samples, while the latter covers only those who have been treated or examined this disease. The estimation model is same as the last section, based on the one-way fixed effect model with only time effect. We add user dummy variable as an explanatory variable, and it enables us to estimate whether there is



difference between users and non-users in medical expenditures of each disease. The results of estimations are summarized in Table 7 for heart disease, high blood pressure, diabetes and strokes. Let us examine the result as follows;

Table 7 shows all selected chronic diseases such as heart disease, high blood pressure, diabetes and strokes at ( $p < 0.01$ ) and are found significant. Besides, user of telehealth system is found significant and shows that the system can save JPY 10,216.70 (US\$ 91.89) which is higher than our previous result as demonstrated in table 6. Besides, the patients who have chronic disease such as heart disease, high blood pressure, diabetes and strokes can save more as JPY 1536.06 (US\$ 13.81).

Table 7: Result of estimation (Chronic diseases)

Variables	Coefficient	Std. Err.	z-value	P-value	
Age	423.2018	212.8200	1.99	0.047	**
Employment	-10891.4000	3330.5930	-3.27	0.001	***
Numberof family members	359.9672	1054.3290	0.34	0.733	
Chronic disease	11163.2500	3131.0460	3.57	0.000	***
User	-10216.7000	5604.2690	-1.82	0.068	*
Heart diseases	17865.5400	4858.6540	3.68	0.000	***
High blood pressure	12131.7700	2821.3540	4.30	0.000	***
Diabetes	17290.0600	4226.8890	4.09	0.000	***
Strokes	14877.7900	6354.9450	2.34	0.019	***
Usage duration	674.6824	597.4991	1.13	0.259	
_cons	-10891.2700	15035.8200	-0.72	0.469	
Number of obs		1550			
Number of groups		205			
R-sq: within		0.0431			
between		0.2371			
overall		0.1081			

Note: \*\*\*, \*\*, and \* indicate the significance level of 1, 5 and 10%, respectively.

## 5. Conclusion

Our results indicate higher level of health cost for ageing and lower level for the participants who use telecare facilities established by the local government. A positive effect of telehealth use is observed among the patients who have chronic disease. Besides, a negative relationship is observed between working people with health cost. The results suggest a reduction of health expenditure by facilitating country-wide telehealth facilities.

### 5.1 Success factors of e-Health

The increase in medical expenditures is common phenomena all over the world. There are two measures to cope with this; the utilization of Information Technology (IT) in medical area and

prevention from being sick or maintain good health. The eHealth system can solve these issues. The results we obtained here provide the rigorous foundation of eHealth.

It is clear from authors' previous studies that eHealth is useful for consultation and maintaining the good health of the elderly and patients suffering from chronic diseases who are in stable condition. However, it is not effective at curing disease as there is no effect for strokes, estimated in this paper. It therefore has the psychological effect of providing a sense of relief to its users by the knowledge of being monitored by a medical institution 24-hours-a-day. This makes it difficult to estimate its benefits in concrete terms. This paper enables to provide concrete amounts for the reduction of users' medical expenditure of some chronic diseases. It is important note that solely introducing eHealth does not contribute to its success, but the fact that eHealth has been supported by eagerness of all related staff of the town office should be noticed. In Nishi-aizu town, there are six public nurses in charge of this system, and they always grasp health conditions of all users.

Moreover, it should be discussed e-Health projects in the UK and US which have the similar peripheral device and system (Darkins, A., Ryan, P., Kobb, R., Foster, L., Edmonson, E., Wakefield, B., Lancaster, A. E., 2008). According to our in-depth surveys of these projects, there are similarities and differences in these projects, but a common success factor lies in the enthusiasm of nurses, public or visiting nurses who participate in these projects to maintain health of the residents in the community. Further detailed study is required for factors of differences.

## *5.2 Economic Foundation of e-Health*

Let us discuss on the economic foundation of the project. Nishi-aizu Town does not charge any fee to users. Other projects in the most of counties are the same. Neither this program nor those referenced in the UK and US charge user fees; rather, all are subsidized by the central as well as local government, as indeed are the UK demonstration programs, since they are national pilot projects. However, the ongoing sustainability of e-Health requires a new financial framework. (Miyahara, S., Tsuji, M., Iizuka, C., Hasegawa, T., Taoka, F., 2007) conducted a cost/benefit analysis of Nishi-aizu's e-Health and calculated a B/C (cost-benefit) ratio which was 0.25. The initial costs of the implementation, such as for host computers and peripheral devices, were borne by the central government, however, excluding them from analysis gave a B/C ratio for Town which bore only operational costs, which is 0.91. But this is not sustainable. One possibility for promoting e-Health is reimbursement using public medical insurance. The amount of reimbursement is based on economic effect of e-Health and must be obtained rigorous analysis. Most of countries are not recognized reimbursement for e-Health, which reason is simple; e-Health is not diagnosis but prevention of diseases. The simple e-Health system does reduce medical expenditures of users. The present paper provides important support for the development of evidence-based policies for the diffusion of e-Health.

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