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Empirical Analysis of the Reduction of Medical Expenditures by eHealth

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Abstract

This paper aims to examine reduction of medical expenditures by utilizing the system of Nishi-aizu Town, Fukushima Prefecture. The town office has been implementing it since 1994 and keeps receipts on medical expenditures of its approximately 4,000 residents paid by National Health Insurance for 5 years from 2002 to 2006. We select (1) users; and (2) non-users of the e-health system, and by comparing their medical expenditures, we examine: (i) difference in medical expenditures between two groups; and (ii) negative correlation between medical expenditures and the length of usage of the e-health system. We find that total medical expenditures of users are larger than those of non-users, whereas by restricting to lifestyle-related illnesses such as high blood pressure, cerebral infarction, strokes, and diabetes, medical expenditures of users are found to be smaller than those of non-users. The results we obtained here provide the rigorous economic foundation of the e-health system.

Keywords:

e-health, Telemedicine, Medical expenditures, Lifestyle-related illnesses, Regression analysis.

Introduction

Medical expenditures in Japan have been increasing steadily, amounting to 32.4 trillion yen (US$ 324 billion) in FY (Fiscal year) 2006. More than half (51.1%) of all expenditures are for persons over 65 years old. Japan is aging rapidly; the current percentage of the elderly (over 65) is more than 20%, and is expected to increase further in the near future. In order to cope with this situation, various policy measures have been taken, including requiring patients to bear more of their own medical costs. Japan has a well-organized universal public health insurance system; due to increasing medical expenditures and deficits in the medical insurance budget, however, the percentage of costs reimbursed by public health insurance has been falling. The elderly have thus been forced to pay more of their medical expenditures.

Another measure to reduce medical expenditures is to focus on prevention of diseases: the healthier people become, the fewer medical costs are required. One example is to enhance consciousness toward health and efforts to prevent illness. To this end, the government has taken initiatives such as the "Health Japan 21 Project." Recent campaigns against Metabolic Syndrome are another example, as this condition is thought to increase risks of hypertension or hyperlipidemia. The campaigns against Metabolic Syndrome include recommending regular physical exercises and monitoring of diet and nutrition. Prevention of illness through health maintenance is an important measure to reduce medical expenditures.

This paper focuses on the utilization of IT (Information Technology) to maintain health. We examine the e-health system, which monitors the health condition of the elderly at home by transmitting users' health-related data, such as blood pressure, ECG (Electrocardiogram), and blood oxygen, to a remote medical institution via a telecommunications network (see [4]). At present, more than 100 Japanese local governments are using such systems, using a total of more than 12,000 devices – more than any other country. The system is equipped with a simple device that records an elderly person's condition or a patient's illness in graphs that are then used for diagnosis and consultation. Reports sent by the medical institution also help users to enhance their daily health consciousness and maintain good health. These positive effects have been identified through field surveys in [4-6].

The e-health system in Japan has already passed the experimental stage, and is entering the diffusion stage. The government expects the e-health system to reduce medical expenditures and enhance the provision of public health and welfare. The authors have been conducting research on economic evaluation of the e-health system, by estimating the system's benefits in terms of WTP (Willingness to pay) and comparing benefits with costs (see [2, 3, 5-7]). Without confirmation of the e-health system's cost-effectiveness, the system's future sustainability cannot be guaranteed.

In this paper, we make an attempt to prove a statistically significant relationship between medical expenditures and the introduction of the e-health system by examining the case of Nishi-aizu Town. Reasons for this region's selection are: (i) the town has been making full use of the system since 1994; (ii) Nishi-aizu is the second town in Japan to introduce the e-health system, and since then the system has been the core of its health, welfare, and medical services; (iii) the authors conducted field research on this town in 2000, 2001 and 2006; and (iv) data on Nishi-aizu's medical expenditures is readily available. The town office has medical receipts paid of National Health Insurance for its 3000 residents for recent five years from 2002 to 2006 (for Nishi-aizu Town, see [1]).

The paper format will be a section explaining the basis of Nishi-aizu e-Health system, and then a section explaining how we construct the data for a survey analysis, and the method of analysis. The next section provides characteristics of sample, which based on our survey data. After that, the results of survey are presented, followed by rigorous statistical analysis by making use of Ordinary Least Squares method (OLS). Brief concluding remarks are stated in the final section.

Data and Methodology

Selection of Sample

As stated earlier, this paper examines the relationship between medical expenditures of Nishi-aizu's residents and the e-health system. According to the Japanese medical insurance system, which is organized and operated by the Ministry of Welfare and Labor, all people must be covered by one of several social health insurance systems. This paper focuses on people in Nishi-aizu who are covered by "National Health Insurance," since data on medical expenditures through this system are handled by local governments. National Health Insurance is not only for self-employed individuals such as farmers or owners and employees of small- and medium-sized firms, but also people who already retired.

One of the purposes of this paper is to compare medical expenditures between two groups such as (i) users and (ii) non-users of the e-health system from medical receipts of Nishi-aizu Town. Samples of two groups are selected according to the following way.

1) User group

We selected 412 users from the list of registered users in the town according year they registered. The total number of users and that selected as the sample is shown Table 1. Then we send questionnaires to them and 311 replies were received. Finally, after checking the replies, 199 replies remain as significant. The rate of valid reply is 48.30%.

2) Non-user group

We selected 450 residents who are covered by National Health Insurance out of total 3,528. Questionnaires were sent to 450 and we received 239 replies. Again by checking the replies, we had 209 significant replies. The rate of significant reply is 46.44%.

In sum, the total number of residents selected as the sample becomes 408. We checked their receipts from those stored in the town office, and total number of receipts of 3,528 residents who are covered by National Health Insurance is 160,000 for five years. It took 8 days for 18 students to picks up those of 408.

Receipt Data

The receipts of National Health Insurance of each month are kept at the town office, in which the data such as name and address of medical institution, birth date, name of disease, date of initial-visit, medicine, and score (amount) of medical treatment are described. In this paper, we use the following data: (i) name of resident, (ii) birth date, (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 needed for treatment, and (vii) cost of medical treatment.

Table 1 – e-health users

Year start using the system	Total number of users: Male	Female	Total	Users selected as sample
1994	9	11	20	20
1995	13	11	24	24
1996	8	14	22	22
1997	30	36	66	66
1998	13	15	28	28
1999	4	6	10	10
2000	8	11	19	19
2001	3	3	6	6
2002	6	7	13	13
2003	91	88	179	95
2004	53	69	122	95
2005	6	6	12	12
2006	2	0	2	2
Total	246	277	523	412

Characteristics of Data

The age distribution of users and non-users is shown in Table 2. As for users, more than half are age of 70s, while for non-users more than one third. Most of samples are age of 60s, 70s and 80s.

Table 2 – Age distribution of users and non-users

	User	Non-user	Total
40 - 49	2	0	2
50 - 59	14	23	37
60 - 69	45	67	112
70 - 79	92	76	168
80 - 89	46	37	83
Over 90	0	6	6
Total	199	209	408

According to Table 3, about 45% of users and 40% of non-users replied they have some kind of chronic diseases. The former has the higher rate than latter because suffering chronic diseases is strong incentive to use e-health service. This coincides with the property of other regions.

Table 4 indicated years of using the e-health system, and except less than one year, the numbers of users are not different in terms of years of use.

Table 3 – Having chronic diseases

	User	Non-user	Total
Yes	90	81	171
No	72	90	162
No reply	37	38	75
Total	199	209	408

Table 4 – Years of using e-health

Years of use	Number of user	
Less than 1year	6	3.0%
1-3	38	19.1
3-5	45	22.6
5-7	35	17.6
7-10	39	19.6
Over 10	36	18.1
Total	199	

Table 5 shows the relation between age and years of use. The longer the use, the older the users become. This is rather natural, longer use implies those users become old. Table 6 indicates the frequency of using the e-health service. Nearly 40% of users use it every day, while 24% use 3-4 times a week. More than 70% use at least one a week.

Table 5 – Years of using and average age

Years of use (years)	Average age (years)
Less than 1	71.3
1 - 3	68.9
3 - 5	70.3
5 - 7	74.8
7 - 10	74.0
Over 10	76.4

Table 6 – Frequency of using

Almost everyday	76	38.19%
3 - 4 times a week	47	23.62
1 - 2 times a week	20	10.05
1 - 2 times a month	23	11.56
Not use	25	12.56
No reply	8	4.02
Total	199	

Hypotheses and Model Specification

According to data discussed in the previous section, at first the following four hypotheses are presented.

- Hypothesis 1: Users of the e-health system have lower medical expenditures of lifestyle-related illness than those of non-users.
- Hypothesis 2: Users of longer practicing the e-health system have lower medical expenditures of lifestyle-related illness than those of non-users.
- Hypothesis 3: Users of longer practicing the e-health system reduce medical expenditures larger than those who use it shorter years if they extend usage one more years.
- Hypothesis 4: The e-health system there has more effect to people who have diseases than those who do not.

We tested these hypotheses based on the model as follows:

$$y_{it} = \alpha + X'_{it}\,\beta + u_{it}$$
$$u_{it} = \lambda_t + v_{it} \qquad (1)$$

where y_{it} denotes the medical expenditures of life-style related diseases, X_{it} indicates each characteristics such as sex, age, education, employment (dummy variable), number of family living together, income, and chronic diseases (dummy variable). We utilized the panel data analysis with one-way fixed effect model where λ_t denotes the year dummy, because the system of calculating medical expenditures is changed every 2 years. Also, individual effect, or dummy might cause serious multicollinearity with each characteristics, so we control only time effect.

Results

Hypothesis 1

Table 7 shows the result of estimation of hypothesis 1 by taking medical expenditures restricted to lifestyle-related illnesses as a dependent variable. The explanatory variables are Sex, Age, Education, Employment (dummy variable), Number of family living together, Income, Chronic diseases (dummy variable), and Use dummy (e-health user). Variables which provide significant effect at the 1 % significant level are Sex, Age, Income, Chronic diseases, and User dummy; and number of family living together at the 5% significant level. The results of this estimation can be interpreted in the following way, in which one medical score is equivalent to 10 yen (US$ 0.1).

- Medical expenditures of e-health users are smaller than those of non-users by 15,688 yen (US$ 156.88) per year. This amount is 21.2% of average annual medical expenditures.
- Medical expenditures of residents with chronic diseases are larger than those without it by 33,440 yen (US$ 334.40) per year.
- Medical expenditures increase 2,197 yen (US$ 21.97) per year when they become one year older.
- Higher income residents have lower medical expenditures than low income group.

Table 7 – Result of estimation (Hypothesis 1)

	Coef.	Std. Err.	
Sex	1467.36	473.55	***
Age	219.67	29.12	***
Education	309.45	315.10	
Employment	95.86	501.79	
No. of family living together	289.24	126.34	**
Income	-19.09	4.08	***
Chronic Diseases	3344.00	476.34	***
User dummy	-1568.79	478.90	***
Constant	-10517.63	2378.58	***
Number of Obs.	1545		
R2 adjusted	0.0819		

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Hypothesis 2

Next, we present the second result by making use of OLS. In this estimation, we take medical expenditures of lifestyle-related illnesses as a dependent variable, and as for independent variable, sex, age, education, employment (dummy variable), number of family living together, income, chronic diseases (dummy variable), and years of e-health use. The estimation result is summarized in Table 8. Variables which provide significant effect at the 1 % significant level are (i) sex, age, income, chronic diseases, (ii) number of family living together at the 5% significant level, and (iii) years of e-health use at the 10% significant level. Again these results can be interpreted in the following way:

- Medical expenditures of lifestyle-related illness can be reduced by 1,133 yen (US$ 11.33) per year, if they extend using the e-health system one more year. The amount of reduction is 1.5% of average annual medical expenditures.

Table 8 – Result of estimation (Hypothesis 2)

	Coef.	Std. Err.	
Sex	1542.36	474.40	***
Age	223.57	29.65	***
Education	302.22	315.90	
Employment	127.48	503.50	
No. of family living together	257.77	126.99	**
Income	-19.24	4.09	***
Chronic Diseases	3315.44	477.95	***
Years of e-health use	-113.32	66.18	***
Constant	-11250.42	2411.04	***
Number of Obs.		1545	
R2 adjusted		0.0780	

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Hypothesis 3

The elasticity, which is is a rate of decrease according to the 1% of increase of years of use, becomes larger, as shown in Table 9. In other words, for users who utilize e-health for more years, additional one year use decreases more medical expenditures than for those who use it for less years.

- This implies that elasticity increases according to years of its use, and the years one uses the system, the larger the reduction in medical expenditures becomes. This is an amazing result and verifies effectiveness of the e-health system.

Table 9 –Elasticity (Hypothesis 3)

Years of e-health use	Elasticity
Non-user	0
0 – 2	-0.01323
2 – 4	-0.04161
4 – 6	-0.07279
6 – 8	-0.09959
8 – 10	-0.12806
10 – 12	-0.15044
Over 12	-0.18321

Hypothesis 4

Nishi-aizu Town distributed the devices according to the following criteria:

(i) Senior people with diseases

(ii) The senior who are recommended by doctors

(iii) People other than the above categories who have chronic diseases or recommended by doctors.

The town office recognizes effects of its e-health system, and especially, it expects the effect to people with chronic diseases. Here we attempt to verify whether the e-health system there has more effect to those than people who do not have chronic disease.

The result of this estimation is indicated in Table 10, which implies that variables such as sex, age, and income are significant in the estimation for people without chronic diseases, while variables such as the number of family and user dummy in addition to above variables of people without chronic diseases. Especially, the dummy variable for people without chronic diseases is not significant, which means that there is no significant difference in medical expenditures between users and non-users. For the estimation of people with chronic diseases, its p-value is less than 1 %, which indicates that there is great difference between two groups. In other words, we cannot identify the difference between two groups for healthy people, while the system has great effect to people with chronic diseases. Our estimation shows that the difference in medical expenditures is 37,942 yen (US$ 379.42). According to this result, the principle of distribution of the device to people is verified.

Table 10 – Result of estimation (Hypothesis 4)

	Without chronic diseases		With chronic diseases	
	Coef. (Std.err.)		Coef. (Std.err)	
Sex	1424.65	**	1681.68	**
	(553.25)		(815.62)	
Age	281.14	***	112.32	**
	(32.95)		(52.40)	
Education	13.26		511.28	
	(390.09)		(508.33)	
Employment	565.58		-592.03	
	(579.25)		(879.79)	
No. of family living together	110.53		588.46	***
	(145.50)		(222.25)	
Income	-14.40	***	-26.23	***
	(4.75)		(7.19)	
User dummy	65.60		-3794.18	***
	(557.77)		(827.54)	
Constant	-14725.31	***	324.68	
	(2720.33)		(4177.35)	
Number of Obs.	755		790	
R2 adjusted	0.0933		0.0485	

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Conclusion

This paper analyzes the relationship between medical expenditures and the e-heath system, which connects senior people at home and medical or health institutions by transmitting vital data via the telecommunications network. Even though the e-health system is simple, it contributes to promote health of senior people. This paper aims to verify empirically whether and how much it contributes to promote senior people's health by examining the system of Nishi-aizu Town, Fukushima Prefecture in Japan. The town office keeps receipts on medical expenditures of its approximately 4,000 residents in a paper form paid by National Health Insurance for 5 years from 2002 to 2006.

First, we can estimate from OLS that users' average annual expenditures per person related to lifestyle-related illnesses is smaller than that of non-users by 15,688 yen (US$ 156.88). This amount is about 21.2% of average expenditures of non-users. Second, if users utilize the system one more year, then the above expenditures decrease about 1,133 yen (US$ 11.33) per year, which is about 1.5% of the average expenditures. We also find that the amounts of the above decrease become larger, if the experience of using the system is longer. Finally, the e-health system there has more effect to those than people who have diseases.

Nishi-aizu Town used to suffer high death rates due to life-style-related illnesses, and it introduced the e-health system as a part of projects such as "Promoting Total Care", and "Challenge to 100 Years Old." The efforts of residents as well as staff engaged in these projects for nearly 20 years achieved medical expenditures significantly smaller than the national average. It should be noted that behind this success lies close collaboration of networks of health, medicine, and welfare. Nishi-aizu's experiences thus establish a model to reduce medical costs and improve health of the residents of other regions.

The increase in medical expenditures is common phenomena all over the world. There are two measures to cope with this; the utilization of IT in medical area and prevention from being illness (or maintain health). The e-health system can solve these issues. The results we obtained here provide the rigorous foundation of the e-health system.

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References

[1] Tsuji M. The telehomecare/e-health system in Japan. Business Briefing: Global HealthCare. 2002; 72-6.

[2] Tsuji M, Suzuki W, Taoka F, Kamata K, Ohsaka H, Teshima T. An empirical analysis of the assessment of the tele-home-care system and burden of costs: based on a survey on kamaishi city. (in Japanese), Japan Journal of Medical Informatics. 2002; 22: 76-89.

[3] Ito Y, Suzuki W, Tsuji M, Taoka F, Comparative analysis of evaluation by users of the e-health system between Kamaishi City, Iwate Prefecture and Nishi-aizu Town, Fukushima Prefecture.(in Japanese), Japan Journal of Medical Informatics.2004; 23, 313-23.

[4] Tsuji M, Suzuki W, Taoka F, An empirical analysis of a telehealth system in term of cost-sharing," Journal of Telemedicine and Telecare. 2003; 9: 41-3.

[5] Tsuji M, Iizuka C, Taoka F, Teshima, M. The willingness of Japanese citizens to pay for e-health systems," Journal on Information Technology in Healthcare. 2006; 4: 103-10.

[6] Miyahara S, Tsuji M, Iizuka C, Hasegawa T, Taoka F, Teshima, M. An economic evaluation of Japanese telemedicine, focusing on teleradiology and telepathology," Journal of Telemedicine and Telecare. 2006; 12: 194-5.

[7] Miyahara S, Tsuji M, Iizuka C, Hasegawa T, Taoka F, On the evaluation of economic benefits of Japanese telemedicine and factors for its promotion, Journal of Telemedicine and eHealth. 2007; 12: 291-9.

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