

An Empirical Analysis on the Reduction of Medical Expenditures by e-Health Systems: Case of Nishiaizu Town, Fukushima Prefecture

Akematsu, Y. ¹, M. Tsuji¹ and F. Taoka ²

¹ Graduate School of Applied Informatics, University of Hyogo, Japan

² Kyoto University of Education, Japan

Email: tsuji@ai.u-hyogo.ac.jp

Keywords: *eHealth system, lifestyle-related illness, receipt of National Health Insurance, OLS.*

EXTENDED ABSTRACT

This paper analyses the relationship between medical expenditures and the eHealth system, which connects senior people at home and medical or health institutions by transmitting vital data via the telecommunications network. Even though the eHealth 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 Nishiaizu 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.

We identify two following groups of its residents: (i) users; and (ii) non-users of the eHealth system, and we compare their medical expenditures. As for the former, we selected 412 out of 523 its total users, and as for the latter, we chose 450 from the list of National Health Insurance. We send questionnaires on their personal characteristics and diseases and obtained 199 replies from users, while 209 for non-users. Then we picked up receipts of these 408 people out of total 160,000 receipts, and made a database on age, diseases, the number of days visiting medical institutions, and medical expenditures. Based on this database, we examine the following hypotheses by using the Ordinal Least Square Method (OLS): (i) whether there is a clear difference in medical expenditures between two groups; (ii) whether there is negative correlation between medical expenditures and the length of usage of the eHealth system; and (iii) elasticity of the reduction of medical expenditures with respect to years of utilization of the eHealth system is larger for longer users.

As for (i), 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. 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 15,302 yen (US\$133.06). This amount is about 20.7% of average expenditures of non-users. As for (ii), if users who are younger than 80 years old utilize the system one more year, then the above expenditures decrease about 13,719 yen (US\$119.30) per year, which is about 18.7% 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.

Other factors which have effects to medical expenditures are age, sex, income, and having chronic diseases. The average age of users is higher than that of non-users, and this makes us to guess that the former has larger medical expenditures than the latter. This result is, therefore, amazing. From examining the relationship between medical expenditures related to lifestyle-related illnesses and the length of using the eHealth system, it takes at least three years for the eHealth system to have effects on the reduction of medical expenditures.

Nishiaizu Town used to suffer high death rates due to lifestyle-related illnesses, and it introduced the e-health system as a part of projects such as "Challenge to 100 Years Old." The town thus achieved medical expenditures significantly smaller than the national average. There are two measures to cope with the increase in medical expenditures; the utilization of IT in medical area and prevention from being illness (or maintain health). The eHealth system can solve these issues. The results we obtained here provide the rigorous economic foundation of the eHealth system.

1. INTRODUCTION

Medical expenditures in Japan have been increasing steadily, amounting to 32.1 trillion yen (US\$292 billion) in FY 2004. 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, and blood oxygen, to a remote medical institution via a telecommunications network (see Tsuji (1)). 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 Ito et al (2002), Tsuji et al (2002) and (2003).

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 Ito et al (2002), Tsuji et al (2002), (2003), and (2006)). 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 Nishiaizu Town. Reasons for this region's selection are: (i) the town has been making full use of the system since 1994; (ii) Nishiaizu 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 Nishiaizu'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.

The paper consists of the following sections; Section 2 explains the basis of Nishiaizu e-Health system, and Section 3 explains how we construct the data for a survey analysis, and the method of analysis. Section 4 provides characteristics of sample, which based on our survey data. In Section 5, the results of survey are presented. Section 6 provides rigorous statistical analysis by making use of OLS method. Brief concluding remarks are stated in the final section.

2. SAMPLE DATA

2.1. Selection of Sample

As stated earlier, this paper examines the relationship between medical expenditures of Nishiaizu's residents and eHealth 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 Nishiaizu 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 eHealth system from medical receipts of Nishiaizu 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 significant reply is 38.05.

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.

Table 1 eHealth users

Year start using the system	Total number of users			Users selected as sample
	Male	Female	Total	
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

2.2. 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) score (amount) of medical treatment.

3. 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

	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 eHealth service. This coincides with the property of other regions

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 indicated years of using the eHealth system, and except less than one year, the numbers of users are not different in terms of years of use. 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 eHealth service. Nearly 40% of users use it everyday, while 24% use 3-4 times a week. More than 70% use at least one a week.

Table 4 Years of using eHealth

Years of use	Number of user	
Less than 1 year	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 Years of use and a average age

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

Table 6 Frequency of use

Almost everyday	76	38.2%
3 - 4 times a week	47	23.6
1 - 2 times a week	20	10.1
1 - 2 times a month	23	11.6
Not use	25	12.7
No reply	8	4.0
Total	199	100.0

4. RESULTS OF RECEIPT ANALYSIS

In this section, we summarize results of analyzing receipts of Nishiaizu Town. The first hypothesis we want to verify is whether there is a significant difference in medical expenditures between users and non-users. This indicates whether the eHealth system of the town actually save medical expenditures. Figure 1 shows the average medical expenditures per resident in one month. Expenditures are related to all diseases. From Figure 1, it follows that users' medical expenditures are larger than those of non-users for all years within the sample period. This result seems to contradict the expectation of the role of the eHealth system. By focusing on medical expenditures of lifestyle-related illnesses such as high blood pressure, cerebral infarction, strokes, and diabetes, Figure 2 is obtained. Figure 2 shows that except 2002, users of the eHealth system have lower medical expenditures of lifestyle-related illnesses than those of non-users.

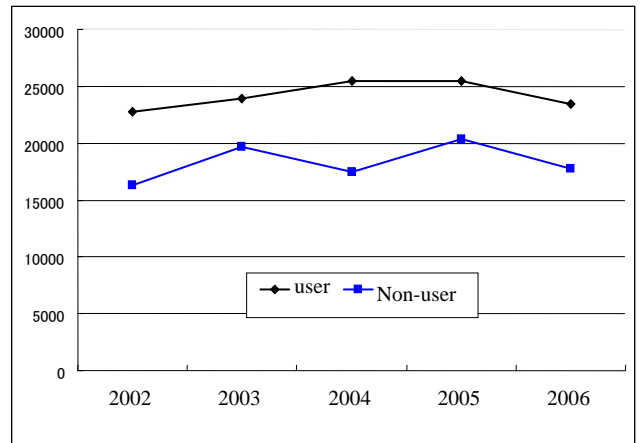


Figure 1 Medical expenditures of users and non-users (all illness) between users and non-users

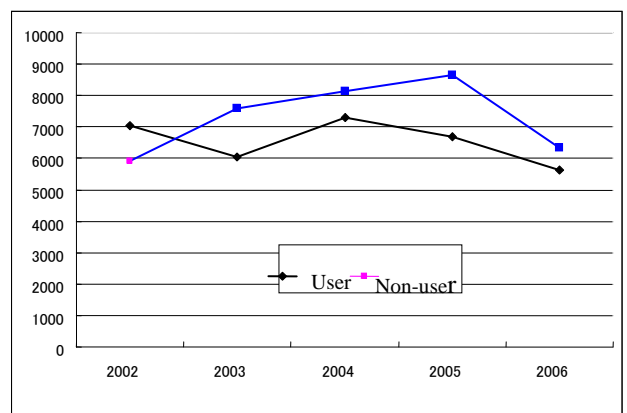


Figure 2 Medical expenditures of lifestyle related illness between users and non-users

5. EMPIRICAL ANALYSIS

In previous data analysis, we make an attempt to verify the following three hypotheses:

- Hypothesis 1: Users of the eHealth system have lower medical expenditures of lifestyle-related illness than those of non-users.
- Hypothesis 2: Users of longer practicing the eHealth system have lower medical expenditures of lifestyle-related illness than those of non-users.
- Hypothesis 3: Users of longer practicing the eHealth system reduce medical expenditures larger than those who use it shorter years if they extend usage one more years.

This section analyzes these hypotheses empirically by using Ordinal Least Square method (OLS).

5.1. 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), eHealth user (dummy variable), and 2004 (dummy variable). Variables which provide significant effect at the 1 % significant level are (i) age, income, chronic diseases, and eHealth user; (ii) sex, 2004 dummy at the 5% significant level; and (iii) number of family living together at the 10% significant level. The results of this estimation can be interpreted in the following way:

- Medical expenditures of eHealth users are smaller than those of non-users by 15,302 yen (US\$ 133.06) per year. This amount is 20.7% of average annual medical expenditures.
- Medical expenditures of residents with chronic diseases are larger than those without it by 33,680 yen (US\$ 292.87) per year.
- Medical expenditures increase 2260 yen (US\$ 19.65) per year when they become one year older.
- Higher income residents have lower medical expenditures than low income group.

Table 7 Result of OLS estimation (hypothesis 1)

	coefficient	Standard error	t-value	p-value	
Sex	1265.0140	489.8683	2.58	0.010	**
Age	225.9026	30.4884	7.41	0.000	***
Education	372.6116	342.2791	1.09	0.276	
Employment	193.6149	524.6889	0.37	0.712	
No. family living together	242.3751	133.0603	1.82	0.069	*
Income	-1.5927	0.3829	-4.16	0.000	***
Chronic Diseases	3367.5390	493.1578	6.83	0.000	***
User dummy	-1530.1800	496.1661	-3.08	0.002	***
2004 dummy	1330.6340	607.8545	2.19	0.029	**
Constant	-11722.1600	2586.2050	-4.53	0.000	***
No. of sample		1730			
R2 adjusted		0.0752			

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

Table 8 Result of OLS estimation (hypothesis 2)

Variables	Coefficient	Standard error	t-value	p-value	
Sex	4820.6470	4719.1740	1.02	0.308	
Age	1038.6950	362.7688	2.86	0.005	***
Education	871.3786	3246.7990	0.27	0.789	
Employment	-1352.3830	4983.0840	-0.27	0.786	
No. of family living together	692.1651	1260.1830	0.55	0.583	
Income	-6.7219	3.4912	-1.93	0.055	*
Chronic diseases	24317.3000	4733.5240	5.14	0.000	***
Years of eHealth use	-1371.9240	701.6089	-1.96	0.052	*
Constant	-50459.4800	27924.2100	-1.81	0.072	*
No. sample		273			
R2 adjusted		0.1186			

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

5.2. Hypothesis 2

Next, we verify the second hypothesis by making use of OLS. In this estimation, we take medical expenditures of users younger than 80 years old 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 eHealth use. The estimation result is summarized in Table 8. Variables which provide significant effect at the 1 % significant level are (i) age, chronic diseases, and (ii) income, and years of eHealth 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 13,719 yen (US\$ 119.30) per year, if they extend using the eHealth system one more year. The amount of reduction is 18.7% of average annual medical expenditures.
- Medical expenditures increase 10,387 yen (US\$ 90.32) per year, when they become one year older.

5.3. Hypothesis 3

In verifying hypothesis 3, let us take users younger than 80 years old as a sample. Here we examine how medical expenditures would be affected by using the eHealth system one more year under the assumption of the experience of its usage so far. In other words, we analyse how the reduction of medical expenditures is different between users of 10 years' experience and those of 2 years, if they extend its use one more year. It is natural to expect that the former shows larger reduction than the latter. In order to examine this, it is sufficient to calculate the elasticity of the reduction with respect to years of usage. The elasticity is obtained by the following procedure.

Since $dy/dx = a$, elasticity $= (x/y^*) (dy/dx) = a(x/y^*)$,

Where y , x , and y^* are medical expenditures, year's of usage, and estimated y from the model. a indicates estimated coefficient. The result of calculation is indicated in Table 9, which clearly implies that users with longer usage experience

tend to reduce larger than those who have less experience.

Nishiaizu Town introduced this system 1994, it has longest history, and this hypothesis shows the reduction medical expenditure can be seen in this way.

Table 9 Elasticity of reduction of medical expenditures

	y^*	(coefficient) * (usage years)	elasticity
Non-user	32379.12	0.00	0.00
Less 1 year	35593.38	-1371.92	-0.04
1 - 3 years	24977.29	-2743.85	-0.11
3 - 5 years	29067.75	-5487.70	-0.19
5 - 7 years	31818.32	-8231.54	-0.26
7 - 10 years	26850.61	-11661.35	-0.43
More than 10 years	26710.53	-13719.24	-0.51

6. CONCLUSION

This paper analyzes the relationship between medical expenditures and the eHealth system, which connects senior people at home and medical or health institutions by transmitting vital data via the telecommunications network. Even though the eHealth 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 Nishiaizu Town, Fuikushima 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.

As for (i), 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. 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 15,302 yen (US\$133.06). This amount is about 20.7% of average expenditures of non-users. As for (ii), if users who are younger than 80 years old utilize the system one more year, then the above expenditures decrease about 13,719 yen (US\$119.30) per year, which is about 18.7% of the average expenditures. We also find that the amounts of the above decrease become larger, if the experience of using the system is Nishiaizu Town used to suffer high death rates due to lifestyle-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. Nishiaizu’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 eHealth system can solve these issues. The results we obtained here provide the rigorous foundation of the eHealth system.

REFERENCES

- Akematsu, Y., M. Tsuji and F. Taoka (2007), An empirical analysis of telehomecare in Nishi-Aizu Town, Fukushima Prefecture based on receipt data of national health insurance (in Japanese), *Journal of Japanese Telemedicine and Telecare Association* (forthcoming),
- Ito Y., W. Suzuki, M. Tsuji, and F. Taoka (2004), Comparative analysis of evaluation by users of the e-Health system between Kamaishi City, Iwate Prefecture and Nishiaizu Town, Fukushima Prefecture (in Japanese), *Japan Journal of Medical Informatics*, 23 (4), 313-23.
- Miyahara, S., M. Tsuji, C. Iizuka, T. Hasegawa, F. Taoka, and M. Teshima (2006), An economic evaluation of Japanese telemedicine, focusing on teleradiology and telepathology, *Journal of Telemedicine and Telecare*, 12 (2), 194-5.
- Miyahara, S., M. Tsuji, C. Iizuka, T. Hasegawa, and F. Taoka (2007), On the evaluation of economic benefits of Japanese telemedicine and factors for Its promotion, *Journal of Telemedicine and eHealth*, 12(6), 291-9.
- Tsuji, M. (2002), The telehomecare/e-health system in Japan, *Business Briefing: Global HealthCare*, 72-6.
- Tsuji, M., W. Suzuki, F. Taoka, K. Kamata, H. Ohsaka, and T. Teshima (2002), 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*, 22(1), 76-89.
- Tsuji, M., W. Suzuki, and F. Taoka (2003), An empirical analysis of a telehealth system in term of cost-sharing, *Journal of Telemedicine and Telecare*, 9(Suppl. 1), 41-43.
- Tsuji, M., C. Iizuka, F. Taoka and M. Teshima (2006), The willingness of Japanese citizens to pay for e-Health systems, *Journal on Information Technology in Healthcare*, 4(2), 103-10.
- Tsuji, M., F. Taoka, and M. Teshima (2007), An analysis of reduction in medical expenditure by eHealth systems: case of Nishiaizu Town, Fukushima Prefecture. Proceeding of Healthcom07, Taipei, Taiwan.