Does Telecare Reduce Medical Expenditure for Heart Failure Patients?

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Abstract

This paper examines the effect of tele-home-care on medical expenditure for heart failure patients using survey data from Nishi-aizu Town, Fukushima Prefecture, Japan, (2002-2006). In town's telecare system, users at home transmit vital data such as ECG, blood pressure, and pulse to the town's health center via the peripheral device, and nurses monitor the data. This study focuses on heart failure which is the second popular chronic disease next to high blood pressure in the town. Medical expenditures of the following groups are compared: the treatment group consists of 199 selected from 523 telecare users according to years of use, while 209 non-users (control) were selected from 3,525 residents, and their medical expenditures obtained from the National Health Insurance scheme were used a dependent variable in estimation. Individual characteristics of the two groups, including age, sex, income, and health conditions, were obtained from replies to the questionnaire and receipts of the National Health Insurance and used for explanatory variables. Heart failure patients were identified by their record of related diseases having treated. We use system GMM, a rigorous estimation method aimed to solve the causality problem. This analysis demonstrates that tele-home-care use itself, duration of, and frequency of telecare use reduce the medical expenditures of heart failure patients.

1. Introduction

Tele-homecare is aimed at monitoring the health of the elderly at home via the transmission of health-related data, and is thereby expected to enhance users' health. We previously confirmed that telecare reduced the medical expenditures of users in Nishi-aizu Town, Fukushima Prefecture, Japan, which in 1994 introduced Japan's longest-running telecare ([1], [2]). The population of about 8,000 resides in 3,000 households, with a percentage of elderly ($\geq$ 65 years) in 2011 of 40.3%. The town had been suffering from chronic diseases such as heart failure, strokes, high blood pressure, and diabetics due to cold climate and traditional salty diet. The town office decided to establish the telecare system in 1994 to reduce the number of the elder with chronic diseases. The system consisted of main servers situated in town's health center and peripheral devices distributed to residents who were chosen to use it. Priority for the provision of peripheral devices to residents is as follows: (i) persons to whom doctors recommend to use; (ii) senior people over 65 years old living alone; and (iii) residents who want to use a device. Users of device measure their health data including blood pressure, ECG, plus, and blood oxygen via a town's CATV network, and send them the health center, review the data at home, and receive advice from public nurses. More than 500 residents have been registering to telecare, and among them, more than two-third use the devices more than three days a week, with health and had an incentive to showing the highest usage in Japan. By checking heath data transmitted by the telecare system, users became more concerned change their behavior to be more health-promoting. This is the reason why telecare reduces users' medical expenditures related to chronic diseases in comparison with non-users.

Generally, the medical cost analysis is difficult in the person level, because several factors may have effects on the person's diseases. For example, there is high possibility the patients who have heat diseases would have high blood pressure or diabetes. But there were no studies by using system GMM to consider above mentioned problems. The causality (endogenous) problem of explanatory variables must be treated properly. Moreover the time lag may occur between heart diseases and chronic diseases. Therefore we use system GMM which is one of dynamic panel models. For detailed discussion on system GMM and economic effect of telecare, see [3] and [4], for example.

2. Data sources and empirical studies

2.1. Data sources

According to the Japanese medical insurance system, which is organized and operated by the Ministry of Health, Labor and Welfare, all residents in Japan must be covered by one of several social health insurance systems.

This article focuses on people in Nishi-aizu Town who are covered by the "National Health Insurance" system, since data on medical expenditures through this system are handled by local governments. We can gather the data set from 2002 to 2006 about medical expenditures and the attributions of patients, for example sex and age, from the receipt of National Health Insurance, and users of the telecare system from the list of town office. In this article, we compare medical expenditures of two groups between (i) users of the telecare system and (ii) non-users of the telecare system.

We try to estimate with methods of panel analysis, and system GMM. We examine the correlation between telecare use and the medical expenditure by controlling age and chronic disease to use panel analysis. Next, we examine the causality between telecare use and the medical expenditure by considering endogenous problem of explanatory variables of diseases especially, and the time lag effect of disease to use system GMM.

And for telecare use variables, we treat telecare use simply, the duration of and the frequency of telecare use. We examine the degree of utilization of telecare by using the data of duration and frequency of telecare use. Table I summarizes the basic statistics of variables in estimations.

2.2. System GMM

Generalized method of moments (GMM) estimator is developed by Arellano-Bond [5], Arellano-Bover [6], and Blundell-Bond [7]. This method is designed for situations with "small T, large N" panels. This situation is fitting to our data set. The particularity of this method can estimate the model that independent variables are not strictly exogenous, meaning correlated with past and possibly error and with heteroskedasticity and autocorrelation within individuals. In our estimation, heart disease with telecare user, heart disease and other diseases are possibly not strictly exogenous. And there is possibly heteroskedasticity and autocorrelation within individuals in our data set. Especially in patients, it is difficult to assume homogeneity. But this method is known that standard errors have a tendency to be downward biased.

Windmeijer [8] reported that standard errors tend to be severely downward biased in estimation and he improved this problem. Thus Windmeijer method is used in this article.

Basic model is as following.

$$y_{i,t} = \sum_{j=t-1}^{t-p} \gamma_j y_{i,j} + \sum_{l=1}^{n} \beta_i X_{i,t,l} + \alpha_i + \varepsilon_{i,t}, t = p+1,...,T$$

$y_{i,t}$ is the dependent variable (medical expenditure)
$X_{i,t}$ is the explanatory variable including age, sex, income, and dummy variables such as telecare use, year and frequency of telecare use
α_i is the patient's specific fixed effect
$\varepsilon_{i,t}$ is the error term.

There are two types of instrument variables, so as to say, usual instrument variable and GMM-style instrument. Usual instrument variable is independent variable. GMM-style instruments are lag period of explanatory variables.

We use mainly time series dummy variables for instrument variables. Also we use the one period lag of the dependant variable, and the explanatory variables with endogeneity, for example, diseases for GMM-style instruments.

3. Results of estimation

Table 1 indicates summary statistics, and Table 2 shows the estimation results. We can find coefficients of heart disease patient by telecare use, the duration of telecare use, and the frequency of telecare use are negative statistically significant (p<0.01, p<0.05, p<0.01, respectively). Coefficient of heart disease patient is positively significant in every three case (p<0.001).

Heart disease related variables are thought to have endogeneity, and thus one period lag of these variables is used as GMM-style instruments. Chronic disease is treated as explanatory variables with endogeneity in cases of heart disease patient by telecare use and the duration of telecare use. In the case of frequency of telecare use, chronic disease is treated as GMM-style instrument. Chronic disease is treated as GMM-style instrument in every three case. Also the lag of medical expenditures for explanatory variable cannot be used. Arellano-Bond AR2 shows there is not strong autocorrelation and Hansen test for over identification restriction shows the instrument variables can be properly chosen in every three case.

The estimation results indicate that the use of telecare by heart disease patient can reduce the medical expenditure, and heart disease is influenced by other diseases especially chronic disease.

Table 1. Summary statistics

Variable	Number of observations	Mean	S.D.	Min	Max
Medical expenditure of outpatient	2040	16997	25084	0	469632
Telecare use	2040	0.40	0.49	0	1
Duration of telecare use	2040	1.88	2.19	0	6
Frequency of telecare use	2040	1.10	1.52	0	5
Heart disease patient	2040	0.10	0.29	0	1
Age	2040	69.98	8.99	43	94
Chronic disease	2040	0.42	0.49	0	1
Lifestyle-related diseases	2040	6836	10266	0	76573

Note:

(1) Unit of medical expenditure of outpatient is point (one point is equivalent to 10 JPY).

(2) Using telecare, duration of telecare use, and frequency of telecare use are categorical data
(usage=1, non usage=0)

(3) Age is five degree categorical data

(4) Chronic disease is categorical data (yes=1, no=0)

Table 2. Result of estimation by system GMM

Variable	Coefficient	S.E.	z value	p>|z|	
Heart disease patient with telecare use	-19.225	6.792	-2.83	0.005	***
Heart disease patient	23.081	8.198	2.82	0.005	***
Chronic disease	7.927	3.675	2.16	0.031	**
Age	4.644	1.365	3.40	0.001	***
Number of observations			1625		
Number of groups			390		
Wald χ square			871.94		
Prob > χ square			0.000		
Arellano-Bond for AR2: Prob. > z			0.182		
Hansen test for overid. Restrictions: Prob. > χ square			0.880		

Variable	Coefficient	S.E.	z value	p>|z|	
Heart disease patient with telecare use	-7.109	3.529	-2.01	0.044	***
Heart disease patient	38.047	14.788	2.57	0.010	***
Chronic disease	16.305	2.379	6.85	0.000	**
Number of observations			1625		
Number of groups			390		
Wald χ square			317.18		
Prob > χ square			0.000		
Arellano-Bond for AR2: Prob. > z			0.188		
Hansen test for overid. Restrictions: Prob. > χ square			0.706		

Variable	Coefficient	S.E.	z value	p>|z|	
Heart disease patient with telecare use	-8.617	3.351	-2.57	0.010	***
Heart disease patient	31.370	10.703	2.93	0.003	***
Age	6.791	1.025	6.63	0.000	***
Number of observations			1625		
Number of groups			390		
Wald χ square			531.92		
Prob > χ square			0.000		
Arellano-Bond for AR2: Prob. > z			0.138		
Hansen test for overid. Restrictions: Prob. > χ square			0.560		

Notes:

(1) Dependent variable and explanatory variables are expressed in logarithmic term

(2) Age is expressed by 20 percentile

(3) Controlled by dummies for year 2002-2005

(4) ***, **, and * indicate 1% , 5%, and 10% significant level.

4.   Conclusion

Conclusion obtained from the analysis is that e-Health use by heart disease has no or positive correlation with the medical expenditures in the estimation method of panel analysis due to endogenous biases. Heart disease is influenced by chronic disease. To eliminate partly the endogenous bias, system GMM is used. The analysis also finds that telecare use itself, duration of telecare use, and frequency of telecare use can reduce the medical expenditures of heart disease patients. This implies that the more is e-Health used by heart disease patients, the more medical expenditures are reduced. From the in-depth interview, after introducing e-Health, severe heart diseases have less occurred among e-Health users. Using e-Health discovers the indication of severe heart disease, and patients can avoid those situation. As the result, the medical expenditures can be saved. It is well known that e-Health can reduces medical expenditures, since e-Health users tend to be more concerned with their health and make effort to improve health indicators such as blood pressures and blood glucose ([1] and [2]). Regarding similar e-Health projects, Kent TeleHealth Evaluative Development Pilot in the UK reported that the number of home visits and GP surgery visits were reduced by 0.5 per participant, Accident and Emergency (A&E) visits by 0.5, and inpatient bed days by 1.5 days, respectively ([9]). Care Coordination/Home Telehealth (CCHT) project in the US by Veterans Health Administration (VHA) also estimated that patients' number of bed days of care was reduced by 25%, the number of hospital admissions 19%, respectively ([10]). Both do not focus on particular diseases. These analyses target e-Health users who have or do not have heart diseases. This paper, on the other hand, focuses on patients who have already heart disease, and proves that those e-Health users also have positive effect on reduction of medical expenditures by preventing from worsening.

Then further studies are to calculate the exact pecuniary amount of reduction of medical expenditures by e-Health, and to verifying effect on other diseases. In so doing, care should be taken of treatment group and control group to examine the effect and to selecting the suitable analytical methods to cope with causality and biases.

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