Hospital Cost-Savings of the Elderly by Tele-Home-Care

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Abstract: Tele-home-care (or tele-medicine) is being implemented by the application of multimedia such as CATV and ISDN. In this paper, by focusing on the so-called "social hospitalization of the aged," we carry out an estimation of the extent to which tele-home-care based on multimedia can help in saving the cost of hospitalization of the aged in the future. Estimation consists of the following two parts. First, we estimate the trends of the aged population and their hospital expenses using the regression analysis. Second, we assume that new technology such as multimedia and new medical instruments develop according to a logistic curve. Thus, we estimate the rate of diffusion of CATV and ISDN by logistic curves. Then, by multiplying this number by hospital costs per elderly patient as estimated previously, we have been able to calculate the extent to which hospitalization costs can be saved in the entire economy. Our results indicated that in the year 2050, US$257.3 billion, or nearly 7.4% of total hospitalization costs of the aged can be saved by tele-home-care.

Keywords: Tele-home-care; Hospitalisation costs; Logistic curves; CATV; ISDN

1. INTRODUCTION

The authors have been examining the characteristics the tele-home-care, based on a field study of local governments which are implementing such systems through the use of information technology such as CATV and ISDN, see Tsuji et al. [1996a, 1996b, 1997, 1998 and 1999]. Much research has been conducted, which estimate the economic effects of Nursing Care Insurance. However, no estimates have been made of the economic effects of tele-home-care which utilizes multimedia. An example of simple estimation is, for instance, found in Kido and Nakamura [1998]. The economic benefits of tele-home-care cover a wide range of areas. Here, this paper focus on the "social hospitalization" of elderly people. Social hospitalization is defined as the aged being hospitalized and given medical treatment at medical institutions in spite of the fact that medical treatment at home is possible. We carry out an estimation of the extent to which tele-home-care based on multimedia can help in saving the cost of hospitalization in the future. In so doing, we estimate the trends of the aged population and their hospital expenses by the regression analysis as well as estimate future increases in tele-home-care utilizing CATV and ISDN by applying logistic curves.

In section 1, which follows, the trend of medical expenses in the coming aging society is analyzed. In section 2, the definition and characteristics of tele-medicine and tele-home-care, both which utilize CATV and ISDN, will be examined. In section 3, the contents of tele-home-care are briefly analyzed based on our field study. An estimation of the extent tele-care can reduce the amount of hospitalization costs of the aged will be carried out in section 4. Based on the regression analysis and our field study, conditions that are considered

essential for tele-home-care to take root in every part of Japan in the future will be identified.

2. THE AGING SOCIETY AND MEDICAL CARE/WELFARE

In this paper, following to the definition of the Ministry of Welfare and Health, the terms "elderly" and "aged" refer to those 70 years of age or older, and those who are bedridden and 65 years or older. In Japan today, the medical expenses of such elderly people account for a large share of the medical expenses. The aging of society will inevitably bring about an increase in the medical expenses of the elderly which totalled US$ 33 billion in 1983, accounting for 23% of the total national medical expenses. In 1995, the medical expenses of the elderly people were approximately US$ 90 billion, accounting for more than 30% of the national medical expenses. This means that the medical expenses of the elderly have risen threefold in the last ten years. The elderly, on the other hand, account for approximately 10% of the entire population of Japan, thus 30% of the aggregate medical expenses are those of the elderly. This is why a new medical expense system such as Nursing Care Insurance is necessary.

Nursing Care Insurance is one of the economic mechanisms related to the sharing of the burden of medical expenses. However, institutional reforms alone on schemes to share the burden and to distribute benefits are not sufficient for dealing with the ever-increasing medical expenses and the shortage of qualified people working in this field. These problems need to be addressed from an entirely different perspective. It is tele-medicine and an information network based on multimedia that will save medical care expenses. The latter can connect all networks, whether physical or human, related to medical, welfare, and health care in the local community together.

3. AN ESTIMATION OF ECONOMIC BENEFITS OF TELE-HOME-CARE

Since economic benefits of tele-medicine based on information technology are quite diversified, it is difficult to make a general estimation. For this reason, this paper focuses on social hospitalization of the aged, and analyzes the extent to which hospitalization costs can be saved in the future by the diffusion of tele-home-care.

3.1 Estimation Methods of Benefits

It is hard to measure benefits of tele-home-care in terms of market values, since it contains various benefits such as feeling of security; namely, patients at home can be monitored from the remote hospital through a camera for 24 hours. In this situation, the methods used in cost-benefit analysis can be applicable. Those methods are classified as follows: (a) consumer's surplus; (b) replacement cost method; (c) travel cost method; (d) contingent valuation method (CVM); and (e) hedonic method. CVM is based on WTP (willingness to pay), and recently becomes popular to estimate the value of environment and public projects. In this paper, we adopt replacement cost method; namely, we conduct an estimation of the extent to which hospitalization costs of the elderly can be reduced by applying the tele-home-care system.

3.2 Estimation of Hospitalisation Costs of the Aged and Number of Elderly Patients

The estimation procedure is as follows. First, we estimated the hospitalization costs of the aged by regression analysis and forecast future values. Second, we estimated the number of elderly inpatients. By dividing the aggregate hospitalization costs of elderly people by the number of elderly inpatients, we obtained the hospitalization costs per elderly patient (more details provided in later section). Then, we multiply the cost per elderly person by the number of elderly people who can be treated by the tele-home-care system, and the hospitalization costs that can be saved are obtained.

Generally, medical expenses are determined by the quantity of medical services and their unit cost. Regarding the former, the following factors are influential: (1) number of persons covered by medical insurance and their dependents; (2) number of elderly people, who are the main recipients of medical services; and (3) benefits from medical insurance. On the other hand, the unit cost of medical services is affected by credits given to doctors, for instance, when they conduct medical examination, treatment, or the price of medication.

In estimating hospitalization costs, by following the method of Phelps [1997] and Hiroi [1994], we conducted regression analysis with the growth rate GNP deflator of medical services, and the aging rate. Since we take hospitalization costs per elderly person as a variable, the effects of an increase of such people to total hospitalization costs cannot occur in theory. However, the increase in the ratio of elderly people does change the contents and

quality of medical services, and thus we retain the ratio as a variable. The data used is based on the 1995 edition of Annual Report of Medical Care for the Aged, published by the Health and Welfare Bureau for the Elderly, Ministry of Health and Welfare. Since only data pertaining to hospitalization costs per person 70 years of age was available, we estimated the hospitalization costs of one elderly person 70 years of age or older based on this data.

The regression equation for hospitalization costs per elderly person and its results are as follows:

$$\ln(\text{COST}) = 11.6000 + 0.030670\,\text{DEFLATOR} + 0.12005\,\text{POP70} \quad (1)$$
$$(79.6338)\quad (2.2511)\qquad\qquad (7.5889)$$

$$\text{Adjusted } R^2 = 0.85909,\ \text{DW} = 1.5382,$$

where COST: Hospitalization costs per elderly person, DEFLATOR: GDP deflator of medical services, POP70: Ratio of elderly 70 years of age or older to total population.

In forecasting future hospitalization costs, we assumed that the GDP deflator increases at 2%. Secondly, we attempt to estimate the future hospitalization costs per elderly inpatient by the following procedure:

hospitalization costs per elderly inpatient
= hospitalization costs per elderly person
x (number of elderly people/number of elderly patients).
= hospitalization costs per elderly person
x (1/ hospitalization rate of elderly people)

According to this equation, we can forecast the future aggregate hospitalization costs of elderly people by multiplying the estimated value of hospitalization costs per elderly person times the future number of elderly people 70 years of age or older, based on data obtained from Population Projections for Japan, January 1997 by the National Institute of Population and Social Security Research. For estimation, we adopted three cases of aging ratio, namely, low, moderate, and high estimation according to the above data. In order to obtain hospitalization costs per elderly inpatient, it is necessary to estimate the number of elderly inpatients in the future. The number of elderly inpatients 70 years of age or older was 625,000 in 1996, and the hospitalization rate accounts for 0.050% of the total population of elderly people 70 years of age or older. We assume that this percentage will not change in the future. We thus multiplied the forecasted value of the number of elderly people by this percentage, and we obtain the figures, as indicated by Table 1.

Table 1. Estimated Hospitalization Costs per Elderly Patient and Number of Tele-home-care Systems in the Future.

Year	Hospitalization Cost US$ Million	Number of Systems CATV	Number of Systems ISDN
2000	61,388	3	14
2005	88,438	9	54
2010	118,781	23	166
2015	159,493	60	485
2020	228,284	148	1,255
2025	265,134	345	2,558
2030	267,729	722	3,832
2035	272,849	1,256	4,559
2040	298,750	1,764	4,854
2045	376,311	2,094	4,957
2050	421,392	2,258	4,991

3.3 Estimation of the Number of Tele-home-care Systems in the Future

In carrying out the tele-home-care system based on multimedia, systems such as CATV and ISDN, as discussed in the previous section, are necessary. Since this paper analyzes tele-home-care carried out by local governments, the number of ISDN and the number of CATV for the purpose of tele-home-care operated by local governments are required. These figures are obtained by the Bureau of Telecommunications, Ministry of Posts and Telecommunications. Based on this data, we estimate the number of CATV and ISDN systems owned or operated by local governments. In the actual estimation, by following Mansfield [1961], we assume that new technology such as multimedia and new medical instrument develop according to logistic curve. Thus, we estimate the rate of diffusion of CATV and ISDN by logistic curves, and we assume that the number of tele-home-care systems will develop along these curves in the coming years.

The original data provided by the Ministry of Posts and Telecommunications is shown in Table 3 (CATV) and Table 4 (ISDN). The original data are expressed in terms of the number of CATV operators and that of ISDN subscribers. As for the number of local governments as ISDN subscribers, there is no existing data. Therefore, we assume that

the first category of INS1500 is equal to the number of ISDN subscribers. We also assume that ISND will be diffused at the same rate as CATV.

In the estimation, the diffusion process of new technology can be expressed by the following logistic curve:

$$\frac{dx}{dt} = kx_t(A - x_t) \tag{2}$$

where $k > 0$ denotes constant, and A satiation demand. The solution of differential equation (2) is expressed as follows:

$$x_t = \frac{A}{1 + \left(\frac{A}{x_0} - 1\right)\exp(-kAt)} \tag{3}$$

The non-linear equation to be estimated is denoted as follows:

$$x_t = \frac{A}{1 + \left(\frac{A}{x_0} - 1\right)\exp(-kAt)} + \varepsilon_t \tag{4}$$

In this type of estimation, error terms tend to be correlated: namely,

$$\varepsilon_t = \rho\ \varepsilon_{t-1} + u_t$$

Inserting this into equation (4), we have the following equation to be estimated.

$$x_t = \frac{A}{1 + \left(\frac{A}{x_0} - 1\right)\exp(-kAt)} + \rho\ \varepsilon_{t-1} + u_t \tag{5}$$

The equation to be estimated is as follows:

$$x_t = \frac{A}{1 + \left(\frac{A}{x_0} - 1\right)\exp(-kAt)} + \rho\left(x_{t-1} - \frac{A}{1 + \left(\frac{A}{x_0} - 1\right)\exp(-kA(t-1))}\right) \tag{6}$$

The estimation results are summarized in Table 2. The expected values of the number of CATV and ISDN installed (which are used in the tele-home-care system) in coming years are shown in Table 3.

Table 2. Parameter estimates for the equation (6).

	Parameter	Estimate	Standard Error	t-statistic
CATV	A	2317.6	138.479	16.7361
	k	0.19116	0.01465	13.047
	Adjusted R-squared = .997280			
ISDN	A	4661.23	401.109	11.6209
	k	0.24087	0.02509	9.59982
	Adjusted R-squared = .992144			

Table 3. Number of CATV Operators.

83	428	'92	1,371
'84	484	'93	1,491
'85	550	'94	1,623
'86	633	'95	1,738
'87	709	'96	1,819
'88	826	'97	1,884
'89	944	'98	1,902
'90	1,091	'99	1,939
'91	1,261		

Source: Ministry of Posts and Telecommunications

Table 4. Number of ISDN Subscribers (Image Transmission Services)

86	815	'93	2,779
'87	890	'94	2,930
'88	1,023	'95	3,321
'89	1,408	'96	3,680
'90	1,740	'97	3,780
'91	2,064	'98	3,907
'92	2,414	'99	3,938

Source: Ministry of Posts and Telecommunications

4. ECONOMIC EFFECTS OF TELE-HOME-CARE

Let us now obtain the number of elderly patients who will be able to have tele-home-care by the introduction of the tele-home-care system. We have found from the field study of tele-home-care systems implemented by local governments that there are 16 terminals at the patient's home on average attached to one CATV system, and 12 terminals on average attached to one ISDN system. An elderly patient is observed regularly by one terminal annually on average. Thus, the estimation

of the number of elderly patient treated by the tele-home-care system is obtained. Then, by multiplying this number by hospital costs per elderly patient as estimated previously, we can calculate how much hospitalization costs can be saved in the entire economy.

Table 5. Reduction of Social Hospitalization Costs.

	Costs (US$ million)		
	CATV	ISDN	Total
2000	4	10	14
2005	12	58	71
2010	39	215	255
2015	122	765	887
2020	388	2,556	2,945
2025	1,031	5,969	6,999
2030	2,249	9,411	11,659
2035	4,154	11,818	15,971
2040	6,544	13,875	20,419
2045	9,582	17,217	26,799
2050	11,709	19,505	31,215

Table 6. Ratio of Hospitalization Cost-Savings to Total Costs.

	Ratio (%)		
	CATV	ISDN	Total
2000	0.065	0.016	0.081
2005	0.014	0.066	0.080
2010	0.033	0.181	0.214
2015	0.076	0.479	0.555
2020	0.170	1.118	1.287
2025	0.387	2.247	2.634
2030	0.836	3.510	4.345
2035	1.514	4.328	5.842
2040	2.183	4.643	6.826
2045	2.541	4.575	7.116
2050	2.776	4.629	7.404

Hospitalization costs for elderly patients that can be saved by a tele-home-care system which uses CATV and ISDN are shown in Table 5. The percentage of hospitalization costs, for instance, that can be reduced to the aggregate hospitalization costs of elderly people is indicated in Table 6. As shown in Figure 1, a reduction of US$ 14 million (0.081% of hospitalization costs of elderly people) will be saved by the year 2000, US$ 252 million (0.214%) by 2010, and US$ 2,842 million (1.287%) by 2020. And by the year 2050, US$ 25.7 billion will be saved, which accounts for 7.4% of the aggregate hospitalization costs of elderly people. Leaving the argument over whether this 7.4% reduction is big or small, there is no doubt that the hospitalization costs of elderly people will be reduced by the introduction of the tele-home-care system.

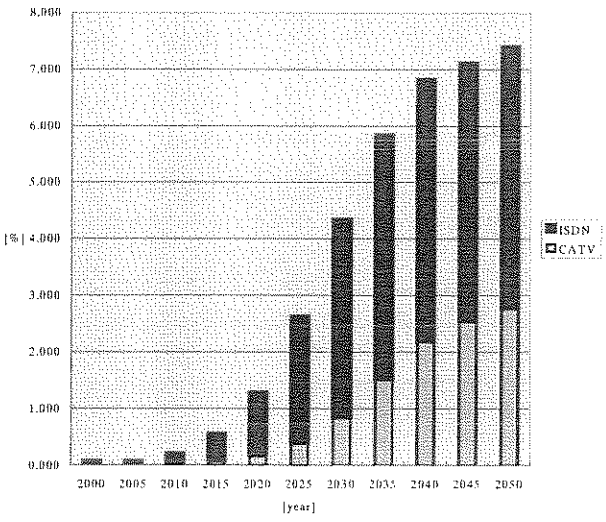

Figure 1. Economic Effects of Tele-home-care.

The sums shown in Table 5 are the net effect of the tele-home-care system; costs have already been deducted when those columns are calculated. Costs include the initial investment to construct CATV and ISDN networks, and equipment such as terminals and devices for tele-home-care, and operation costs such as telecommunications bills. Here, we regard the initial investment as the only cost incurred when the tele-home-care is introduced[1]. Based on our findings from field research, the initial investment is approximately US$ 1 million per system on average in the case of CATV, and US$ 500 thousand in the case of ISDN. We disregarded depreciation and accounted only for the cost of the newly-built system. Those were subtracted from the aggregate medical expenses saved by a tele-home-care system.

[1] The construction cost of a CATV network is distributed proportionally among other services and can be considered as being imputed to tele-home-care. Tele-home-care is not the principal service provided by CATV. Furthermore, in addition to the labor costs of public health nurses and home-helpers that accompany tele-home-care, costs such as imputed wage of the family as a provider of care service and imputed rent of residence should be considered, in general.

5. CONCLUSION

There is a sense of impending crisis among those who belong to local governments and those engaged in welfare activities regarding the implementation of Nursing Care Insurance. Is it actually possible to ensure the provision of care services that Nursing Care Insurance guarantees in words? Is it possible to secure enough funds and qualified persons for the provision of services? At present, tele-home-care services are provided free of charge. But when Nursing Care Insurance is implemented, patients will have to contribute 10% of the expenditures and the quality of services provided will also be an important. It is highly advisable that the entire local community be involved in building an information sharing network system, which covers such areas as health preservation/health/welfare for adequate provision of care services. The solution to these issues rests upon how the tele-home-care system will evolve in the coming years.

One of the largest obstacles to the success of tele-medicine lies in the social systems, regulations, and attitude towards multimedia. They are constructed on the basis of past systems, and not aimed for information technology of the future. Current regulations prohibit medical treatment that is not face-to-face to patients, and the existing insurance system and adherence to traditional medical practices stand in the way of information technology. The cost of telecommunications, for instance, is not covered by medical insurance, and this is a burden to doctors and hospitals. Tele-medicine thus depends on volunteer work, and this does not provide an economic incentive to the practice of tele-medicine.

Another obstacle is telecommunications regulations such as charges. The current rate system for telecommunications is based upon the transmission of voice via metal cables, thus rates depend on the time and distance of calls. However, telephone calls via optical fibers do not depend on those factors due to the capacity of optical fibers. The current Japanese rate system is thus an obstacle to the introduction of Internet as well as multimedia. Japanese tele-medicine is characterized as a small network covering only one local government; on the other hand, tele-medicine in the U.S., for instance, covers one entire state.

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