An Empirical Analysis of the Economic Assessment of the Tele-health System by CVM

M. Tsuji[a], W. Suzuki[a], and F. Taoka[b]

[a] Osaka School of International Public Policy (OSIPP), Osaka University, Osaka, Japan

[b] Kyoto University of Education, Kyoto, Japan

Abstract: The tele-health system is a type of tele-home-care, which transmits health-related data of its users such as blood pressure, ECG, and blood oxygen to a remote medical institution via a telecommunications network. Eighty Japanese local governments are already implementing such systems, utilizing a total of more than 10,000 devices. This paper analyzes the economic benefits of the tele-health system in Kamaishi City, Iwate Prefecture, Japan. The Contingent Valuation Method (CVM), which has been recently widely adopted in the fields of Environmental Economics and Health Economics to measure the benefits of services which are not traded in the market, is used, We conducted a survey of 348 users in Kamaishi City by asking how much they were willing to pay (WTP) to use the service. According to their WTP, we estimate the demand function of the system, which is assumed to be a logistic curve. The average amount of WTP calculated is 4,519 yen (approximately US$37). We then compare the benefits with the costs of the system, which consists of equipment, salaries of doctors and nurses, and other operations. The ratio of benefits over costs (B/C ratio) is about 1.07, which implies that the system of Kamaishi City yields more benefits than costs. This is a rather surprising result when viewed in comparison with the systems of other regions. The paper also analyzes how the benefits expressed in terms of WTP are attributed in exact monetary terms to factors such as (a) less anxiety in day-to-day life, (b) stabilizing illness, (c) enhancement of health consciousness, and (d) decrease in medical expenditures. The parties bearing the costs of the system are identified, namely, the amounts paid by individual users and public fund such as tax and medical insurance. Thus, this paper suggests reimbursement to the tele-health system using medical insurance.

Keywords: *Tele-health system, CVM, WTP, B/C ratio, reimbursement.*

1. INTRODUCTION

The tele-health system transmits health-related data of its users such as blood pressure, ECG, and blood oxygen to a remote medical institution via a telecommunications network. To date, eighty Japanese local governments are currently implementing such systems, utilizing a total of more than 10,000 devices -- the largest in the world. Several household electric appliance manufacturers such as Panasonic, NEC, Fujitsu, Sanyo, and Hitachi, are producing and selling remote monitors at a price of US$2,000 to US$4,000 per set. This system is equipped with a simple device which, when used continuously, records the condition of the elderly or a patient's illness in graphs, which are then used for diagnosis and consultation. Reports sent by the medical institution are also helpful for users to enhance their daily health consciousness and make an effort to maintain good health. Such positive effects have been identified through field surreys.

The tele-health system in Japan has already passed the experimental stage, and is entering the diffusion stage. In order for the system to be diffused further, it is necessary to prove its cost-effectiveness by comparing its benefits and costs. The latter consists of equipment such as servers and peripheral devices, salaries and wages of doctors and nurses, and maintenance fees such as

telephone charges and other miscellaneous operating costs. On the other hand, to indicate its concrete benefits in monetary terms is analytically difficult, since the benefits mainly come from users' subjective satisfaction which is difficult to measure. Without a firm basis of its cost-effectiveness, the future sustainability of the tele-health system cannot be guaranteed.

This paper aims to analyze the Cost Benefit Analysis of the tele-health system in Kamaishi City, Iwate Prefecture, Japan. Benefits are expressed in terms of WTP (willingness to pay) based on CVM (Contingent valuation method), whereas the costs are calculated as the sum of equipment, salaries of doctors and nurses, and other operations. Then, the benefits and costs are compared in terms of the B/C ratio. We also discuss policy measures to increase this ratio by means of reimbursement using medical insurance as well as direct subsidies from tax money.

2. THE SYSTEM OF KAMAISHI CITY

Kamaishi City, Iwate Prefecture, Japan, which started its tele-health system in 1993, was chosen for survey data, for it has one of the longest records of implementation. In addition, the system has the characteristics of a medical corporation named *Rakuzankai* operating the system at a monthly charge of 2,500 yen (approximately US$20) per family up to four persons, and a users' association conducting many events to promote usage. Since it uses the CATV network, the transmission charges are free. The peripheral device used by Kamaishi City called "*Urara*," is manufactured by *Nasa* Corporation. The device is equipped with memory, an electric sphygmomanometer, electro-cardiograph, electric signboard, and button for answering questions. At the hospital, nurses check transmitted data and report to the doctor as well as its users, whenever they notice abnormal symptoms. The hospital sends monthly reports to all users with comments, which are used for their health management. There are 211 devices and the total number of users is 409.

3. ESTIMATION METHOD

3.1. Contingent valuation method (CVM)

In order to measure the benefits of services which are not traded on the market, the following methods are utilized: (a) travel cost method: (b) replacement costs method; (c) hedonic approach; and (d) CVM. In what follows, we use CVM, which has been recently widely adopted in the fields of Health Economics and Environmental Economics. In CVM, the benefits to users are measured in terms of WTP, which is the monetary amount which users are willing to pay for receiving the service. By asking the WTP of each user, we can then construct the surrogate demand function for the tele-health system. Although CVM and WTP have a strong theoretical basis, CVM tends to have a bias because it asks for concrete valuation and choice under fictitious circumstances. Care should be taken to clarify what kind of bias it possesses and to remove them.

3.2. Questionnaire

We interviewed 348 users of the tele-health system in Kamaishi City in October 2000, and asked questions pertaining to the following: (a) WTP; (b) effectiveness; (c) frequency of usage; and (d) user properties such as age, gender, income, education, and health condition. The questionnaire related to WTP is as follows: We begin by asking whether they would be willing to pay monthly charges of 5,500 yen (US$45). If their answer is "yes," we then ask whether they would be willing to pay 7,500 yen (US$62.5). If they reply "yes" again to 7,500 yen, their WTP is 7,500 yen. If "no", then we lower the amount to 6,500 yen (US$54.17). If they reply "yes" to 6,500 yen, then that is their WTP. If again their answer is "no," we lower the amount further to 5,500 yen. We repeat this process until their WTP is determined. The distribution of WTP from the survey is as follows: 10,000 yen (16 users), 8,000 yen (1), 7,500 yen (12), 6,500 yen (11), 5,500 yen (62), 4,500 yen (8), 3,500 yen (69), and 2,500 yen (112). The distribution of replies is shown in Table 1.

Table 1. Distribution of replies

WTP (yen)	Number of users
10,000	16
8,000	1
7,500	12
6,500	11
5,500	62
4,500	8
3,500	69
2,500	112

3.3. Estimation of demand function and WTP

Based on the above WTP of each user, we estimate the demand function of the system; more precisely, we estimate the probability of acceptance to amounts questioned and the number of users who will agree to pay. The functional form of demand to be estimated is assumed to be logistic, namely,

Probability of acceptance = $1 - 1/(1 + \exp(-\alpha - \beta \log WTP))$.

The probability of acceptance is the ratio of the number of users who reply that they are willing to use the device at the amount of charges provided in the questions. The estimated coefficients α and β are summarized in Table 2.

The estimated demand function for the tele-health system is shown in Fig. 1. The average WTP is calculated as the area under this demand function, which results in being 4,519 yen (approximately US$37) per user per month.

Table 2. Results of Estimation

	α	β
Estimated	27.441134	3.3033572
Standard error	2.0739667	0.2474318
t-value	13.231	0.0000
p-value	13.351	0.0000

Log likelihood function: -475.7578

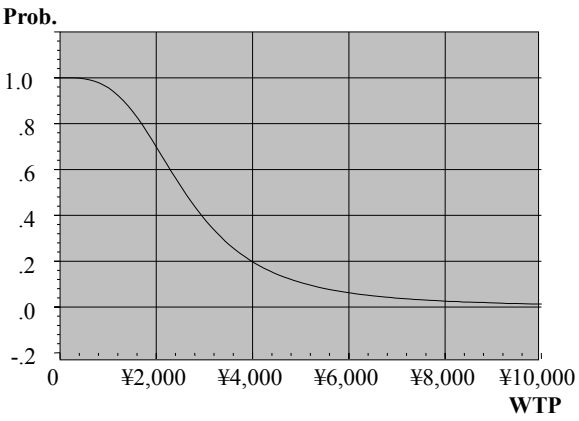

Figure. 1. Estimated demand function

4. COST BENEFIT ANALYSIS

A. Total benefits

In the Cost Benefit Analysis, total benefits and costs are compared over the period of several years. In this paper, the time span is assumed to be six years, since all device parts have been held as inventory for six years. WTP obtained above is for per user per month, and it is multiplied by the number of users and 12 months. Three hundred forty-eight users were registered at the time of the survey (October 2000). One-year benefits total approximately 18,871,344 yen (US$157,261). In order to obtain six years' worth of benefits, we calculate the present value of six years' benefits with a 4% discount rate, and we assume that the number of registered users remains at the level for six years. This results in six years' benefits totalling 95,782,869 yen (US$798,182).

B. Total costs

The cost of the system covers that for equipment, salaries and wages of doctors and nurses, and other miscellaneous costs which include maintenance. The cost of host computers at the hospital is about 1,700,000 yen (US$14,166) which includes installment fees, at the cost of 250,000 yen (US$2,083) per device. The total costs of 200 devices are about 37,600,000 yen (US$313,333). Development of software prior to installment cost 4,000,000 yen (US$33,333), which is also considered part of the initial costs. We assume that 10% of the value of equipment can be considered its current value after six years of operation, therefore 90% of the value of equipment is included in the costs, which amounts to 38,970,000 yen (US$324,750). This is paid for with a one-time payment at the beginning.

Regarding salaries and wages, a part-time doctor is paid about 1,728,000 yen (US$14,400) per year, a full-time nurse is paid about 5,040,000 yen (US$42,000), and one part-time worker receives about 1,800,000 yen (US$15,000). The doctor and part-time worker spend half of their working hours on this system. Thus, total yearly salaries are 8,568,000 yen (US$71,400). Other maintenance costs such as those for printer toner and postage per year are about 1,851,600 yen (US$15,430). As mentioned earlier, there are no telecommunications charges. Thus, total annual operational costs are about 10,419,600 yen (US$86,830). According to this calculation of six years' operational costs as well as those of equipment with a 4% discount rate, the costs of the tele-health system in Kamaishi City total 95,782,869 yen (US$789,190).

C. B/C ratio

From the above calculation, benefits total 95,782,869 yen (US$798,182), whereas costs total 95,782,869 yen (US$789,190) over the period of six years. Therefore, the B/C ratio is 1.07, that is, benefits exceed costs. This is a rather surprising result, because all other local governments where field research was conducted show ratios less than 1. The B/C ratio being larger than 1 does not necessarily indicate that the medical corporation, *Rakuzankai*, earns a positive profit. Since its revenues consist of user charges of 2,500 yen, this amount is smaller than that of WTP; more precisely, 211 peripheral devices are being leased, and 2,500 yen is being charged per family up to four users. The monthly revenue from rental devices thus totals 527,500 yen (US$4,396), with an annual revenue of 6,330,000 yen (US$52,750). On the other hand, annual operational costs as obtained in the previous subsection are approximately 10,419,600 yen (US$86,830). Thus, revenues are far less than operational costs. Though *Rakuzankai* is losing money by its operation, losses are covered by other hospital income.

D. Comparison with other local governments

Let us examine other local governments where we conducted field research. Tables 3 and 4 summarize similar statistics of other systems obtained by surveys implemented in Katsuro Village and Nishiaizu Town, Fukushima Prefecture, and Sangawa Town, Kagawa Prefecture. These local governments distribute peripheral devices to the elderly without charge. They are the same as "*Urara*," except for Katsurao Village.

Table 3. Comparison of benefits (unit: yen)

	No. of users	WTP yen	Benefit 6 years	Fee yen
Kamaishi	405	4,519	102.9 mil.	2,500
Katsurao	926	1,640	99.4	none
Nishiaizu	518	3,177	107.7	none
Sangawa	484	2,955	106.5	none

E. B/C ratio for local governments

If the tele-health system of Kamaishi City were to be considered a private business, its profits would be negative; however, as a public project, it creates more benefits to society than costs. For the other three local governments, the costs are larger than benefits. Then why do they implement such projects? This is a common question to all local governments in Japan. Let us consider the viewpoint of local governments for this answer. Most tele-health systems in Japan are supported by the central government, that is, it provides subsidies to local governments of the same amount as the cost of equipment.

For all other local governments, exceeding Kamaishi City, the B/C ratio is smaller than 1. This difference is due to the costs of equipment; Katsurao Village purchased rather sophisticated and expensive devices capable of transmitting motion pictures. Nishiaizu and Sangawa received subsidies from different Ministries at different times, and since these devices cannot be utilized as one single system, it was necessary to install various kinds of equipment for each system. Kamaishi City purchased devices at the lowest price and this mainly contributes to the highest B/C ratio. Thus, local governments need only to cover operating costs such as salaries and wages, and maintenance costs. The B/C ratios recalculated in this way are denoted by (B/C)* in Table 4. All (B/C)* become larger than 1, and this is the answer to the above question -- for local governments, such projects create more benefits than costs.

Table 4. Comparison of cost and B/C ratio

	Kamaishi	Katsurao
No. of device	211	325
Equipment	39,9mil. yen	111.4mil. yen
Salaries	8.6mil	3.3
Others	1.9mil	10.4
Costs (6 years)	95.5iml.	184.2
B/C	1.07	0.54
(B/C)*	1,87	1.42
	Nishiaizu	Sangawa
No. of device	400	225
Equipment	136.7mil. yen	133.5mil. yen
Salaries	3.7.	4.5
Others	3.7	3.0
Costs (6 years)	184.5	174.3
B/C	0.58	0.61
(B/C)*	2.31	2.60

The previous result shows that WTP in Kamaishi is 4,519 yen. Here, we decompose this WTP into the effects of tele-health system, and calculate who and how much bears the costs of the tele-health system examined in the previous section.

In the survey of users, we asked whether the system provided four effects: (a) less anxiety in day-to-day life, (b) stabilizing illness, (c) enhancement of health consciousness, and (d) decrease in medical expenditures. We regressed the users' stated WTP on their replies. Thus, we estimated the following equation:

$$W = ax_1 + bx_2 + cx_3 + dx_4 + e,$$

where a, b, c, and d are coefficients to be estimated, x_1, x_2, x_3, and x_4 are dummy variables which take 1 if their replies are "yes" and 0 if they are "no", and e is an error term. The result is shown in Table 5.

Based on the above estimation, the extent to which each effect had monetary value was calculated, that is, how the WTP decomposes into these four components. The p-value of "decrease in medical expenses" was not significant, so this component was ignored. The results are summarized in Table 6.

Table 5. Estimated components (n=288)

	Co-efficient	Stand. Error	*t*-value	*p*-value
Stabilization of illness	979.0	298.6	3.3	< 0.001
Enhancement of health consciousness	2612.9	224.1	11.7	< 0.001
Less anxiety in day-to-day life	1535.7	264.3	5.8	< 0.001
Decrease in medical expenses	767.9	701.8	1.1	0.28

Table 6. Decomposition of WTP into four components (Kamaishi City)

Component	Value (yen)
Stabilization of illness	349
Enhancement of health consciousness	1834
Less anxiety in day-to-day life	929
Decrease in medical expenses	not significant

The results of four regions ia summarized in Table 7.

Table 7a. Decomposition (Nishiaizu)

Component	Value (yen)
Stabilization of illness	439
Enhancement of health consciousness	1,075
Less anxiety in day-to-day life	680
Decrease in medical expenses	not significant

Table 7b. Decomposition (Katsurao)

Component	Value (yen)
Stabilization of illness	not significant
Enhancement of health consciousness	179
Less anxiety in day-to-day life	475
Decrease in medical expenses	not significant

Table 7c. Decomposition (Sangawa)

Component	Value (yen)
Stabilization of illness	not significant
Enhancement of health consciousness	not significant
Less anxiety in day-to-day life	774
Decrease in medical expenses	not significant

. The effects of enhancement of health consciousness and less anxiety in day-to-day life contribute to the users themselves, since they enrich their personal life. On the other hand, in addition to this, stabilizing illness has another effect, since it is helpful to society by means of decreased medical expenditures, less medical resources, etc. That is, it also has an external effect. This argument suggests who bears the cost of the telehealth system. If the effect gives rise to individual users, then they are willing to pay that amount. On the other hand, if it affects the entire society, then it can bear that amount. According to the above figures, in Kamaishi City individual users bear 2763 yen in cost, while society pays 349 yen as reimbursement. In Nishiaizu reimbeursement is 439 yen Surprisingly, 2763 yen obtained here is very close to the amount of 2500 yen charged by Kamaishi City.

5. CONCLUSION

So far, we have conducted surveys of four local governments. Except for Kamaishi City, their B/C ratios are approximately 0.5, that is, benefits cover only half of the costs. In addition, regarding the frequency of usage of the device, Kamaishi City also has a much higher ratio than the other local governments. Thus, Kamaishi City reveals quite specific characteristics. This is due to their efforts to promote usage such as a users' association which organizes events to enhance consciousness towards health, and the participation by medical doctors in this system, which increases the users' reliance on the system.

It is clear from our previous studies that the tele-health system is useful for consultation and maintaining the good health of the elderly and patients suffering from chronic diseases who are in stable condition, but not it is for curing disease. It therefore has a psychological effect such as providing a sense of relief to it s users by the knowledge being monitored by a medical institution 24 hours a day. This makes it difficult to estimate its benefits in concrete terms. We are able to provide concrete amounts to this effect in this paper.

6. REFERENCES

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