An Analysis of Economic Evaluation of Japanese Telemedicine: Teleradiology and Telepathology

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EXTENDED ABSTRACT

In February 2005, we conducted a comprehensive mail survey on the current situation of Japanese telemedicine, including teleradiology, telepathology, teleconferencing, and teleconsultation, in order to estimate these services' economic values and to extract factors for and against promotion of telemedicine. This paper analyzes mainly teleradiology and telepathology. This is the first analysis aimed at evaluating teleradiology and telepathology as a whole in Japan. By analyzing the problems and scopes of telemedicine, this paper will contribute to further implementation.

Estimations are based on CVM (Contingent valuation method), and we estimate demand functions of teleradiology and telepathology from replied WTP. However, the number of institutions that replied exact WTP and WTA are relatively small, due to doctors' difficulty in answering such questions. Thus we cannot use standards methods such as ordinal least squares (OLS); instead we applied the Kernel estimation method, which is often used in such cases. After estimating WTP and WTA, we obtain the total value for Japan by multiplying by the number of medical institutions which have been implementing telemedicine. We also utilize the Tobit Model to extract factors that influence WTP and WTU.

Estimated WTP is 4,379 yen (about US$39.81) for teleradiology, while 9,526 yen (about US$86.59) for telepathology. Estimated WTU is 3,875 yen (about US$35.23) for teleradiology, while 17,918 yen (about US$162.89) for telepathology. Based on these results, we estimate the economic benefits of these two to the whole economy for one year. The estimated results are approximately 140.2 million yen (US$1.27 million) for WTP of teleradiology and 30.6 million yen (US$278.6 thousand) for that of telepathology. WTU is 1.1 billion yen (US$10.0 million) for teleradiology, while 40.0 million yen (US$393.4 thousand) for telepathology.

This paper also analyzed the factors that influence WTP and WTU by utilizing the Tobit Model, and found only a few significant factors. Medical institutions with the following characteristics tend to state larger WTP: (i) university hospital; (ii) internal medicine; (iii) radiology; and (iv) using a video conference system. The following characteristics influence WTU; (i) using PCs; (ii) using telepathology equipment; (iii) highly satisfied with the quality of telemedicine; and (iv) having experience with telemedicine.

The future potential of telemedicine is analyzed by the binary probit model. We found that medical institutions having the following opinions have strong desire to request telemedicine services: (i) telemedicine can cope with people's various needs for health, medicine, and care; and (ii) hospitals implementing more telemedicine are advancing. On the other hand, for those medical institutions undertaking telemedicine, those with high level of medical quality – for example, those registered for special functions or medical training – have a strong desire to provide such services in the future. Moreover, being of the opinion that telemedicine provides a chance for exchanging medical and health information significantly correlates with a desire to expand telemedicine services.

It follows from the above estimations that medical institutions requesting telemedicine recognize it as a tool for coping with patients' various needs for diagnoses and accurate explanations, while those institutions undertaking telemedicine utilize it as a tool to respond to the above desires and to fulfill their duty of providing a higher level of services.

In sum, we estimated the total value of telemedicine in Japan. Qualitative aspects of implementation of telemedicine, such as factors for and against promotion of telemedicine, are also analyzed. The results obtained in this paper hold strong implications for future implementation of telemedicine.

1. INTRODUCTION

In February 2005, we conducted a comprehensive mail survey on the current situation of Japanese telemedicine, including teleradiology, telepathology, teleconferencing, and teleconsultation, in order to estimate these services' economic values and to extract factors for and against promotion of telemedicine. At the present time, there is no comprehensive statistical data regarding the total number and content of currently implemented telemedicine projects. Economic evaluation of telemedicine has been conducted by Tsuji et al (2003a), for instance, in the field of tele-home-care, but there has been no such research in other areas. Economic benefits are here defined as WTP (willingness to pay) and WTU (willingness to undertake). We also attempted to isolate the factors that significantly influence WTP and WTU, by correlating the values for individual institutions with the responses to various questions on our survey

2. WTP AND WTU

We collected information on 622 Japanese medical institutions that use telemedicine, including university hospitals, public as well as private hospitals, clinics, and health centres. To these institutions, we sent questionnaires dealing with (i) characteristics of the institutions, such as the numbers of medical staff and beds and the type of care offered; (ii) the number, costs, and actual charges of telemedicine implementation for one month; (iii) the level of satisfaction with the implemented telemedicine; (iv) the values of WTP (willingness to pay) and WTU (willingness to undertake); and (vi) future plans for implementation. 220 usable replies were received.

The analysis of this paper is based on CVM (Contingent valuation method), and we estimate demand functions of teleradiology and telepathology from replied WTP and WTU. Special attention should be paid to the concept of WTU. This indicates the pecuniary amount of telemedicine service requested by the medical institution that provides the service. The notion is different from WTA (willingness to accept), which is used in the usual CVM. WTP and WTU (WTA) tend to be different, because of the existence of various biases (see Tsuji et al (2003c)).

In our survey, the number of institutions that gave exact replies for WTP and WTU were relatively small, which is due to the medical doctors have in answering such questions. Because of this, we could not make use of standard methods of estimation such as ordinal least squares (OLS); we instead applied the Kernel estimation method, which has recently been widely used for cases with small numbers of data points. After estimating WTP and WTU, we obtained the values for all of Japan by multiplying by the number of medical institutions that have implemented telemedicine.

3. CURRENT SITUATION OF TELEMEDICINE

3.1. Current implementations

Experiences with telemedicine are summarized in Table 1. Medical institutions with larger (smaller) numbers of beds tend to undertake (request) telemedicine.

Table 1. Experience of telemedicine

Have requested	24.5%
Have undertaken	30.0
Both	11.4
Neither	32.7
Unknown	1.4

3.2. Telemedicine charges

36.7% (33.0%) of medical institutions that requested (undertook) telemedicine services pay (receive) charges. The amounts of these charges are summarized in Table 2.

Table 2. Amounts of Telemedicine charges

	Charges to ask	Charges to undergo
Teleradiology	2,141.7	1,393.8
Teleradiology	7,442.4	8,476.3
Teleconference	1,768.2	0.0
Teleconsultation	625.0	--

3.3. Implementations

The average numbers of requests and undertakings are summarized in Table 3.

4. ECONOMIC EVALUATION OF TELEMEDICINE

4.1. Estimation of WTP and WTU

Table 3. Experiences of Telemedicine

	Have experiences to ask		Have experiences to undertake	
	No. of Intuitions	Times per month	No. of Intuitions	Times per month
Teleradiology	42	58.7	55	430.8
Telepathology	29	91.6	30	6.2
Teleconference	20	14.8	22	1.4
Teleconsultation	18	2.0	27	2.4
Advise of operation	9	1.0	9	1.0
Catheter intervantion	4	0.0	4	0.0
Telecare with image	4	0.0	4	3.0
Telecare with live information	4	1.0	12	6.0

In our questionnaires (Q15), we asked WTP and WTU. The former represents the maximum amount customers are willing to pay when requesting telemedicine, while the latter the minimum charge to undertake the service. In the ordinal CVM, we are required to estimate these by the statistical method in Tsuji et al (2003b), (2005). In this paper, however, the numbers of replies to these questions was too few to apply the above method. We instead use a non-parametric method, the Kernel Method, which is applied for estimation of models with small numbers of data points. This method estimates the density function itself from data, and the estimated value is not influenced by extra ordinal observations. Table 4 and 5 indicate the results of the Kernel estimation for WTP and WTU, respectively.

Table 4. Estimated WTP

	Kernel estimate	Simple average
Teleradiology	4,379.0	4,383.6
Telepathology	9,525.6	9,538.5
Teleconference	2,084.0	2,008.3
Teleconsultation	633.3	625
Advice for operations	20,000.0	----
Catheter intervention	0.0	----
Telecare with images	-----	----
Telecare with live information	5,000	----

Table 5. Estimated WTU

	Kernel estimate	Simple average
Teleraidology	3,874.9	3,913.8
Telepathology	17,918.0	17,416.7
Teleconferencing	3,229.6	3,027.5
Teleconsultation	3,642.5	3,693.8
Advice for operation	8,576.2	8,600.0
Catheter intervention	4,323.4	4,333.3
Telecare with images	2,110.7	2,083.3
Telecare with live information	3,443.5	3,500.0

4.2. Total benefit of telemedicine

Based on the above results, we calculated the total benefit of telemedicine in one year. Table 4 and 5 indicate the average amount of WTP and WTU per month and per institution; multiplying these by the number of implementing institutions and by 12 months, the total annual benefits are obtained. Those amounts are shown in Tables 6 and 7.

Table 6. Annual benefit in terms of WTP

	Annual benefit
Teleradiology	140,202,306.0
Telepathology	30,646,602.5
Teleconferencing	74,002,510.0
Teleconsultation	23,585.6

Table 7. Annual benefits in terms of WTU

	Annual benefit
Teleradiology	1,101,753,939.0
Telepathology	39,992,976.0
Teleconferencing	1,190,333.7
Teleconsultation	2,832,370.2
Advice for operation	926,208.0
Telecare with images	911,822.4
Telecore with live information	2,975,184.0

5. FACTORS THAT INFLUENCE WTP AND WTU

5.1. Factors that influence WTP

Let us analyze the factors which influence WTP and WTU. Since the number of observations is small, OLS failed to extract these factors. We then utilized the Tobit Model, and found that only a few factors are significant. The results of our estimation are summarized in Tables 8 and 9.

Regarding WTP in Table 8, the following variables are found to be significant – that is, medical institutions with these characteristics tend to reply larger WTP: (i) university hospital; (ii) specialized in internal medicine; (iii) radiology; and (iv) using the video conference system. Internal medicine and radiology seem to require more telemedicine, since these fields require very accurate diagnosis and explanation. The video conference system is essential for telemedicine, so that medical institutions that own it naturally value telemedicine more.

Table 9 summarizes the estimation of WTU; the following characteristics of medical institutions influence WTU; (i) using PCs; (ii) using telepathology equipment; (iii) highly satisfied with the quality of telemedicine; and (iv) having experience with telemedicine. Dummy variables attached to teleradiology and telepathology are also significant. PCs and equipment are also important for telemedicine. The fact that higher satisfaction implies larger WTU is useful for further implementation, since the improvement of telemedicine quality increases WTU and thus makes institutions more likely to offer more telemedicine services.

6. FUTURE POSSIBILITY OF TELEMEDICINE

6.1. Experiences of Telemedicine

We isolated the factors that influence replies to Q5, which asked which institutions "have experiences requesting and/or undertaking" telemedicine. We select the following variables as potential factors: (i) the number of beds (Q2); (ii) type of hospital (specific registered hospital, for instance) (Q4); (iii) category of medicine, such as radiology, pathology, internal medicine, or surgery (Q3); (iv) the level of satisfaction with telemedicine (Q17); and the survey respondent's opinion of telemedicine (Q20). To relate these variables to the Q5 responses, we use binary probit model. The estimation equation is expressed as follows:

$$F(\mathbf{x}_i \Phi b) = \mathrm{F}(\mathbf{x}_i \Phi b), \qquad (1)$$

where F indicates the standard normal distribution function and $\boldsymbol{x}_i$ is a matrix which is composed by (the number of variables) times (the number of observation), which are indicated in Table 10.

As shown in Table 10, we obtained the following results: The level of satisfaction with telemedicine is positively correlated with having experience with telemedicine, while Q20-8 (Telemedicine will create new businesses) has a negative correlation with experience. In addition, variables such as Q20-3, 4 and 9 are also slightly significant. These indicate that telemedicine, as currently implemented, is more useful for providing more accurate explanations and diagnoses than for providing new services or businesses.

6.2. Potential of Telemedicine

Question 18, which is related to the future possibility of telemedicine services, was asked to medical institutions that request telemedicine; we here examine the variables that influence perceptions of telemedicine's future. The results are summarized in Table 10. The following variables are found to be significant: (i) yes on Q20-4 (telemedicine can cope with various needs of people for health, medicine, and care); (ii) yes on Q20-9 (medical institutions with more telemedicine implementation are thought to be advancing; and (iii) surgery. Other variables such as the level of satisfaction and having experience are also significant, but with low t-values.

On the other hand, for the future possibility of undertaking telemedicine, the following results are obtained: The number of beds is negatively correlated (smaller institutions have fewer plans to offer telemedicine), while the level of satisfaction and being registered as a specific hospital are positively significant. Yes on Q20-1 (telemedicine provides a chance for exchanging medical and health information) is also positively correlated and significant.

It follows from the above estimations that medical institutions requesting telemedicine require it as a tool for coping with various needs for medicine and accurate explanations to patients, while undertaking institutions utilize telemedicine as a tool to respond to the above desires and to fulfil their duty of providing a higher level of medical services.

Table 8. Factors that influence WTP

Variables	OLS			Tobit Model			Tobit Model*		
	coefficient	t-value	p-value	coefficient	t-value	p-value	coefficient	t-value	p-value
Univ. hospital	13514.4	1.5	-0.1	13974.7	1.8	-0.1	11964.4	1.8	-0.1
Public hospital	3015.0	0.6	-0.6	2951.5	0.6	-0.5			0.0
Private hospital	1588.2	0.3	-0.8	1800.5	0.4	-0.7			0.0
Physician	5161.9	1.1	-0.3	5600.4	1.3	-0.2	3286.1	2.3	0.0
Radiology	4041.8	1.7	-0.1	3642.1	1.7	-0.1	4749.5	2.5	0.0
Surgery	-3352.9	-1.1	-0.3	-3469.9	-1.3	-0.2			0.0
Using video confer. system	4658.4	1.5	-0.1	4776.3	1.7	-0.1	4526.6	1.8	-0.1
Using PC	-645.0	-0.2	-0.8	-484.9	-0.2	-0.9			0.0
Using pathology equipment	3549.6	1.3	-0.2	4089.1	1.6	-0.1			0.0
Satisfaction with quality	127.0	0.2	-0.9	50.5	0.1	-0.9			0.0
Experience of telemedicine	-2052.5	-0.7	-0.5	-2565.0	-0.9	-0.4			0.0
Dummy variable: radiology and pathology	-1194.7	-0.4	-0.7	-1138.7	-0.5	-0.6			0.0
Log likelihood	-494.6			-478.1			-480.5		

* Irrelevant variables are omitted.

Table 9. Factors that influence WTU

Variables	OLS			Tobit Model			Tobit Model*		
	coefficient	t-value	p-value	coefficient	t-value	p-value	coefficient	t-value	p-value
University hospital	13514.4	1.5	-0.1	13974.7	1.8	-0.1	11964.4	1.8	-0.1
Public hospital	3015.0	0.6	-0.6	2951.5	0.6	-0.5			0.0
Private hospital	1588.2	0.3	-0.8	1800.5	0.4	-0.7			0.0
Physician	5161.9	1.1	-0.3	5600.4	1.3	-0.2	3286.1	2.3	0.0
Radiology	4041.8	1.7	-0.1	3642.1	1.7	-0.1	4749.5	2.5	0.0
Surgery	-3352.9	-1.1	-0.3	-3469.9	-1.3	-0.2			0.0
Using video conference system	4658.4	1.5	-0.1	4776.3	1.7	-0.1	4526.6	1.8	-0.1
Using PC	-645.0	-0.2	-0.8	-484.9	-0.2	-0.9			0.0
Using pathology equipment	3549.6	1.3	-0.2	4089.1	1.6	-0.1			0.0
Satisfaction with quality of telemedicine	127.0	0.2	-0.9	50.5	0.1	-0.9			0.0
Experience of telemedicine	-2052.5	-0.7	-0.5	-2565.0	-0.9	-0.4			0.0
Dummy variable: radiology and pathology	-1194.7	-0.4	-0.7	-1138.7	-0.5	-0.6			0.0
Log likelihood	-494.6			-478.1			-480.5		

* Irreverent variables are omitted.

Table 10. Experience and Possibility of Telemedicine

	Q5			Q18 Future possibility			Q19 Future possibility		
	Having experience			Asking institutions			Undertaking institutions		
Variable	Estimate	t-statistic		Estimate	t-statistic		Estimate	t-statistic	
No. of Bed	0.022	0.107		-0.237	-1.144		-0.540	-2.600	***
Satisifaction	1.916	5.039	***	0.339	1.380	+	0.466	1.897	*
Q20_1	0.078	0.208		-0.339	-1.001		0.820	2.314	**
Q20_2	-0.187	-0.505		-0.044	-0.124		-0.194	-0.561	
Q20_3	0.426	1.564	+	0.221	0.901		0.036	0.148	
Q20_4	-0.516	-1.575	+	0.597	2.198	**	0.241	0.881	
Q20_5	0.131	0.451		-0.273	-1.028		-0.021	-0.083	
Q20_6	0.088	0.317		-0.107	-0.451		-0.062	-0.264	
Q20_7	-0.907	-2.543	**	0.464	1.566	+	-0.061	-0.205	
Q20_8	0.324	1.027		-0.179	-0.649		0.139	0.491	
Q20_9	0.424	1.525	+	0.555	2.250	**	0.177	0.741	
Specified hospital	0.280	0.757		0.110	0.323		0.795	2.334	**
Medicak training hospital	-0.484	-1.473	+	0.217	0.736		0.361	1.240	
Third emergency hospital	-0.157	-0.424		-0.188	-0.565		-0.222	-0.690	
Internal medicine	-0.596	-1.314	+	-0.217	-0.499		-0.815	-1.648	*
Radiology	0.249	0.734		-0.331	-1.106		0.431	1.319	+
Surgery	0.798	1.629	+	1.061	2.153	**	0.550	1.171	
Orthopaedic	0.588	1.388	+	-0.529	-1.201		0.246	0.638	
Exp. of asking				0.396	1.360	+			
Exp.of undertaking							0.332	1.207	
Exp. of both				0.474	1.344	+	0.230	0.667	
No. of observation		187			179			169	
Log likelihood		-78.9742			-99.8655			-100.946	

***, ** and * indicate the 1%, 5 %, and 10 significant level. For the reference, + implies the 20 significant level.

Q20-1. Telemedcicine proveides a chance for exchanging medical and health information.

Q20-2. Telemadicine can play a role of providing medical services to residents in rural as well as urban areas.

Q20-3. Telemedicine promotes self medications regarding health and medicine.

Q20-4. Telemedicine can cope with various needs of people for health, medicine, and care.

Q20-5. Telemedicine supports people to obtain second opinions.

Q20-6. Telemedicine promotes outsourcing in the medical field.

Q20-7. Telemedicine nurtures new businesses in the medical field.

Q20-8. Telemedicine converts the medical field from public to the private market.

Q20-9. Medical institutions more implementing telemedicine are more advancing.

10 OBSTACLES TO TELEMEDICINE

In the questionnaires, medical institutions were asked to write freely the reasons that they do not utilize telemedicine (or do not utilize it more). The reasons they typically mentioned are (i) concerns about quality; (ii) concerns about reliability; and (iii) time required. The question regarding problems of telemedicine was asked to medical institutions that already undertake telemedicine. The replies typically given are (i) the responsibility involved; (ii) insufficient time for implementation; and (iii) lack of manpower.

11. CONCLUSION

In this paper, based on a nationwide mail survey on telemedicine, we estimated the total values of telemedicine in terms of WTP and WTU, especially in the fields of teleradiology, telepathology, teleconferencing, and teleconsultation. In addition to the evaluation, qualitative aspects of implementation of telemedicine, such as factors for and against promotion of telemedicine, were analyzed. By making use of these results, we specified policy measures to promote telemedicine further, such as improvement of quality and reimbursement. These results are applicable not only to Japan but to other countries as well.

11. ACKNOWLEDGMENTS

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