ORIGINAL ARTICLE

Cost-effectiveness analysis of dialysis and kidney transplants in Japan

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Abstract. **Although kidney transplantation is considered to be more desirable than dialysis in terms of cost-effectiveness and patients' quality of life, there have been very few cases of kidney transplants in Japan. This study was conducted to compare the cost-effectiveness of dialysis and kidney transplants using Disability-Adjusted Life Years (DALYs) as an indicator of effectiveness. Most data necessary for the DALYs analysis were obtained from publications. The disability weights for dialysis patients and kidney transplant patients were estimated based on a questionnaire emailed to medical officials of the Japanese Government. Expected duration of treatment was estimated from the survival rates of dialysis patients and the graft-survival rates of transplant patients using the Weibull model method. The cost of dialysis and living-related donor (LRD) transplant included only medical expenditures and neglected all other costs, and the cost of cadaveric donor (CAD) transplant included the budget for organ procurement and distribution in addition to medical expenditures. The analysis showed that dialysis averted 138,019 DALYs/year, living-related donor transplant averted 5,740 DALYs/year, and CAD transplant averted 1,892 DALYs/year. The cost-effectiveness ratio (C-E ratio) was 9,546 thousand yen/DALY for dialysis, 1,809 thousand yen/DALY for LRD transplant, and 2,322 thousand yen/DALY for CAD transplant. These results could be used for the decision making of the Government on what resources should be allocated to the promotion of kidney transplantation. Also, the methodology used in this study can be applied to cost-effectiveness analysis of other organ transplants.** (Keio J Med 50 (2): 100–108, June 2001)

Key words: dialysis, kidney transplant, cost-effectiveness analysis, DALYs, Weibull model

Introduction

There are two major treatments for end-stage renal diseases (ESRD): dialysis and a kidney transplant. In Japan, there were 152,373 dialysis patients as of the end of 1995, and the number at that time had been expanding at more than 10,000 patients per year.[1] With the medical expenditures for dialysis in 1996 at 9,073.6 thousand yen/year/inpatient and 5,380.3 thousand yen/year/outpatient, according to *The National Sakura Hospital*, the leading institution for ESRD treatment in Japan, huge medical resources were consumed by dialysis patients. On the other hand, although the medical expenditures for kidney transplants in 1996 were much lower, at only 5,319.5 thousand yen/year/patient for the first year and 1,736.2 thousand yen/year/patient for the following years (*The National Sakura Hospital*), there were only 604 kidney transplants executed in 1995: 172 cadaveric donor (CAD) transplants and 432 living-related donor (LRD) transplants.[2] In addition, the dialysis patients still awaiting the chance for a kidney transplant as of the end of 1994 totaled 22,129 (*The National Sakura Hospital*).

Generally speaking, a kidney transplant is considered to be more cost-effective and more desirable for patients' quality of life than dialysis, as shown by several studies.[3–5] This study was conducted to compare the cost-effectiveness of dialysis and kidney transplantation using Disability-Adjusted Life Years (DALYs), which were developed as a time-based measure for mortality and non-fatal health outcomes and have been widely applied to assess technologies and interventions.[6–12] The effectiveness of dialysis and kidney transplants can be estimated more precisely using DALYs,

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because the measure includes patients' quality of life in addition to mortality aspects of disease.

Materials and Methods

Calculation of effectiveness

The effectiveness was estimated based on the DALYs calculation described by Murray and Lopez.[13] DALYs are composed of two elements: Years of Life Loss (YLLs), which measures time lost due to premature mortality, and Years Lived with Disability (YLDs), which measures burden of time lived with a disability due to morbidity. DALYs can be calculated using the following formula:

$$DALYs = YLLs + YLDs$$

$$YLLs = \frac{KCe^{ra}}{(r+\beta)^2}[e^{-(r+\beta)(L+a)}\{-(r+\beta)(L+a)-1\} - e^{-(r+\beta)a}\{-(r+\beta)a-1\}] + \frac{1-K}{r}(1-e^{-rL})$$

$$YLDs = D\left[\frac{KCe^{ra}}{(r+\beta)^2}[e^{-(r+\beta)(L+a)}\{-(r+\beta)(L+a)-1\} - e^{-(r+\beta)a}\{-(r+\beta)a-1\}] + \frac{1-K}{r}(1-e^{-rL})\right]$$

where e is the natural logarithmic base, r is the discount rate, β is the age-weighting parameter, K is the age weighting modulation factor, C is the adjustment constant equal to 0.16243, D is the disability weight, which describes health states spanning from death ($D = 1$) to perfect health ($D = 0$), a in the YLLs formula is the age at death, a in the YLDs formula is the age of onset of the disability, L in the YLLs formula is the remaining years of life at death, and L in the YLDs formula is the duration of disability. In this analysis, a discount rate (r) of 3% and the standard age weighting function ($\beta = 0.04$ and $K = 1$) adopted by the World Bank were used.[14] The other variables necessary for DALYs calculation were estimated as follows.

The annual incidence of dialysis was determined as the number of new dialysis cases in 1995 and the annual number of kidney transplants came from the number of recipients in 1995.[1,2] Patients were grouped by age into 10 classes of 10 years each (0–9 to 90+ years) for dialysis patients, and 6 classes of 10 years each (0–9 to 50+ years) for kidney transplant patients (column A of Table 1). The age distribution of kidney transplant patients in 1995, which was not published, was assumed to be same as that of patients from 1983 to 1994.[15] In addition, kidney transplant patients were divided into two donor-related groups, LRD transplants and CAD transplants. The annual incidences are shown in column B of Table 1.

The disability weights (D) for the dialysis and kidney transplant patients were estimated based on the questionnaire emailed to 95 officials, all of whom were doctors engaged in health related policy making in the Japanese Government. The Person Trade-Off method[13] was used as the protocol. Here, two alternatives are offered to subjects. Alternative 1 is to extend life for 1,000 individuals in normal health and alternative 2 is to extend life for X individuals in health state Y (e.g. patients undergoing dialysis or transplant). X is varied until the respondent is indifferent to the choice between the two alternatives, at which point the preference for state Y is $1{,}000/X$ and the disability weight (D) is $1–1{,}000/X$. The emailed questionnaire contained an explanation of the Person Trade-Off method, definitions of physical conditions of dialysis and kidney transplant patients, and a table of 7 disability classes with 22 indicator conditions which were developed by the WHO study group.[13] The response rate of the questionnaire was 45.3% (43/95). As a normal distribution was not obtained, the median data, 0.231 for dialysis patients and 0.100 for transplant patients, were adopted for DALYs calculation (Table 2).

Expected duration (L in YLDs formula) was estimated using the Weibull model formula, $RS(t) = \exp(-at^b)$, where t is years after the onset of treatment, $RS(t)$ is survival rate at the point of t, and a and b are parameters. With survival rates at two points of time, for example 2 year and 5 year survival rates, a and b can be determined and a model curve of survival rates can be drawn from the formula. *The Japanese Society for Dialysis Therapy* provides 12 survival rates of dialysis patients spanning from 1 year to 12 years for 7 age classes, 0–14, 15–29, 30–44, 45–59, 60–74, 75–89, and 90+ years.[1] Two survival rates were chosen arbitrarily, and the Weibull curve fit 12 actual data points very well (Fig. 1). The Weibull curves were modified using data from *The Abridged Life Table for Japan (1995)*[16] to reflect the effect of aging. The area under the curve, which can be determined by accumulating survival rates from onset to extinction, shows average duration from onset to death. As for the age classes of 75–89 and 90+ years, the expected duration was estimated by simply summing up the 12 survival rates from 1 year to 12 years, because the 12-year survival rates for these age classes were close to zero and it was not necessary to use the Weibull model estimation. Then, the expected duration estimated for the 7 age classes was converted to 10 age classes by interpolation; for example, the expected duration for the 20–29 year class (midpoint: 25.0 years) was obtained from those for the 15–29 year class (midpoint: 22.5 years) and the 30–44 year class (midpoint: 37.5 years) (column E of Table 1).

As for kidney transplants, using survival rates will lead to overestimation of the effectiveness of kidney

Table 1 Data Used for Estimation of Effectiveness

Dialysis

Age (years)	Annual Incidence (1995) (persons)	Average Age of Onset (years)	Lost Duration of Life at Onset (years)	Expected Duration (years)	Average Age of Death (years)	Lost Duration of Life at Death (years)
A	B	C	D	E	F (C + E)	G
0–9	25	5	75.1	50.2	55.2	26.9
10–19	118	15	65.2	46.8	61.8	21.3
20–29	606	25	55.5	41.2	66.2	17.8
30–39	1,201	35	45.7	28.9	63.9	19.6
40–49	3,163	45	36.2	19.2	64.2	19.3
50–59	5,587	55	27.1	11.6	66.6	17.4
60–69	7,416	65	18.7	7.2	72.2	13.3
70–79	5,389	75	11.3	4.7	79.7	8.5
80–89	2,032	85	5.9	3.0	88.0	4.8
90+	92	95	2.8	2.5	97.5	2.2
Total	25,629	–	–	–	–	–

LRD Transplant

Age (years)	Annual Incidence (1995) (persons)	Average Age of Onset (years)	Lost Duration of Life at Onset (years)	Expected Duration (years)	Average Age of Rejection (years)	Lost Duration of Life at Rejection (years)
A	B	C	D	E	F (C + E)	G
0–9	11	5	75.1	20.4	25.4	55.1
10–19	49	15	65.2	25.6	40.6	40.3
20–29	131	25	55.5	9.9	34.9	45.9
30–39	160	35	45.7	15.6	50.6	31.1
40–49	59	45	36.2	11.2	56.2	26.0
50+	22	55	27.1	16.2	71.2	14.0
Total	432	–	–	–	–	–

CAD Transplant

Age (years)	Annual Incidence (1995) (persons)	Average Age of Onset (years)	Lost Duration of Life at Onset (years)	Expected Duration (years)	Average Age of Rejection (years)	Lost Duration of Life at Rejection (years)
A	B	C	D	E	F (C + E)	G
0–9	2	5	75.1	9.3	14.3	65.9
10–19	4	15	65.2	15.1	30.1	50.5
20–29	26	25	55.5	12.7	37.7	43.1
30–39	71	35	45.7	12.8	47.8	33.6
40–49	58	45	36.2	10.6	55.6	26.6
50+	11	55	27.1	12.7	67.7	16.6
Total	172	–	–	–	–	–

LRD Transplant: living-related donor transplant, CAD Transplant: cadaveric donor transplant.

Table 2 Results of Questionnaire on Disability Weight

	Dialysis	Transplant
Minimum	0.000	0.000
First Quartile	0.139	0.034
Median	**0.231**	**0.100**
Third Quartile	0.333	0.233
Maximum	0.700	0.667
Mean	0.261	0.148

Response Rate: 45.3% (43/95).

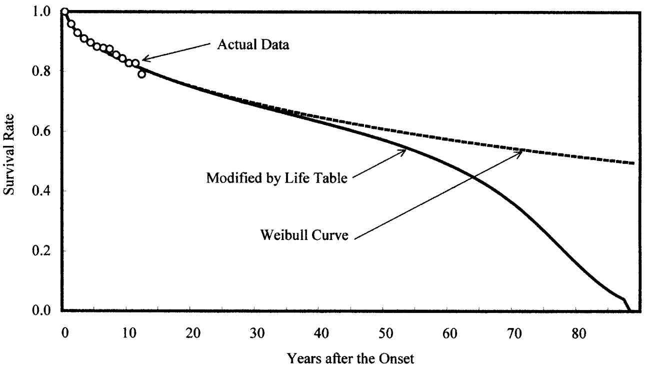

Fig. 1 Survival rate curves estimated by the Weibull model (dialysis patients, age 0–14). Twelve data plots (o) show survival rate data provided by *The Japanese Society for Dialysis Therapy*. The broken line (---------) was drawn using the Weibull model formula, and the solid line (———) was obtained by correcting for the aging effect using *The Abridged Life Table for Japan (1995)*. The expected duration from the onset to death was obtained by calculating the area surrounded by the solid line and the two axes.

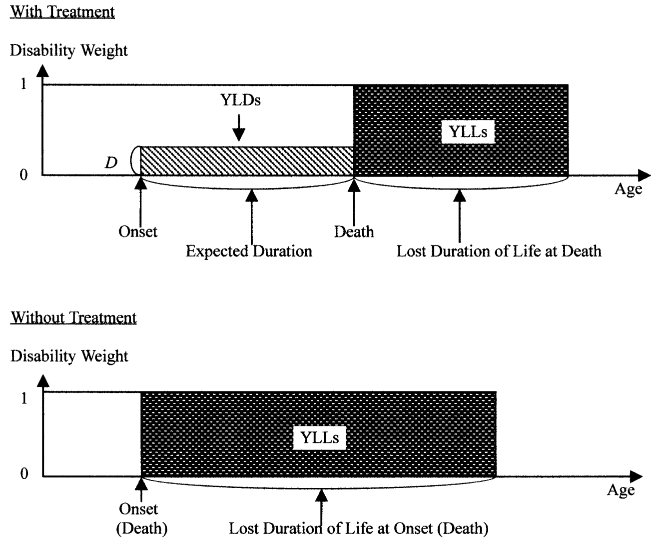

Fig. 2 Model for DALYs calculation. Effectiveness is equivalent to the difference between "DALYs without treatment" and "DALYs with treatment". "DALYs with treatment" are a summation of YLDs caused by the disability during treatment, and YLLs caused by the death after treatment. "DALYs without treatment" was YLLs caused by the death just after the onset.

transplants, since kidney transplant patients whose organs are rejected could survive with dialysis and thus raise the survival rate considerably. To eliminate such bias, graft-survival rates were used to estimate the expected duration for a kidney transplant assuming that transplant patients died just after the rejections. *The Japan Society for Transplantation* provides 10 graft-survival rates of kidney transplants by donor category (LRD transplant and CAD transplant) spanning from 1-year to 10-years for 8 age classes, 0–4, 5–9, 10–19, 20–29, 30–39, 40–49, 50–59, and 60+ years.[15] To adjust the age-classes, the graft-survival rate for the 0–9 class was obtained from the data of the 0–4 and 5–9 year classes, and the data of the 50–59 and 60+ year classes were recalculated to determine a 50+ year class.

The midpoint of each age class was used for average age of onset (*a* in YLDs formula) as shown in column C of Table 1. Average age of death of dialysis patients and average age of rejection of transplant patients (*a* in YLLs formula) were obtained by summation of the average age of onset and expected duration (column F of Table 1).

The Abridged Life Table for Japan (1995)[16] was used to estimate the lost duration of life at the age of onset and death (or rejection) (*L* in YLLs formula). Lost duration of life at onset is shown in column D of Table 1, and lost duration of life at death (or rejection) is shown in column G of Table 1.

Effectiveness is equivalent to "DALYs averted by treatment", which is the difference between "DALYs without treatment" and "DALYs with treatment". DALYs without treatment were estimated by calculating DALYs of ESRD patients in a hypothetical world where ESRD patients die just after the onset. DALYs without treatment have only the YLLs element since ESRD patients die at the onset without a disability period. On the other hand, DALYs with treatment are a summation of YLDs caused by the disability of disease lasting for the years of expected duration, and YLLs caused by the death coming after the expected duration (Fig. 2). The element of YLLs was discounted to the present value at the time of onset using a discount rate of 3%. For example, if the age of the patient at onset is 20 years old and the expected duration is 30 years, the present value of YLLs from death of a 50-year-old person will be as follows:

$$\frac{\text{(YLLs from death of 50-year-old person)}}{(1+r)^{30}}$$

(r: discount rate of 3%)

Estimation of cost

Average health insurance payments for ESRD treatments provided by *The National Sakura Hospital* were used for cost estimation, because the insurance payments are almost uniform among institutions under universal health insurance coverage in Japan.

Cost of dialysis included only the medical expenditures neglecting all other costs, such as transportation cost and opportunity cost of time during dialysis. Medical expenditures for dialysis as of April 1996 were 9,073.6 thousand yen/year/inpatient and 5,380.3 thousand yen/year/outpatient. As the proportion of inpatient dialysis was 13.8%, according to the survey of the Ministry of Health and Welfare,[17] the figure 5,888.4 thousand yen/year/patient ($9,073.6 \times 13.8\% + 5,380.3 \times 86.2\%$) was used for the estimation of dialysis cost.

The medical expenditures for kidney transplants were 5,319.5 thousand yen/year/patient for the first year and 1,736.2 thousand yen/year/patient for the following years. In addition to the medical expenditures, the cost of CAD transplant included the budget for the kidney transplant information system, which was used for kidney procurement and distribution necessary for CAD transplants. As the budget for kidney transplants was 706,000 thousand yen/year and the annual incidence of CAD transplants was 172 in 1995, the operation cost of the kidney transplant information system per patient was estimated as 4,105 thousand yen (706,000/172). The cost necessary for the second and following years was discounted to the present value at the point of onset using a discount rate of 3%, then summed up through the total process of treatment.

Results

Column L of Table 3 shows the effectiveness per patient (EPP), which is the gap between DALYs without treatment (column K of Table 3) and DALYs with treatment (column J of Table 3). The EPP of dialysis was higher than that of transplant in five age classes, 0–9, 10–19, 20–29, 30–39, and 40–49 years. Column M of Table 3 shows the total effectiveness, which corresponds to EPP (column L of Table 3) multiplied by incidence (column B of Table 1). The total effectiveness of dialysis was 138,019 DALYs and was much greater than that of transplants (5,740 DALYs for LRD transplants and 1,892 DALYs for CAD transplants).

The cost per patient is shown in column N of Table 4 and the total cost is shown in column O of Table 4. The cost per dialysis patient was greater than that per transplant patient. For example, in the case of the 10–19 year age class, the cost was 151,523 thousand yen for dialysis, 35,240 thousand yen for LRD transplant, and 29,146 thousand yen for CAD transplant.

Table 5 shows the Cost-Effectiveness ratios (C-E ratios) of dialysis and kidney transplants. The C-E ratios were 9,546 thousand yen/DALY for dialysis, 1,809 thousand yen/DALY for LRD transplants, and 2,322 thousand yen/DALY for CAD transplants. As the C-E ratios of the same age classes were compared, the C-E ratio of dialysis was 3 to 4 times higher than that of transplantation.

Sensitivity Analysis

Sensitivity analysis of discount rate, age weight, and disability weight was carried out. As shown in Fig. 3, the C-E ratios were insensitive to discount rate. Figure 4 shows how the C-E ratios of dialysis varied when K, the age weighting modulation factor, changed from 0 to 1. Larger K worsened the C-E ratios for elderly patients, especially for patients 70 years and older. Figure 5 shows how the C-E ratios varied with the disability weight obtained from the questionnaire. Although the C-E ratio of dialysis worsened more markedly than the C-E ratios of transplants when applying larger disability weight data, there was no effect on the order of the magnitudes of the C-E ratios among dialysis, LRD transplants, and CAD transplants.

Discussion

Weibull model estimation of expected duration

It takes a long time to determine the duration of diseases by means of disease registration, since treatment outcome would not be clear even after decades of follow-up, especially for chronic diseases. The Weibull model is a useful method to estimate a decades-long survival rate and the duration of a disease, and has been applied in several studies.[17,18] Although the Weibull model needs survival rate data only at two points of time, the curves drawn by this method fit the actual surveillance data quite well. However, since the Weibull model does not reflect the effect of aging, the range of error becomes wider as the duration increases. In this study, the Life Table data was used to adjust for such an error. Although it is a convenient method to estimate duration of chronic diseases, the validity of this modification should be inspected more carefully.

In this analysis, discontinuity was observed in the expected duration of LRD transplants: the duration of the 20–29 year age class was unexpectedly short (9.9 years) compared to those of the adjacent age classes, 25.6 years for the 10–19 year class and 15.6 years for the 30–39 year class. This may be due to the small sample size of the graft survival rate data from *The*

Table 3 Results of Effectiveness Estimation

Dialysis

Age (years)	DALYs with Dialysis per patient			DALYs w/o Dialysis per patient (DALYs)	Effectiveness per patient (DALYs)	Total Effectiveness (DALYs)
	YLLs (DALYs)	YLDs (DALYs)	Total (DALYs)			
A	H	I	J (H + I)	K	L (K – J)	M (L × B)
0–9	3.2	7.6	10.7	35.7	25.0	624
10–19	2.7	7.8	10.4	36.0	25.6	3,023
20–29	2.5	6.9	9.4	31.9	22.5	13,620
30–39	4.1	5.1	9.2	26.0	16.7	20,109
40–49	5.4	3.4	8.8	19.8	11.0	34,911
50–59	6.0	2.0	7.9	14.1	6.2	34,433
60–69	4.9	1.1	6.0	9.1	3.1	23,144
70–79	3.1	0.6	3.7	5.1	1.4	7,321
80–89	1.6	0.3	1.9	2.3	0.4	825
90+	0.6	0.2	0.8	0.9	0.1	8
Total	–	–	–	–	–	138,019

LRD Transplant

Age (years)	DALYs with Transplant per patient			DALYs w/o Transplant per patient (DALYs)	Effectiveness per patient (DALYs)	Total Effectiveness (DALYs)
	YLLs (DALYs)	YLDs (DALYs)	Total (DALYs)			
A	H	I	J (H + I)	K	L (K – J)	M (L × B)
0–9	17.3	1.9	19.2	35.7	16.5	177
10–19	10.6	2.6	13.1	36.0	22.9	1,131
20–29	19.5	1.3	20.7	31.9	11.1	1,465
30–39	10.5	1.6	12.0	26.0	14.0	2,233
40–49	9.6	1.0	10.7	19.8	9.2	536
50+	4.0	1.1	5.1	14.1	9.0	198
Total	–	–	–	–	–	5,740

CAD Transplant

Age (years)	DALYs with Transplant per patient			DALYs w/o Transplant per patient (DALYs)	Effectiveness per patient (DALYs)	Total Effectiveness (DALYs)
	YLLs (DALYs)	YLDs (DALYs)	Total (DALYs)			
A	H	I	J (H + I)	K	L (K – J)	M (L × B)
0–9	27.5	0.8	28.4	35.7	7.3	12
10–19	18.5	1.8	20.3	36.0	15.7	67
20–29	16.7	1.5	18.2	31.9	13.6	352
30–39	12.4	1.4	13.8	26.0	12.2	865
40–49	10.1	1.0	11.1	19.8	8.8	510
50+	5.4	0.9	6.3	14.1	7.8	86
Total	–	–	–	–	–	1,892

LRD Transplant: living-related donor transplant. CAD Transplant: cadaveric donor transplant. YLLs: years of life loss. YLDs: years lived with disability.

Table 4 Results of Cost Estimation

Dialysis

Age (years)	Cost per patient (thousand yen)	Total Cost (thousand yen)
A	N	O (N×B)
0–9	156,355	3,908,869
10–19	151,523	17,879,694
20–29	142,357	86,268,081
30–39	116,052	139,378,604
40–49	87,700	277,395,654
50–59	58,697	327,940,847
60–69	38,865	288,224,033
70–79	25,963	139,915,248
80–89	17,369	35,293,026
90+	14,322	1,317,649
Total	–	1,317,521,706

LRD Transplant

Age (years)	Cost per patient (thousand yen)	Total Cost (thousand yen)
A	N	O (N×B)
0–9	30,537	327,851
10–19	35,240	1,738,561
20–29	18,668	2,452,835
30–39	25,550	4,088,525
40–49	20,437	1,196,344
50+	26,277	577,663
Total	–	10,381,779

CAD Transplant

Age (years)	Cost per patient (thousand yen)	Total Cost (thousand yen)
A	N	O (N×B)
0–9	21,985	35,423
10–19	29,146	123,274
20–29	26,363	679,646
30–39	26,455	1,880,844
40–49	23,718	1,380,531
50+	26,401	292,455
Total	–	4,392,173

LRD Transplant: living-related donor transplant. CAD Transplant: cadaveric donor transplant.

Japan Society for Transplantation rather than methodological problems.

Discounting

Although discounting future health is still controversial, it is strongly supported by some arguments: the opportunity cost argument, the time paradox argument, and the disease eradication paradox argument.[13,20,21] The discount rate could influence the consequences of analysis; generally, a higher discount rate is more advantageous to C-E ratios of curative procedures than to those of preventive procedures, because effectiveness of curative procedures occurs earlier and is affected little by discount rate. In this study, the sensitivity analysis was carried out and showed that discount rate had little effect on the C-E ratios of dialysis and kidney transplants.

Age weighting

The sensitivity analysis of age weighting showed that effectiveness for the elderly was greatly dependent upon the age weighting modulation factor (K). If health policy decisions are made based on cost-effectiveness analysis using DALYs, the value of K will greatly influence the destiny of the elderly. As the value of K may vary among societies, surveys to determine K might be necessary before DALYs analysis could be put into practical use. In the case of Japan, K seems to be almost zero when considering the Government's positive attitude on the welfare policy for the elderly.

Disability weight

Disability weights for dialysis patients and kidney transplant patients were determined by questionnaire. The respondents to the survey seemed to be well qualified in the sense that they had sufficient knowledge regarding medicine and policy making. Although there were some inappropriate responses, such as the disability weight of "0" for ESRD patients, such responses seem to be rather natural since the design of the Person Trade-Off method itself contains ethical problems which never would be accepted by some people. However, the medium data being used for the analysis were quite reasonable with reference to the table of 22 indicator conditions, which was attached to the questionnaire.

Cost-effectiveness of dialysis and transplant

This study suggests that a kidney transplant is much more cost effective than dialysis in all age classes. As stated above, this relationship would not change with

Table 5 Results of Cost-effectiveness Ratio

Age (years)	Dialysis (thousand yen/DALY)	LRD Transplant (thousand yen/DALY)	CAD Transplant (thousand yen/DALY)
A	P (O/M)	P (O/M)	P (O/M)
0–9	6,259	1,851	2,992
10–19	5,915	1,537	1,852
20–29	6,334	1,675	1,932
30–39	6,931	1,831	2,174
40–49	7,946	2,232	2,706
50–59	9,524	2,913	3,399
60–69	12,453	–	–
70–79	19,112	–	–
80–89	42,755	–	–
90+	170,834	–	–
Total	9,546	1,809	2,322

LRD Transplant: living-related donor transplant. CAD Transplant: cadaveric donor transplant.

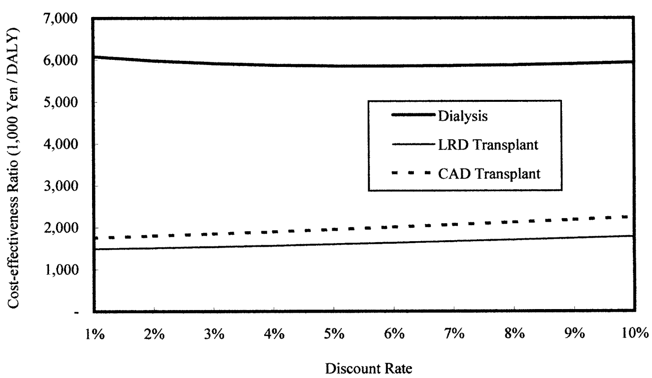

Fig. 3 Sensitivity analysis by discount rates (age 10–19).

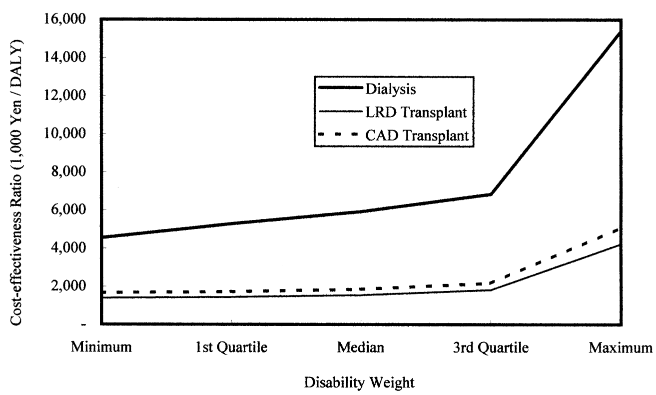

Fig. 5 Sensitivity analysis by disability weight (age 10–19).

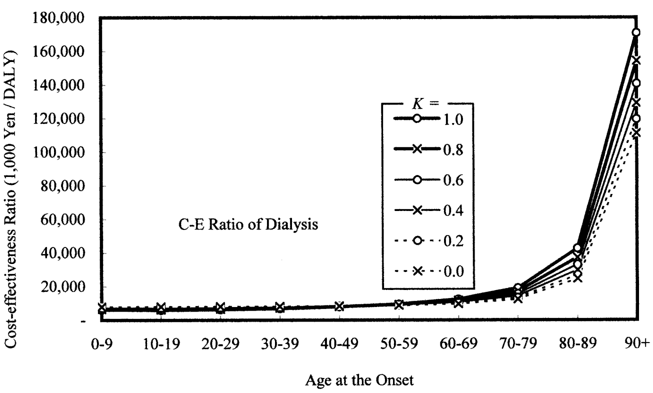

Fig. 4 Sensitivity analysis by age weight (dialysis).

discount rate and disability weight. As for limitations of this study, the study was based on statistical data of practical treatments, and therefore matching of patients among treatments was not considered. It is possible that the difference of patients' conditions affected the values of the C-E ratio. Nevertheless, the results suggest that the difference of C-E ratio between dialysis and transplants is large enough to allow disregarding the patients' conditions.

On the other hand, this result does not mean that a transplant is superior to dialysis in all aspects. As shown in column L of Table 3, we can expect dialysis to produce a higher EPP than a transplant. This means that dialysis is favorable to extend life longer easily compared to a kidney transplant, which has a considerable risk of rejection. Also, we cannot neglect the fact that dialysis averts a much greater number of DALYs than does a kidney transplant, as shown in column M of Table 3 (138,019 DALYs for dialysis, 5,740 DALYs for LRD transplants, and 1,892 DALYs for CAD transplants).

Application to the health policy in Japan

If the C-E ratios of health interventions are less than the price, which the society is willing to spend to avert 1 DALY (call this *the S value*), such interventions should be made. *The S value* is considered to be at least equal to the gross domestic product (GDP) per capita, because averting 1 DALY is equivalent to gaining 1 person year in perfect health, which would increase the GDP per capita. The GDP in Japan was 462 trillion yen, and the GDP per capita was 3,716 thousand yen in 1995. Therefore LRD transplants (1,809 thousand yen/DALY) and CAD transplants (2,322 thousand yen/DALY) can be judged to be cost-effective. Then, should we continue dialysis, for which the C-E ratio is 9,546 thousand yen/DALY? The decision would depend on the background of a country, such as history, social solidarity, and political situation. If we make decisions from a utilitarian standpoint, dialysis might be given up completely or be limited to young patients. However, such a policy would never be accepted by the Japanese society, where egalitarianism has permeated the whole system; all people have a right to access to health services equally regardless of wealth, age, or sex under universal health insurance coverage. The possible Government policy derived from this study would therefore not be suppression of dialysis, but rather promotion of kidney transplants. At least, the results of this study can be used for decision making of what resources should be allocated to promote kidney transplantation.

Although the Government's health policy at present is rarely formed based on cost-effectiveness analysis in Japan, rapidly increasing medical expenditures will someday lead to a realization that we have to manage the health care system with scarce resources and choose cost-effective treatment using cost-effectiveness analysis.

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