**Cost-effectiveness of haemodialysis and peritoneal dialysis for patients with end-stage renal disease in Singapore**

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Running Title: **Cost-effectiveness of HD and PD in Singapore**

**Cost-effectiveness of haemodialysis and peritoneal dialysis for patients with end-stage renal disease in Singapore**

**Abstract**

**Aim**

This study aimed to evaluate the cost-effectiveness of haemodialysis (HD), continuous ambulatory peritoneal dialysis (CAPD) and automated peritoneal dialysis (APD) for patients with end-stage renal disease (ESRD) in Singapore.

**Methods**

A Markov model was developed to examine the incremental cost-effectiveness ratios (ICERs) of HD, CAPD and APD over the 10-year time horizon from the societal perspective, using clinical data from an observational study and the national renal registry, utilities from published studies and costs from dialysis services providers. The base-case analysis was for a hypothetical cohort of 60-year-old non-diabetic ESRD patients. A high-risk group of 60-year-old diabetic ESRD patients was also studied.

**Results**

In the base-case analysis, the quality-adjusted life-years (QALYs) were 3.27 with CAPD, 3.48 with APD and 4.69 with HD. The total costs were Singapore dollar $169,872 for CAPD, 201,509 for APD and 306,827 for HD. CAPD and HD had extended dominance over APD. The ICER of HD versus CAPD was $96,447 (US$69,121) per QALY. One-way sensitivity analyses indicated that the results were most sensitive to the utility of HD. Probabilistic sensitivity analyses demonstrated that CAPD had the maximum probability of being cost-effective among treatments under evaluation at a willingness-to-pay (WTP) threshold of $60,000 (US$43,000) per QALY. The high-risk group analyses showed similar results. The ICER of HD versus CAPD was $106,281 (US$76,168) per QALY and the probability of CAPD being optimal was the highest using the same WTP threshold.

**Conclusions**

Our analysis suggested that starting dialysis with CAPD is most cost-effective for ESRD patients in Singapore.

**Key words**

haemodialysis, continuous ambulatory peritoneal dialysis, automated peritoneal dialysis, cost-effectiveness, end-stage renal disease

**Introduction**

Because of the growing number of patients with chronic kidney disease, hypertension, and diabetes mellitus, the number of patients with end-stage renal disease (ESRD) requiring renal replacement therapy (RRT), either kidney transplantation (TX) or chronic dialysis, is vastly increasing ([1](#_ENREF_1)). By the end of 2004, about 1.8 million patients were treated with RRT globally, 77% on chronic dialysis and 23% living with a functional transplant ([2](#_ENREF_2)). Transplantation leads to longest survival and best health-related quality of life (HRQOL) and is most cost-effective for ESRD patients ([3](#_ENREF_3), [4](#_ENREF_4)). However, due to the shortage of organ donors and the ageing of ESRD population who may not be suitable for transplantation, haemodialysis (HD) or peritoneal dialysis (PD) is the common treatment for ESRD. HD is usually performed in a dialysis center. PD has two main options, either with manual exchange of dialysis fluid (continuous ambulatory peritoneal dialysis [CAPD]) or with automated exchange of dialysis fluid at night (automated peritoneal dialysis [APD]).

Worldwide, the highly growing ESRD patient population results in expanding costs of RRT programs. In most developed countries, about 2% of the national healthcare budgets is spent caring for ESRD patients, despite the fact that less than 0.1% of the total population has ESRD ([5](#_ENREF_5)). In Singapore, the incidence and prevalence of ESRD is high and projected to increase rapidly due to ageing and the high prevalence of diabetes ([6](#_ENREF_6)). According to Ministry of Health Singapore, the annual direct costs of dialysis provision and its associated services were about Singapore dollar $36,000 (US$21,000) per patient in 2000 and the total national expenditure was estimated to increase by 2.5-fold from $90 million in 1999 to $241 million in 2010 ([6](#_ENREF_6)).

Given the heavy health burden and budget constraints, the assessment of the cost-effectiveness of treatments for ESRD is critical for current and future healthcare sustainability. Economic evaluations about the dialysis modalities have been performed in many countries ([7-17](#_ENREF_7)). While majority of these studies reported the consistent conclusion that PD was more cost-effective than HD, one UK study concluded that HD may be more cost-effective than CAPD ([8](#_ENREF_8)) and the studies done in Malaysia and Chile showed that the cost-effectiveness of both modalities was nearly equal ([13](#_ENREF_13), [14](#_ENREF_14)). Due to the differences in dialysis service provision and financing systems between these countries and Singapore, any of these findings may not be generalizable to the local setting.

Hence, in this study, we performed a cost-effectiveness analysis of three dialysis treatments for ESRD, i.e. HD, CAPD and APD using local costs and effectiveness data.

**Methods**

**Overview**

This was a model-based cost-effectiveness analysis. A Markov model was used to project the quality-adjusted life years (QALYs) that a typical patient on HD, CAPD or APD would have gained over a 10-year time horizon and the costs associated with the treatments and disease progression. The costs and effectiveness were compared to determine the relative cost-effectiveness of the modalities. The analysis took the societal perspective; therefore, direct (medical and nonmedical) and indirect costs were both considered. The model was developed and analyzed using Microsoft Excel 2010 (Microsoft Corporation, Redmond, WA).

**Model structure**

A Markov model consisting of 3 discrete states and pathways between the states were used to simulate the disease processes of dialysis patients, as illustrated in Figure 1. The health states in the model included dialysis, TX and death. In Cycle 0, the patient cohort enters the model in the ‘dialysis’ state, which could be HD, CAPD or APD. All patients could remain in the ‘dialysis’ state or make a transition to another health state in a subsequent cycle. Transition between HD, CAPD and APD was not allowed in any cycle. A cycle length of 1 year was used.

**Clinical inputs**

The mortality rates of dialysis patients were obtained from a study investigating survival outcomes of 871 incident ESRD patients in Singapore ([18](#_ENREF_18)). Due to the lack of survival data for CAPD and APD patients, we assumed that the mortality rates were the same for both PD modalities. Since the study indicated that the mortality rates would change as the duration of dialysis increased, cycle-specific mortality rates were computed for the first 5 cycles, and the mortality rates from the 5th year onwards were assumed to be constant. Data from Singapore Renal Registry 2009 ([19](#_ENREF_19)) was used to estimate the transplantation rates and the mortality rates of TX patients.

**Utility inputs**

Health utility scores of HD, CAPD and APD were obtained from a patient survey, in which 502 Singaporean dialysis patients were interviewed using the EuroQol 5-dimension (EQ-5D) instrument ([20](#_ENREF_20)), while the utility values for TX were from a meta-analysis conducted by Wyld ([21](#_ENREF_21)).

**Cost inputs**

***Direct medical costs***

*Costs of HD, PD and TX*

We assumed that patients get HD 3 times per week, CAPD is performed every day, and APD is conducted every night at home. The costs of access surgery for HD, the peritoneal access costs and the training costs for PD were estimated by consulting the dialysis center staff from the National University Hospital (NUH), Singapore. The depreciated infrastructure costs of HD and the costs of HD per session were estimated using data from the National Kidney Foundation (NKF), the main HD services provider in Singapore. The monthly costs of CAPD and APD were obtained from the NUH databases. HD patients are required to see their specialists once every 6 months, and PD patients are required to see their specialists once every 3 months. The costs of erythropoietin (EPO), outpatient clinics follow-ups and laboratory were retrieved from the NUH databases. The costs of TX surgery and the immunosuppressant medication were obtained from the Ministry of Health, Singapore.

*Costs of hospitalization*

The medical records of the dialysis patient cohort (n=871), whose survival outcomes have been studied ([18](#_ENREF_18)), were used to estimate the annual length of stay (LOS). As the dataset failed to differentiate CAPD and APD, we assumed that the LOS was the same for both modalities. The annual costs of hospitalization were based on the costs of un-subsidized general ward multiplied by the LOS. Because the maximum follow-up time of the patient cohort was 5 years, we assumed that the annual LOS was constant from the 5th year onwards.

***Direct nonmedical costs***

Based on the assumption that patients were living in an area with a diameter of 10 km and they would go to hospital for specialist clinic by taxi and go to dialysis center by public transportation, we used data from Land and Transportation Authority Singapore to estimate the costs of transportation.

***Indirect costs***

Indirect productivity costs were calculated based on 80% of missed working days due to dialysis treatments, outpatient clinics, and hospitalization, multiplied by the 2014 average national wage in Singapore (median monthly income $3770). Considering the retirement age of 62 years in Singapore, we assumed that patients aged 62 years or above would not incur any productivity loss. All costs were present in 2015 Singapore dollar.

**Model analysis**

The modality-specific Markov models were run for the 10,000 hypothetical patients for 10 cycles to estimate the costs consumed and QALYs gained in a period of 10 years. The results generated from all cycles were aggregated and then averaged across all patients as the expected total costs and QALY estimates per patient for each dialysis modality. Half-cycle correction and discounting at an annual rate of 3% were performed to both costs and QALYs from individual cycles before aggregation. The main outcome measure was incremental costs effectiveness ratio (ICER). The willingness-to-pay (WTP) was set as Singapore’s average per-capita gross domestic product (GDP) from 2005 to 2014 ([22](#_ENREF_22)), i.e. $60,000 per QALY, which was US$43,700 per QALY according to purchasing power parities ([22](#_ENREF_22)). For an intervention which is more effective than its comparator, it would be considered cost-effective if the ICER is less than $60,000 per QALY in this study.

**Base-case analysis**

A hypothetical cohort of adult patients with the following baseline characteristics was used as the base-case to go through the model: 1) newly diagnosed ESRD patients, 2) 60 years of age, 3) without diabetes, 4) no contradiction to any of the dialysis modalities, 5) no prior transplantation. All the parameters used in the model for the base-case are presented in Table 1.

**Sensitivity analysis**

***One-way sensitivity analysis***

The impact of parameter uncertainty for the optimal strategy was explored in one-way sensitivity analysis on each parameter. The 95% confidence intervals of the transition probability and health utility point estimates were used as plausible ranges. The published health utility estimates of HD, CAPD and APD from a published meta-analysis ([21](#_ENREF_21)) were also used as upper and lower ranges for sensitivity analysis. Because of the greater uncertainty regarding cost estimates, a wider range of 50% to 200% of the base-case values was used. The parameter ranges for the base-case are presented in Table 1.

***Probabilistic sensitivity analysis***

In order to evaluate the impact of uncertainty on all the parameter values simultaneously, a probabilistic sensitivity analysis was performed using a Monte Carlo simulation with 1,000 iterations. We assumed a log-normal distribution for event rates, a beta distribution for utilities and a gamma distribution for costs. The parameterization of distributions is shown in Table 1.

**High-risk group analysis**

Additionally, we performed same analyses for the high-risk group, i.e., diabetic patients with the same characteristics as the cohort for the base-case analysis. Transition probabilities, health utilities and costs were re-estimated. All parameter values, ranges and distributions for the high-risk group are presented in Table 2.

**Results**

**Base-case analysis**

The base-case analysis showed that the QALYs were 3.27 with CAPD, 3.48 with APD and 4.69 with HD (Table 3). The total costs were $169,872 for CAPD, 201,509 for APD and 306,827 for HD. The ICER of APD versus CAPD was SG$150,652 per QALY and the ICER of HD versus CAPD was 96,447. Both exceeded the WTP threshold at $60,000 per QALY. CAPD and HD had extended dominance over APD. Extended dominance is a method for eliminating from consideration a strategy (i.e. APD in this study), when the combination of two other alternatives (i.e. a proportion of patients were given CAPD and other patients were given HD) can gain the same or more QALYs with lower or same costs ([23](#_ENREF_23)). Therefore, CAPD was cost-effective in the base-case scenario.

**One-way sensitivity analyses**

One-way sensitivity analyses showed that several parameters influenced the cost-effectiveness of HD versus CAPD. The model was most sensitive to the utility of HD. However, when the values of all model parameters were varied across plausible ranges, the ICER values of HD versus CAPD remained more than $60,000 per QALY, indicating CAPD was more cost-effective than HD.

**Probabilistic sensitivity analysis**

The uncertainty of the cost-effectiveness results for a range of WTP threshold is presented as cost-effectiveness acceptability curves in Figure 2. The acceptability curves for base-case showed that the probabilities of CAPD, APD and HD being the optimal treatment strategy were 36.2%, 33.2% and 30.6%, respectively, using a WTP threshold of $60,000 per QALY. But if the threshold increased to $70,000, the probability of HD being cost-effective was more than that of CAPD, i.e. 35.2% versus 32.9% (Figure 2).

**High-risk group analysis**

The analysis of high-risk group showed that the QALYs were 2.50 with CAPD, 2.54 with APD and 3.69 with HD (Table 4). The total costs were $144,972 for CAPD, 169,282 for APD and 271,446 for HD. The ICER of APD versus CAPD was $607,750 per QALY and the ICER of HD versus CAPD was 106,281. Both exceeded the WTP threshold. CAPD and HD had extended dominance over APD. Therefore, CAPD was also cost-effective in the high-risk group. Similar to the base-case analysis, this model was most sensitive to the utility of HD. Probabilistic sensitivity analysis indicated that CAPD was more cost-effective than HD over the entire parameter values. The probabilities of CAPD, APD and HD being the optimal treatment strategy were 44.9%, 30.5% and 24.6%, respectively, using a WTP threshold of $60,000 per QALY. If the threshold increased to $100,000, the probability of HD of being optimal was more than that of CAPD, i.e. 37.4% versus 37.0% (Figure 3).

**Discussion**

To the best of our knowledge, this is the first cost-utility analysis of dialysis therapies for patients with ESRD in Singapore. The findings of this study may be used to inform policy and clinical decision making and also provide an important reference for future cost-effectiveness studies of ESRD treatments in Singapore as well as other countries with similar healthcare settings.

In both base-case (60-year-old non-diabetic patients) and high-risk group (60-year-old diabetic patients) analyses, CAPD as an initial treatment was more cost-effective than HD and APD, using a WTP threshold of $60, 000 per QALY. The robustness of the results was further confirmed by the sensitivity analysis over a wide range of values for the model inputs. The cost-effectiveness of HD versus CAPD was most sensitive to utility of HD. These results have particular implications for current ESRD care to identify and guide appropriate patients to CAPD treatment, especially in Singapore, where less than 14% of the incident ESRD patients aged 30-59 years old initiated their dialysis on PD in 2009 ([19](#_ENREF_19)).

Although there is no agreed willingness-to-pay threshold for adopting health technologies in Singapore, the threshold of one GDP per capita is commonly used, as recommended by World Health Organization (WHO) ([24](#_ENREF_24)). In this study, the acceptability curves showed how the cost-effectiveness of the three dialysis modalities would change if different thresholds were used. Only when decision-makers are willing to pay $70,000 per QALY for base-case and $100,000 per QALY for high-risk group, ‘HD first’ would be the optimal choice for ESRD patients.

The findings of this study were consistent with most previous cost-effectiveness analyses, which showed HD was more costly, more effective, but less cost-effective than CAPD ([7](#_ENREF_7), [9-12](#_ENREF_9), [15-17](#_ENREF_15)). However, these studies reported cost-effectiveness ratios (CERs) of different dialysis modalities or ICERs compared with palliative care, instead of ICER of HD versus CAPD, so we could not directly compare the ICER values. Nevertheless, one UK study ([8](#_ENREF_8)) using data from literature concluded that it may be cost-effective to manage patients starting dialysis with HD than with CAPD. This contradicting finding could possibly be explained by the fact that only direct medical costs of each treatment were included in that study, but indirect costs resulted from loss of productivity would be much higher in HD than in PD ([13](#_ENREF_13)). The authors also attributed the cost-effectiveness of HD to the fact that patients undergoing CAPD would incur more costs by switching to HD than a HD patient would by switching to CAPD. In our study, we assumed no transfer between modalities, so costs associated with modality switch were not included in analyses. What’s more, our results were conflicting with the results of the studies in Malaysia and Chile ([13](#_ENREF_13), [14](#_ENREF_14)), both of which reported no difference in cost-effectiveness between HD and PD. This may be due to the lower costs of human resources in these countries ([25](#_ENREF_25)). HD is more labor intensive than PD and thus its costs are determined more by staff salaries than is the case for PD ([25](#_ENREF_25)). So the clear cost advantage seen for PD would be more apparent in the developed countries than in developing countries.

This study was based on various sources of data and assumptions. Therefore, these results are subject to considerable uncertainty of parameter estimation. Although great efforts were made to identify the best data available, there are some limitations in this study.

A detailed bottom-up costing exercise was used to derive information from local healthcare providers. However, as there was no individual-level data available, we could not quantify the uncertainty surrounding the costs of each treatment and explore its impact on ICER. In this study, a 50% to 200% plausible range was assumed to all cost items, which may not fully reflect the uncertainty in costs. Also, due to the unavailability of data, the costs of hospitalization were estimated only in terms of the bed charges of inpatient care; costs of procedures and other tests were not considered. However, because the study focused on the incremental cost-effectiveness of therapies, the results should not have been significantly biased.

Because of unavailability of randomized controlled trial data, our model used survival parameters estimated from a patient cohort. The survival parameters may not be accurate due to possible selection bias. Specifically, the survival outcomes of PD may be underestimated because patients on PD in that cohort were older and had more comorbid conditions than patients on HD ([18](#_ENREF_18)). Consequently, the cost-effectiveness of CAPD and APD versus HD might be underestimated. What’s more, the results of APD versus CAPD were based on the assumptions of equal survival and same LOS between CAPD and APD; nevertheless, there may be differences in mortality and hospitalization between these two PD modalities. The utility values for dialysis patients were obtained from a cross-sectional study of prevalent dialysis patients, which failed to quantify the change of health utility during long-term dialysis. Using health utilities derived from prevalent patients may underestimate the health utility of incident patients at the initial period of dialysis since previous studies have shown that there was a reverse correlation between duration dialysis and quality of life ([26](#_ENREF_26)). Given the results of the extensive sensitivity analyses in this study, however, we do not think that this affects the cost-effectiveness status of the CAPD.

Regarding the model building, first, we assumed no transfer between dialysis modalities. The main reason was the lack of data about rates of dialysis switch. Second, transition from TX back to dialysis due to transplantation failure was not considered in the model. This was because that no data was available for estimating this transition probability in Singapore or the possibly increased probability of those patients to get re-transplantation ([27](#_ENREF_27)). Because the transplantation rate in Singapore is low, it is unlikely that our conclusions would be different if transplantation failure had been modeled in this study.

In conclusion, this study found that CAPD treatment appeared to be the cost-effective and optimal strategy compared with HD and APD in patients with ESRD in Singapore. Probabilistic sensitivity analysis demonstrated the robustness of the results. Despite the limitations in this model-based study, this finding is potentially useful to all stakeholders of the local dialysis care.

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*Conflict of interest statement.* None declared.

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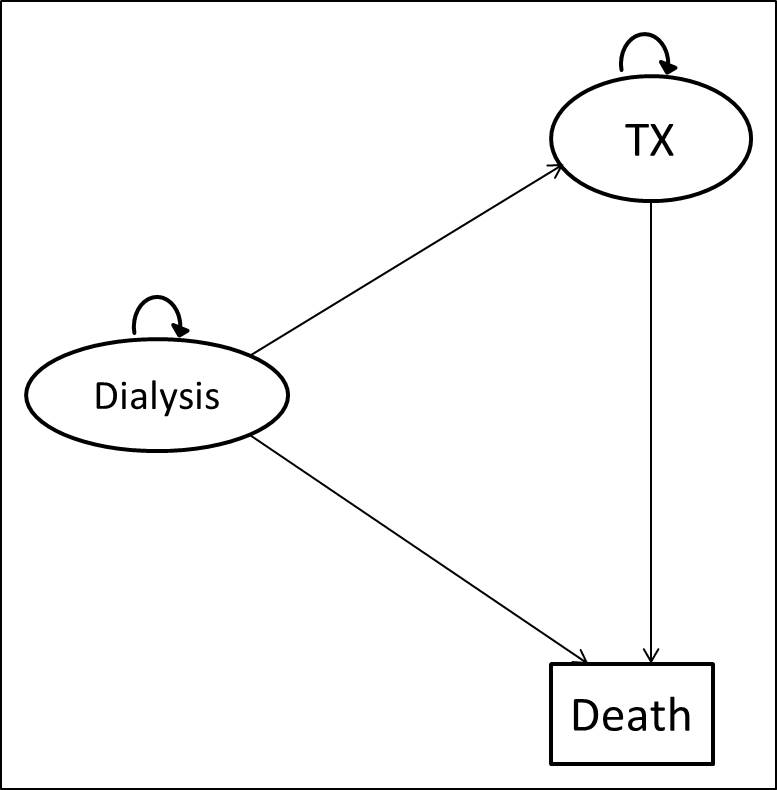
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**Fig. 1** Structure of the Markov model.

TX: kidney transplantation

**Fig. 2** Cost-effectiveness acceptability curves in the base-case analysis (60-year-old non-diabetic patients). The dotted line represents the cost-effectiveness threshold of SG$60,000 per QALY.

QALYs: quality-adjusted life years; SG$: Singaporean dollar; HD: haemodialysis; CAPD: continuous ambulatory peritoneal dialysis; APD: automated peritoneal dialysis.

**Fig. 3** Cost-effectiveness acceptability curves in the high-risk group (60-year-old diabetic patients). The dotted line represents the cost-effectiveness threshold of $60,000 per QALY.

QALYs: quality-adjusted life years; $: Singaporean dollar; HD: haemodialysis; CAPD: continuous ambulatory peritoneal dialysis; APD: automated peritoneal dialysis.

**Table 1.** Parameter values, ranges and distributions used in sensitivity analyses for the base-case (60-year-old non-diabetic patients)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | | Value | Range | Distribution (parameters) | Reference |
| **Transition probabilities** | |  |  |  |  |
|  | HD-death |  |  | Lognormal (u, sigma) | [18] |
|  | Year 1 | 0.031 | 0.006-0.083 | 0.031, 1.406 |  |
|  | Year 2 | 0.033 | 0.005-0.113 | 0.033, 1.511 |  |
|  | Year 3 | 0.028 | 0.008-0.050 | 0.028, 1.263 |  |
|  | Year 4 | 0.020 | 0.003-0.060 | 0.020, 1.498 |  |
|  | Year 5 | 0.040 | 0.0004-0.125 | 0.040, 2.052 |  |
|  | PD-death |  |  |  | [18] |
|  | Year 1 | 0.076 | 0.024-0.159 | 0.076, 1.275 |  |
|  | Year 2 | 0.093 | 0.007-0.249 | 0.093, 1.571 |  |
|  | Year 3 | 0.147 | 0.005-0.293 | 0.147, 1.696 |  |
|  | Year 4 | 0.082 | 0.009-0.176 | 0.082, 1.457 |  |
|  | Year 5 | 0.111 | 0.011-0.279 | 0.110, 1.513 |  |
|  | HD/PD-TX | 0.018 | NA |  | SRR 2009 [19] |
|  | TX-Death | 0.021 | NA |  | SRR 2009 [19] |
| **Health utilities** | |  |  | Beta (alpha, beta) |  |
|  | Utility for HD | 0.635 | 0.549-0.734 | 44.34, 25.49 | [20] |
|  |  |  | 0.45-0.66 |  | [21] |
|  | Utility for CAPD | 0.587 | 0.538-0.651 | 97.35, 68.61 | [20] |
|  |  |  | 0.46-0.71 |  | [21] |
|  | Utility for APD | 0.629 | 0.544-0.739 | 44.54, 26.24 | [20] |
|  |  |  | 0.55-0.77 |  | [21] |
|  | Utility for TX | 0.68 | 0.60-0.76 | 58.51, 27.53 | [21] |
| **Direct medical costs** | |  | 50%-200% | Gamma (alpha, beta) |  |
|  | Set-up costs for HD | 4000 |  | 1, 4000 | Hospital databases |
|  | Set-up costs for PD | 3201 |  | 1, 3201 | Hospital databases |
|  | Costs for TX | 55423 |  | 1, 55423 | Ministry of health, Singapore |
|  | Annual depreciated infrastructure cost for HD | 1320 |  | 1, 1320 | Dialysis services provider |
|  | Annual dialysis cost for HD | 28860 |  | 1, 28860 | Dialysis services provider |
|  | Annual dialysis cost for CAPD | 20214 |  | 1, 20214 | Hospital databases |
|  | Annual dialysis cost for APD | 26555 |  | 1, 26555 | Hospital databases |
|  | Annual drug cost for HD | 2812 |  | 1, 2812 | Hospital databases |
|  | Annual drug cost for PD | 1815 |  | 1, 1815 | Hospital databases |
|  | Annual outpatient and laboratory tests for HD | 3161 |  | 1, 3161 | Hospital databases |
|  | Annual outpatient and laboratory tests for PD | 3391 |  | 1, 3391 | Hospital databases |
|  | Annual outpatient and laboratory tests for TX, including drugs | 13926 |  | 1, 13926 | Ministry of health, Singapore |
|  | Yearly costs of hospitalization for HD |  |  |  | Hospital databases |
|  | Year 1 | 5417 |  | 1, 5417 |  |
|  | Year 2 | 2604 |  | 1, 2604 |  |
|  | Year 3 | 2318 |  | 1, 2318 |  |
|  | Year 4 | 2360 |  | 1, 2360 |  |
|  | Year 5 | 2553 |  | 1, 2553 |  |
|  | Yearly costs of hospitalization for PD |  |  |  | Hospital databases |
|  | Year 1 | 4239 |  | 1, 4239 |  |
|  | Year 2 | 2312 |  | 1, 2312 |  |
|  | Year 3 | 2652 |  | 1, 2652 |  |
|  | Year 4 | 2515 |  | 1, 2515 |  |
|  | Year 5 | 2884 |  | 1, 2884 |  |
|  | Cost of death for HD | 4199 |  | 1, 4199 | Hospital databases |
|  | Cost of death for PD | 3359 |  | 1, 3359 | Hospital databases |
|  | Cost of death for TX | 2100 |  | 1, 2100 | Assumed |
| **Direct non-medical costs, e.g. transportation** | |  | 50%-200% |  | Estimate |
|  | Annual cost with HD | 765 |  | 1, 765 |  |
|  | Annual cost with PD | 74 |  | 1, 74 |  |
| **Indirect costs, e.g. loss of productivity** | |  | 50%-200% |  |  |
|  | Annual cost due to dialysis for HD | 7267 |  | 1, 7267 | Estimate |
|  | Annual cost due to dialysis for PD | 3839 |  | 1, 3839 | Estimate |
|  | Annual cost due to hospitalization for HD |  |  |  | Hospital databases and estimate |
|  | Year 1 | 3538 |  | 1, 3538 |  |
|  | Year 2 | 1700 |  | 1, 1700 |  |
|  | Annual cost due to hospitalization for PD |  |  |  |  |
|  | Year 1 | 2769 |  | 1, 2769 |  |
|  | Year 2 | 1510 |  | 1, 1510 |  |

HD: haemodialysis; PD: peritoneal dialysis; TX: kidney transplantation; CAPD: continuous ambulatory peritoneal dialysis; APD: automated peritoneal dialysis; SRR: Singapore Renal Registry; NA: Not applicable.

**Table 2.** Parameter values, ranges and distributions used in sensitivity analyses for the high-risk group (60-year-old diabetic patients)

(60-year-old diabetic patients)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | | Value | Range | Distribution (parameters) | Reference |
| **Transition probabilities** | |  |  |  |  |
|  | HD-death |  |  | Lognormal (u, sigma) | [18] |
|  | Year 1 | 0.067 | 0.008-0.225 | 0.067, 1.524 |  |
|  | Year 2 | 0.083 | 0.006-0.243 | 0.083, 1.646 |  |
|  | Year 3 | 0.079 | 0.004-0.242 | 0.079, 1.697 |  |
|  | Year 4 | 0.040 | 0.003-0.139 | 0.040, 1.626 |  |
|  | Year 5 | 0.086 | 0.001-0.193 | 0.086, 1.933 |  |
|  | PD-death |  |  |  | [18] |
|  | Year 1 | 0.088 | 0.012-0.210 | 0.088, 1.439 |  |
|  | Year 2 | 0.136 | 0.016-0.394 | 0.136, 1.509 |  |
|  | Year 3 | 0.204 | 0.015-0.491 | 0.204, 1.559 |  |
|  | Year 4 | 0.187 | 0.015-0.544 | 0.187, 1.580 |  |
|  | Year 5 | 0.252 | 0.008-0.776 | 0.252, 1.794 |  |
|  | HD/PD-TX | 0.018 | NA |  | SRR 2009 [19] |
|  | TX-Death | 0.021 | NA |  | SRR 2009 [19] |
| **Health utilities** | |  |  | Beta (alpha, beta) |  |
|  | Utility for HD | 0.599 | 0.509-0.698 | 41.68, 27.90 | [20] |
|  |  |  | 0.35-0.56 |  | [21] |
|  | Utility for CAPD | 0.577 | 0.473-0.659 | 53.04, 38.85 | [20] |
|  |  |  | 0.36-0.61 |  | [21] |
|  | Utility for APD | 0.588 | 0.493-0.686 | 47.83, 33.48 | [20] |
|  |  |  | 0.45-0.67 |  | [21] |
|  | Utility for TX | 0.63 | 0.55-0.71 | 58.11, 34.13 | [21] |
| **Direct medical costs** | |  | 50%-200% | Gamma (alpha, beta) |  |
|  | Set-up costs for HD | 4000 |  | 1, 4000 | Hospital databases |
|  | Set-up costs for PD | 3201 |  | 1, 3201 | Hospital databases |
|  | Costs for TX | 55423 |  | 1, 55423 | Ministry of health, Singapore |
|  | Annual depreciated infrastructure cost for HD | 1320 |  | 1, 1320 | Dialysis services provider |
|  | Annual dialysis cost for HD | 28860 |  | 1, 28860 | Dialysis services provider |
|  | Annual dialysis cost for CAPD | 20214 |  | 1, 20214 | Hospital databases |
|  | Annual dialysis cost for APD | 26555 |  | 1, 26555 | Hospital databases |
|  | Annual drug cost for HD | 2812 |  | 1, 2812 | Hospital databases |
|  | Annual drug cost for PD | 1815 |  | 1, 1815 | Hospital databases |
|  | Annual outpatient and laboratory tests for HD | 3161 |  | 1, 3161 | Hospital databases |
|  | Annual outpatient and laboratory tests for PD | 3391 |  | 1, 3391 | Hospital databases |
|  | Annual outpatient and laboratory tests for TX, including drugs | 13926 |  | 1, 13926 | Ministry of health, Singapore |
|  | Yearly costs of hospitalization for HD |  |  |  | Hospital databases |
|  | Year 1 | 7105 |  | 1, 7105 |  |
|  | Year 2 | 4365 |  | 1, 4365 |  |
|  | Year 3 | 4031 |  | 1, 4031 |  |
|  | Year 4 | 4065 |  | 1, 4065 |  |
|  | Year 5 | 4189 |  | 1, 4189 |  |
|  | Yearly costs of hospitalization for PD |  |  |  | Hospital databases |
|  | Year 1 | 6150 |  | 1, 6150 |  |
|  | Year 2 | 4162 |  | 1, 4162 |  |
|  | Year 3 | 4378 |  | 1, 4378 |  |
|  | Year 4 | 4185 |  | 1, 4185 |  |
|  | Year 5 | 4909 |  | 1, 4909 |  |
|  | Cost of death for HD | 4199 |  | 1, 4199 | Hospital databases |
|  | Cost of death for PD | 3359 |  | 1, 3359 | Hospital databases |
|  | Cost of death for TX | 2100 |  | 1, 2100 | Assumed |
| **Direct non-medical costs, e.g. transportation** | |  | 50%-200% |  | Estimate |
|  | Annual cost with HD | 765 |  | 1, 765 |  |
|  | Annual cost with PD | 74 |  | 1, 74 |  |
| **Indirect costs, e.g. loss of productivity** | |  | 50%-200% |  |  |
|  | Annual cost due to dialysis for HD | 7267 |  | 1, 7267 | Estimate |
|  | Annual cost due to dialysis for PD | 3839 |  | 1, 3839 | Estimate |
|  | Annual cost due to hospitalization for HD |  |  |  | Hospital databases and estimate |
|  | Year 1 | 4640 |  | 1, 4640 |  |
|  | Year 2 | 2851 |  | 1, 2851 |  |
|  | Annual cost due to hospitalization for PD |  |  |  |  |
|  | Year 1 | 4016 |  | 1, 4016 |  |
|  | Year 2 | 2718 |  | 1, 2718 |  |

HD: haemodialysis; PD: peritoneal dialysis; TX: kidney transplantation; CAPD: continuous ambulatory peritoneal dialysis; APD: automated peritoneal dialysis; SRR: Singapore Renal Registry; NA: Not applicable.

**Table 3.** Projected costs, QALYs and ICERs in base-case analysis (60-year-old non-diabetic patients)

|  |  |  |  |
| --- | --- | --- | --- |
| Modality | Cost (SG$) | Effectiveness (QALY)\* | Incremental cost per QALY gained ($/QALY) (CAPD as comparator) |
| CAPD | 169,872 | 3.27 | NA |
| APD | 201,509 | 3.48 | 150,652 (dominated by extended dominance) |
| HD | 306,827 | 4.69 | 96,447 |

QALYs: quality-adjusted life years; ICER: incremental cost-effectiveness ratio; SG$: Singaporean dollar; HD: haemodialysis; CAPD: continuous ambulatory peritoneal dialysis; APD: automated peritoneal dialysis; NA: Not applicable.

\*The numbers are rounded to two decimal places.

**Table 4.** Projected costs, QALYs and ICERs in high-risk group (60-year-old diabetic patients)

|  |  |  |  |
| --- | --- | --- | --- |
| Modality | Cost (SG$) | Effectiveness (QALY)\* | Incremental cost per QALY gained ($/QALY) (CAPD as comparator) |
| CAPD | 144,972 | 2.50 | NA |
| APD | 169,282 | 2.54 | 607,750 (dominated by extended dominance) |
| HD | 271,446 | 3.69 | 106,281 |

QALYs: quality-adjusted life years; ICER: incremental cost-effectiveness ratio; SG$: Singaporean dollar; HD: haemodialysis; CAPD: continuous ambulatory peritoneal dialysis; APD: automated peritoneal dialysis; NA: Not applicable.

\*The numbers are rounded to two decimal places.