ORIGINAL ARTICLE

THE COST OF DIALYSIS IN MALAYSIA: HAEMODIALYSIS AND CONTINUOUS AMBULATORY PERITONEAL DIALYSIS

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ABSTRACT

In Malaysia, dialysis-treated end stage renal disease (ESRD) patients have been increasing rapidly. Haemodialysis (HD) and continuous ambulatory peritoneal dialysis (CAPD) use a disproportionately large amount of limited healthcare resources. This study aims to estimate the costs of HD and CAPD from the Ministry of Health (MOH) perspective. One year prospective multicentre study was conducted from October 2016 to September 2017 to assess direct medical costs of 90 HD patients and 73 CAPD patients from five large MOH dialysis centres. A mixed method of activity-based costing and step-down was used. The capital costs included land, building, medical equipment and furnishing. The recurrent costs included staff emoluments, facility utilities, patients' medical costs and dialysis consumables. One-way sensitivity analysis was performed to investigate variability in the data. One hundred and forty-one patients (82%) completed the study comprising of 77 patients on HD and 64 patients on CAPD. Majority of the patients were between 46-65 years old (n=75, 53.2%). The most common aetiology of ESRD was diabetes mellitus (44.2% in HD and 48.4% in CAPD). Cost per patient per year was RM39,790 for HD and RM37,576 for CAPD. The main cost drivers were staff emoluments (37.6%) and dialysis consumables (70.5%) for HD and CAPD respectively. HD is highly sensitive towards all the variables analysed except for dialysis consumables. In CAPD, there are minimal sensitivities except for the 5% discount rate. Knowledge of the costs of modalities are useful in the context of planning for dialysis services and to optimise the number of kidney failure patients treated by dialysis within the MOH.

***Keywords**: Haemodialysis, continuous ambulatory peritoneal dialysis, end stage renal disease, cost, Malaysia.*

INTRODUCTION

End stage renal disease (ESRD) refers to the condition of irreversible loss of kidney function which fails to support life where glomerular filtration rate (GFR) had fallen to <15 ml/min/1.73 m^2 [1]. Patients with ESRD require renal replacement therapy (RRT) in the form of dialysis or a kidney transplant. Kidney transplantation offers a nearly normal life and is considered the optimum treatment for eligible patients[2]. Despite kidney transplants from live and deceased donors, organ shortage remains a worldwide problem producing increasing waiting lists for transplantation and necessity for dialysis treatments[3]. Alternative dialysis modalities are haemodialysis (HD) and peritoneal dialysis (PD).

Worldwide, there was approximately 3,200,000 patients on RRT at the end of 2013. Majority of them were on HD (70.3%) and 8.5% on PD. The RRT population is increasing at a significantly greater rate than the world population with an annual growth rate of ~6%[4]. There are many complications associated with ESRD including anaemia, mineral and bone disorders, increased cardiovascular risk, dyslipidaemia and malnutrition[5]. Dialysis patients have significantly higher mortality, and fewer expected remaining life years as compared to the general population[6] and have significantly poor health related quality of life (HRQOL)[7,8]. As a result, ESRD has received increased attention as a prominent public health problem[9].

In Malaysia, ESRD population on dialysis almost tripled from 2004 to 2015. This scenario was observed due to a mixed private and public model for financing dialysis therapy with some contributions from non-governmental organisations (NGOs)[10]. According to the 23rd report of the

Malaysian Dialysis and Transplant Registry (MDTR), 6479 new HD patients and 1118 new PD patients were reported in 2015 representing an acceptance rate of 213 per million population (pmp) and 37 pmp respectively. Overall, the total number of HD and PD dialysis patients increased to 33,456 patients (1097 pmp) and 3727 patients (122 pmp) respectively in 2015[11].

The government remained the main source of funding for dialysis (63%). These funds were channeled not only as subsidies to NGO HD centres but also as payment of dialysis treatment for public pensioners, civil servants and their dependents in private centres. Out of pocket payment or self-funding was 17.3% and charity 14.7% [11]. Managing ESRD patients through RRT imposes a substantial economic burden which may be not sustainable even in advanced Western countries[12].

Although kidney transplantation is more desirable than dialysis in terms of patients' survival and quality of life, Malaysia has one of the lowest organ donation rates in the world[13]. It was 1 pmp in 2015[14]. Hence, it is inevitable that almost all ESRD patients in Malaysia require dialysis therapy, either HD or PD to sustain life[15]. Previous studies that compared the mortality of patients in PD and HD have shown varying results since patients' survival are confounded by many demographic and clinical factors[11, 16-21]. Some researchers adopted propensity cross matching approach to compare the relative effectiveness of both modalities. In such attempt by Chang et al., they concluded that the estimated life expectancy between HD and PD were nearly equal (19.11 versus 19.08 years) in the national cohort study with 14 years follow-up[21].

The difference in outcome between modalities or in patient preferences do not justify the variation in dialysis provision[15]. It has been shown that economic factors including financial and reimbursement strategies are important non-medical factors that influence dialysis modality selection in various countries[23-25]. This is particularly significant because PD is underutilized in Malaysia[15] and around the globe. It is imperative to determine the true costs of dialysis due to the multi-payer and multi-provider system in Malaysia. The previous economic evaluation in Malaysia was conducted in 2001[26]. Since most HD is conducted at hospital or clinic while PD is performed at home, costs of both treatments could have changed considerably.

This study aims to compare the direct costs of providing HD and continuous ambulatory peritoneal dialysis (CAPD) services from Malaysian Ministry of Health (MOH) perspective and to identify the differences in costs drivers between the dialysis modalities.

METHODS

Study design

A prospective multicentre study was conducted to estimate the direct medical costs of HD and CAPD from MOH perspective. Five centres were selected to participate in this study comprising of one federal and four large state hospitals (north, south, east, and west). The sampling frame was the MOH hospitals which had >80% data contribution to the Malaysian Dialysis and Transplant Registry (MDTR). A principal site investigator, sub-investigators and research assistants were appointed at each centre. Only chronic dialysis units in the respective dialysis centres were subjected for the data collection. For HD, however, if the centres used similar area/facility to conduct acute HD, the total number of procedures were recorded to facilitate costs apportionment in the later analysis. The data collection period was one year, from 1st October 2016 to 30th September 2017.

Inclusion and exclusion criteria

Patients were enrolled if they were above 18 years old, initiated dialysis between 2011 and 2015, and dialysis treatment is subsidized by MOH. Patients were excluded if they died, underwent a kidney transplant, switched dialysis modality, patient with other advanced disease i.e. late stage cancer or transferred to a new centre during the study period.

Ethics, consent and permissions

Ethics approvals were obtained from Pusat Perubatan Universiti Kebangsaan Malaysia (JEP-2016-360) and Malaysian Medical Research Ethics Committee (NMRR-16-1341-30856). All research participants were provided with the Patient Information Sheet (PIS) and gave their permission to be part of the study by signing the informed consent form.

Sample size

The sample size was calculated via the comparison of two means formula. The PS programme developed by Dupont and Plummer (1990) was used to calculate the sample size[27]. The computer programme was designed to calculate the sample size for studies with dichotomous, continuous, or survival response measures. The following input was used; α (Type I error) =0.05, power=0.080, δ (a difference in population (cost) means) = RM4000 and m=1:1 (ratio of HD to CAPD patients). The minimum sample size required to conduct the study is 128 patients. The sample size was adjusted for the dropout rate of 20% because the costs of dialysis were collocated prospectively. Hence, 168 patients were sufficient to address the formulated research

questions of this study. However, a total of 173 patients were recruited to facilitate an even number of patients at each centre for each dialysis modality; 36 patients per centre, 18 patients from HD and CAPD respectively (one of the centre had only 11 CAPD patients based on the criteria mentioned above).

Sampling

A stratified random sampling was employed to select the patients. At first, a latest master list of patients from the chosen dialysis centres was acquired from the MDTR based on the predetermined criteria. Secondly, the list was detached based to the patient's dialysis modality of each dialysis centre and sorted in an ascending order using the patients registered identification number. Next, a simple random sampling was applied to select the patients.

Patient recruitment

The selected patients' lists were disseminated to the respective principal site investigators at each site for the verification and recruitment. The patients' status was verified at the time of recruitment including their dialysis modality, current sponsor, current centre and any disabilities that prohibit them from participating in this study. If any patient who were randomly selected failed the initial assessments, the patient is excluded from the study and a new patient was selected randomly. Patients who were verified and eligible for the study were asked to read the information sheet before signing a consent form. In the circumstance that the selected patient refused to participate in the study, he/she was excluded and a new patient was selected randomly.

Cost analysis

The cost analysis was conducted based on guidelines of cost analysis in primary healthcare by Creese and Parker[28] and methods for the economic evaluation of health care programmes by Drummond and colleagues[29]. Referring to Table 1 costs data were collected through the specially designed centre costing form and patient resource utilization form. The capital costs included land, building, medical equipment and furnishing. The recurrent costs included staff emoluments, facility utilities, patients' medical costs and dialysis consumables. The patients 'medical costs were extracted via reviews of the patients' medical records comprising clinic visits, laboratory tests, imaging, medications including erythropoietin (EPO), access surgeries and referrals to non-nephrology specialist services. Hospitalization costs were calculated by the ascertainment of resources consumed during each hospitalization including procedures, drugs and blood products, laboratory tests and imaging via a review of the discharge sheet. The dialysis consumables costs data were obtained from the respective dialysis unit. The quantity of resources used in each category were calculated.

Source of costs

Item costs were based on the purchase price, market price or published fee schedules. Table 2 shows the relevant sources for cost references. The references used depends on the data availability and close proximity to resemble costs incurred by MOH. The value of Ringgit Malaysia (RM) dropped significantly in the past few years (average US$1=RM4.30 in 2017).

Costing method

As described in Table 1, a mixed step down and activity-based costing (ABC) were used in this study. The step-down costing starts with total expenditure, divided by the value of the total output (patient-year for CAPD, number of sessions for HD) to give an average cost per patient per year. The ABC costing is a method of allocating costs to services (dialysis) by assigning cost to all the items used.

Capital costs

Building cost for each patient was calculated using the annualized value of the building. This was done using the replacement costs of the building, i.e. the cost of constructing a similar building today, and the annualization factor that incorporates the useful life of the building (depreciation) and the opportunity costs (interest rate) of the funds utilized to construct the building. In this study, the cost of constructing the building was estimated based on price per square metre (sq) to construct main hospital building (RM1524.60)[30]. The cost was annualized over the lifetime span of 30 years with 3% interest rate (annualization factor: 19.600) in base case analysis. The land cost is not depreciated. The cost for medical equipment was annualized over the useful life years of ten years with 3% interest rate (annualization factor: 8.530) and the cost for office equipment was annualized over five years with 3% interest rate (annualization factor: 4.580) in base case analysis. The original price was inflated to current price (2017) via the Consumer Price Index (2.9%) per year.

Table 1: Cost items, costing method, valuation method of cost items and choice of allocation factors

Nature of Cost	Resources/cost items	Costing method	Valuation method	Allocation factor
Capital (Last >1 year)	Building	Step down	Life spam of building was estimated at 30 years with an annual discount rate of 3%: an annualization factor of 19.600 was used. This value then was applied in proportion of floor space being utilized for dialysis activities.	Floor Space
	Asset (instruments/equipment/furniture (e.g. dialysis machine, PD cycler furniture)	ABC	Cost of instruments were determined using their life span with an annual discount rate of 3%. Annualization factor was determined at the time of evaluation.	Patient on dialysis
Recurrent (Last <1 year)	Emolument (salary)	ABC	The total annual gross income of dialysis staff.	Full time equivalent (FTE)
	Dialysis solutions and consumables-drug and non-drug	ABC	Cost of purchase of dialysis related consumables including dialysers, CAPD solutions	Patient on dialysis
	Outpatient medications	ABC	Cost of purchase of medications including erythropoietin.	Patient on dialysis
	Hospitalisation	ABC	Cost of hospitalization including procedures done, laboratory and imaging investigations and medications.	Patient on dialysis
	Laboratory tests and imaging	ABC	Costs of various blood tests performed, urine culture and others. Costs of imaging such as X-Rays. ECG, Ultrasound and others.	Patient on dialysis
	Other consumables-office stationeries	ABC	Cost of non-clinical consumables.	Patient on dialysis
	Overheads	Step down	Costs of electricity, telephone and water usage and payment made to Radicare Sdn Bhd or Medivest Sdn Bhd for cleaning, waste management and laundry.	Floor Space

**Activity-based costing*

Table 2: Sources of cost

Resources	Reference (s) for cost
Building	Price per square meter from Works Department
Staff emolument	Public Service Department (PSD)
Medicine	Pharmacy department, Hospital Kuala Lumpur
Access surgeries	MMA Schedule of fees
Blood product	National Blood Bank
Procedures and surgeries	MMA Schedule of fees
Laboratory investigations and imaging	Universiti Kebangsaan Malaysia Medical Centre
Clinic visits and referrals	MMA Schedule of fees
General ward and ICU stay	Hospital Putrajaya private wing
Dialysis machines, PD cyclers, dialysis solutions, dialysis consumables-drug and non-drug, other equipment and furniture	Purchase price by the respective hospitals

**MMA-Malaysia Medical Association*

Recurrent costs

a) Medications, blood products, investigations, clinic visits and referrals

In this study, the reference costs for medicine consumption were based on the price list provided by the nephrology pharmacy department, Hospital Kuala Lumpur. The unit prices of each medicine were computed by dividing the purchase price with the package size. It was then multiplied with the total units consumed. There would be changes to the medicine prescribed dose during the study period and the changes in the doses were calculated accordingly. Blood products used (e.g. packed red blood cells and fresh frozen plasma) were calculated and multiplied with its unit price. The total number of laboratory and radiology investigations were multiplied with the respective reference costs. Patients' scheduled and unscheduled clinic visits and referrals to non-nephrology services were recorded and its associated costs were calculated based on specialist and General Practitioner (GP) follow-up fees.

b) Dialysis access

Since a dialysis access was created before dialysis initiation, all attempts at dialysis access placement were recorded and included in the final analysis. The costs of access surgeries per year was calculated by dividing the total costs by the duration the patient was in the programme for.

c) Hospitalizations

The total resource consumption at hospitalizations including medications, blood products, referrals, laboratory investigations, imaging and procedures were calculated as units utilized. The costs references were described in the previous section.

d) Staff emoluments

Emolument included the basic salary and allowances for each dialysis staff in each dialysis unit. It was calculated as the full time equivalent (FTE). The FTE is an estimate of the time allocated by the dialysis staff to deliver different functions at the centre. Only workload related to chronic HD and CAPD units were taken into the consideration in the calculations. The annual gross salaries of each staff were appraised based on their employment grades and duration of service. The published Malaysian Public Service Department (PSD) schedule was used for the calculations.

e) Facility utilities/Overheads

Overheads comprising of electricity, water, cleaning, waste management and laundry were acquired from the finance department of each centre. The total expenditure was allotted to each dialysis unit by multiplying with its floor space divided by the total built-up area of the hospital.

f) Dialysis consumables

I. *CAPD*

Cost of dialysis consumables is the total cost of all purchase of drugs and non-drugs used for dialysis related activities. A typical prescription for CAPD requires four exchanges a day done at home. The patients received therapy using Standard CAPD-Y-System with 2L solutions using either Fresenius or Baxter system during their treatment. Each patient is supplied with the dialysis consumables to perform the fluid exchanges. The consumables used in the units were also taken into consideration for the cost calculations.

II. *HD*

For HD, the disposables used in each chronic dialysis session was counted. Most of the patients re-use dialysers except for Hepatitis B & C co-infected patients where single use of dialyser is mandatory. The unit's consumables including dialysers, blood lines, arteriovenous fistula needles, reprocessing solutions, HD machine disinfectant and other

consumables.

g) Office consumables

The items prices of office consumables were acquired from published prices where appropriate and costs were calculated. These costs were added together with the dialysis consumables and referred as the 'costs of dialysis consumables'.

Cost efficiency
The cost efficiency of each centre was measured by the cost per HD procedure and CAPD cost per month agonist the number of outputs. Costs that were considered in this section were building and land, dialysis consumables, staff, equipment and overheads.

Data analysis
Results were shown as means and standard deviation (SD) for continuous variables and frequencies and percentages for categorical variables. Chi Square test or Fisher's exact test was used to report the differences between HD and CAPD patients. For continuous data, independent t test was used. A *p* value <0.05 was considered significant. Costs were expressed as number (percent) or mean (± standard error of the mean or standard deviation).

RESULTS

Centre and patients' characteristics
Table 3 describes the patients' characteristics. One hundred and forty-one patients completed the study – the mean age of the patients was 53.7 ± 14.20 years. Patients were predominantly male (55.3%), from Malay ethnicity (46.1%), with household income below RM3000 per month (80.9%), attained secondary education (59.6%) and unemployed (73.0%). The mean dialysis duration was 3.9 ± 1.43 years. The main aetiology of ESRD was diabetes mellitus (46.1%). A significantly lower utilization of EPO was observed in CAPD with EPO dosage above 6000 UI per week administered to only 15 patients (23.4%) compared to 49 patients in HD (63.9%), *p* <0.001. EPO was not administered to 16 patients.

Table 4 defines the characteristics of the dialysis centres. HD unit has a bigger built-up area (579.83 ± 495.55 square meter) than CAPD unit (115.86 ± 53.27 square meter). Three PD centres have seven or more PD cyclers and three HD units have more than 30 HD machines. There was a difference in the number of staffs working in dialysis units. There was an average of 15 medical assistants in HD units but none in PD units. HD units also had more attendants than PD units. However, PD units employed more nurses. An average of 14,700 chronic HD was being done per year compared to the PD unit with average CAPD output of 230 patient years.

Costs
Table 5 presents the annual costs per patient for HD and CAPD. The costs per patient per year was RM39,790.58 ± 4696.28 in HD and RM37,576.03± 4369.59 in CAPD. The biggest cost contributor in HD was staffing (RM14,818.36± 2063.42) and the least contributor was building and land (RM783.95 ± 782.99) in HD. The biggest cost contributor in CAPD is dialysis consumables (RM26,486.05± 568.85) and the least contributor was building and land (0.2%, RM68.57 ± 32.46) in CAPD. The maximum annual costs in the sample was RM55996.57 and RM55,817.90 in HD and CAPD respectively. The minimum annual costs in the sample was RM30663.33 in HD and RM31,867.17 in CAPD (Figure 1).

The optimal output appears to be a volume of approximately 15000 HD procedures per year at a cost of RM182 per procedure. The cost per procedure ranged from RM182 to RM241 with a mean cost RM206. For CAPD, an output of 426 patients per year appeared to be efficient with RM2437 per month. The cost ranged from RM2437 to RM2761 with mean cost of RM2599 per month.

Sensitivity analysis

Table 6 shows the sensitivity analysis of costs in HD and CAPD. HD is highly sensitive towards all the variables analyzed except for dialysis consumables. A five percent discount rate resulted in a 15% increase of the total costs. Staffing is another important determinant for variability in HD costs where there is 6.5% increase in total costs using the maximum input value and a massive decrease by 15% using the minimum input value. In this scenario, HD become slightly cost effective than CAPD. The HD to CAPD cost ratio become narrower when the costs were calculated without taking into account the access surgeries costs since majority of them were created before the study period. In CAPD, there are minimal sensitivities towards all the variables analyzed except for the 5% discount rate which resulted 12.1% increase in the total costs. There was no sensitivity towards minimum and maximum input of dialysis consumables in CAPD and maximum input of dialysis consumables in CAPD.

Table 3: Patient characteristics

Characteristics	All patients (n=141)	HD (n=77)	CAPD (n=64)	*P* value
Age (years), mean (SD)	53.7 (14.20)	53.9 (14.90)	53.5 (13.43)	0.830[a]
Age group, n (%)				0.100[b]
Young, 18-45	36(25.5)	19(24.7)	17(26.6)	
Middle aged, 46-65	75(53.2)	41(53.2)	34(53.1)	
Elderly, >65	30(21.3)	17(22.1)	13(20.3)	
Gender, n (%)				0.066[b]
Male	78 (55.3)	48 (62.3)	30 (46.9)	
Female	63 (44.7)	29 (37.7)	34 (53.1)	
Ethnicity, n (%)				0.335[b]
Malay	65 (46.1)	32 (41.6)	33 (51.6)	
Chinese	51 (36.2)	32 (41.6)	19 (29.7)	
Indian/others	25 (17.7)	13 (16.9)	12 (18.8)	
Household income per month (RM), n (%)				0.453[b]
<3000	114 (80.9)	64 (83.1)	50 (78.1)	
≥3000	27 (19.1)	13 (16.9)	14 (21.9)	
Education level, n (%)				0.100[b]
Primary	39 (27.7)	19 (24.7)	20 (31.3)	
Secondary	84 (59.6)	44 (57.1)	40 (62.5)	
Tertiary	18 (12.8)	14 (18.2)	4 (6.3)	
Occupation, n (%)				0.634[b]
Employed	38 (27.0)	22 (28.6)	16 (25.0)	
Unemployed/Retired/Housewife	103 (73.0)	55 (71.4)	48 (75.0)	
Primary Renal disease, n (%)				0.966[b]
Diabetes mellitus	65 (46.1)	34 (44.2)	31 (48.4)	
Hypertension	32 (22.7)	17 (22.1)	15 (23.4)	
SLE / Glomerulonephritis	24 (17.0)	14 (18.2)	10 (15.6)	
Polycystic kidney	7 (5.0)	4 (5.2)	3 (4.7)	
Unknown cause /Others	13 (9.2)	8 (10.4)	5 (7.8)	
Dialysis duration (years), mean (SD)	3.9 (1.43)	4.1 (1.46)	3.7 (1.37)	0.114[a]
Body Mass Index (kg/m^2), *n* (%)				0.134[b]
Underweight (< 18.5)	16 (11.3)	13 (16.9)	3 (4.7)	
Normal weight (18.5-24.9)	73 (51.8)	37 (48.1)	36 (56.3)	
Overweight (25.0-29.9)	31 (22.0)	15 (19.5)	16 (25.0)	
Obese (≥30)	21 (14.9)	12 (15.6)	9 (14.1)	
Wheelchair-bound				1.000[c]
Yes	5 (2.8)	3 (3.9)	2 (3.1)	
No	136 (97.2)	74 (96.1)	62 (96.9)	
Average weekly erythropoietin utilization				**<0.001**[b]
No utilization	16 (11.3)	8 (10.4)	8 (12.5)	
≥6000 UI per week	64 (45.4)	49 (63.6)	15 (23.4)	
<6000 UI per week	61 (43.3)	20 (26.0)	41 (64.1)	

HD: Haemodialysis; CAPD: Continuous ambulatory peritoneal dialysis; CVD: cardiovascular disease; SD: standard deviation; SLE: Systemic lupus erythematosus

[a] *Independent t-test;* [b] *Chi-Square test;* [c] Fisher's exact test

Table 4: Characteristics of participating centres

Characteristics		HD	CAPD
Unit built-up area, square meter, mean (SD)		579.83 (495.55)	115.86 (53.27)
PD cycler in unit, n (%)			
	<7	-	2 (40)
	≥7	-	3 (60)
HD machines in unit, n (%)			
	<30	2 (40)	-
	≥30	3 (60)	-
No. of staff in unit, mean (SD)		35 (8)	17 (5)
	Nephrologist	3 (1)	3 (1)
	Trainee Nephrologist	1 (1)	1 (1)
	Medical officer	1 (1)	1 (1)
	Nurses	8 (2)	10 (4)
	Medical assistants	15 (6)	0
	Attendant	5 (2)	1 (1)
Service provision			
	Chronic HD, mean (SD)	14700 (4455)	-
	CAPD output, patient year, mean (SD)	-	230 (128)

Table 5: Annual costs (RM) for patients undergoing HD and CAPD in MOH dialysis centres

Cost components	HD		CAPD	
Outpatient clinic care	**Mean, SD (RM)**	**%**	**Mean, SD (RM)**	**%**
Medications (including EPO)	3647.09(2226.17)	9.1	2868.99(2228.88)	7.6
Laboratory	972.47(74.01)	2.4	1018.33(100.06)	2.7
Radiology	249.16(38.81)	0.6	209.12(10.98)	0.6
Clinic visits and referrals	447.69(118.10)	1.1	386.17(98.66)	1.0
Access surgeries	1209.24(894.67)	3.0	477.26(218.70)	1.3
Building and land	783.95(782.99)	2.0	68.57(32.46)	0.2
Equipment	3299.05(785.98)	8.3	417.73(245.10)	1.1
Staff	14818.36(2063.42)	37.6	3815.55(609.81)	10.2
Overheads	1775.30(856.72)	4.4	223.72(160.77)	0.6
Dialysis consumables	11700.99(679.13)	29.3	26486.05(568.85)	70.5
Hospitalisation	887.28(2619.22)	2.2	1604.55(3377.27)	4.3
Total	39,790.58(4696.28)	100	37576.03(4369.59)	100

Cost efficiency

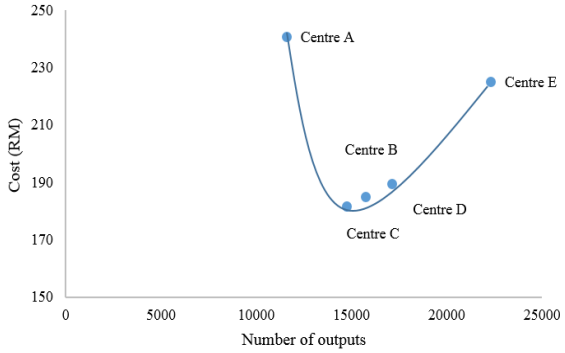

Figure 1 (a): Cost-efficiency of HD

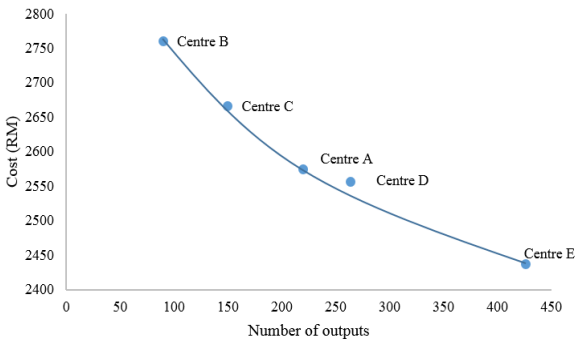

Figure 1 (b): Cost-efficiency of CAPD

Table 6: Sensitivity analysis

Costs and outcomes	HD (RM)	% changes	CAPD (RM)	% changes	HD:CAPD[a]
Access surgeries					
Included	39,790.58	-	37,576.03	-	-
Excluded	38581.34	-3.0	37098.77	-1.3	1.04
Overheads					
Maximum	41,415.56	+3.5	37,892.73	0.8	1.09
Minimum	38,799.82	-3.0	37,442.43	-0.4	1.04
Staffing					
Maximum	42,472.02	+6.2	38,522.07	+2.5	1.10
Minimum	33,259.44	-15.4	36,771.95	-2.1	**0.90**
Discount rate					
Undiscounted	39,329.24	-1.7	37,498.91	-0.2	1.05
5%	46,004.50	+15.0	42,135.03	+12.1	1.09
Dialysis consumables					
Maximum	40,894.51	+2.2	38,260.99	+1.8	1.07
Minimum	38,978.81	-2.6	36,881.65	-1.8	1.06

a= HD to CAPD costs ratio

DISCUSSION

The cost analysis framework was a combination of step-down and micro-costing. These methods of cost calculation are favored than the 'gross costing; or full step-down method. Drummond et al. indicated that 'gross-costing' needs relatively few resources but provides a limited level of detail compared to 'micro-costing', which provides a high level of detail but is resource and data intense[31]. Micro-costing studies can be reported as standalone studies or used as inputs directly into cost-effectiveness analyses[31]. In this study, the micro-costing method was used to evaluate resource consumptions by each patient (drugs, laboratory, radiology, access surgeries, clinic visits, hospitalization) and unit (dialysis consumables, office consumables). The step-down method was used to allocate the fixed costs (building, land, equipment) and overheads to the respective dialysis units and further apportioned to the number of outputs. These methods enabled the costs to be varied based on the floor space of dialysis units, number of outputs and patient characteristics. The perspective taken was from a MOH viewpoint.

In the previous micro-costing study of centre HD versus PD in Malaysia by Hooi et al., it was indicated that centres had to deliver at least 15,000 HD procedures or to deliver 1,245 patient months per annum of CAPD for optimum cost efficiency[26]. This was consistent with the current study where a production of 15,000 HD and 426 CAPD patients per year were cost-efficient. For HD, however, the centre became less efficient when the production exceeded the optimal value.

Haemodialysis is viewed as labor-intensive, while PD is more consumables-intensive[22,32,33]. The major quantum of costs for HD is from the remunerations of medical personnel devoted to assisting the patients, including doctors, nurses and technicians, since HD is predominantly performed in-hospital or in-centre. In contrary, CAPD costs are mainly composed of dialysis consumables which include the dialysate, disposable masks, minicaps and dressing sets[32,33]. PD relies on special dialysis bags, which must be manufactured under stringent standards and regulations. If not manufactured locally, such bags need to be imported from abroad. The economics of scale is achievable in the provision of PD by ensuring the national market for PD must be ample enough so that a local manufacturer can be established to serve the market at relatively low cost (e.g. Mexico, India) or if the government relieves restrictions on their import duties, effectually taking advantage of the economies of scale of another country (e.g. Thailand)[32]. The total costs of CAPD consumables per patient annually increased from the previous study. This increment could be attributed by the change of CAPD system from the ultraset which is a single bag system with reusable drain bag and no minicap[34] to twin-bag disconnect system. The twin-bag system uses disposable drain bags, minicaps and other related consumables four times a day. In 2005, only 30% of CAPD patients used twin-bag system in Malaysia[34].

Continuous ambulatory peritoneal dialysis acceptance rate grew from 11 pmp to in 2004 to 37 pmp in 2015[11]. One of the major reasons is almost all CAPD patients (n=3778) are being treated in public settings (38 public hospitals) around Malaysia. Only seven private centres provide PD services to 95 PD patients[11]. CAPD patients dialyzing in government hospitals and sponsored by the MOH are only required to pay a minimal amount of fee (RM100 per month). However, almost all of PD patients funded by other government agencies were also treated at government settings. The

acceptance rate of HD rose from 414 pmp in 2004 to 1097 pmp in 2015 (almost three-fold increase). Six thousand six hundred and ninety-six (20%) patients were being treated in public settings from a total of 33,456 patients in 2015[11]. Patients dialyzing in government settings and sponsored by the MOH are only required to pay a minimal amount of fee (RM13 per session,). Patients are also being sponsored by other government agencies including SOCSO, PSD and the Baitumal state-run Islamic social welfare organizations. These organizations in general pay the full cost of dialysis and EPO injections to private HD units. Presently, a mix of 60% HD patients and 40% of CAPD patients are dialyzing in the government settings[11]. In contrast, the national dialysis provision is 90% HD and 10% CAPD. This situation is observed as a result of private sector domination in HD provision and lack of reimbursement to do CAPD in private setting.

The annual drugs cost in the current study was lower compared to the previous economic evaluation by Hooi et al.[26]. This may be attributed to large reductions in the price of EPO. The currently used biosimilar EPO costs less than the innovator drug in 2001. At present, 2000 IU EPO costs about RM15 per vial as compared to approximately RM75 per vial in 2001. As a consequence, the administration of EPO nationally jumped from 62% and 45% in 2001 to 91% and 81% in 2015 in HD and PD patients respectively[11]. The increased use of cheaper generic medicines may have reduced the overall medicine costs. The generic medicines policy (GMP) which is part of the National Medicines Policy was established in Malaysia in 2006 to encourage the utilization of generic medicines among different healthcare stakeholders.

The sensitivity analysis confirmed the dissimilar cost proportions between these dialysis modalities. It is particularly important to note that annual cost of HD become lower than CAPD with the minimum input of staffing' cost. However, the difference of annual costs between HD and CAPD was small and not comparable to the most developed and some developing countries[23,32,33,36,37]. The ratio of HD to PD costs ranged from 0.70 in Nigeria to 1.90 in Canada[36]. HD is generally more expensive than PD in developed countries but data was not adequate to make any generalizations about the costs in developing countries. In developed countries, due to expensive labor and infrastructure costs, HD is frequently reported to be more expensive than CAPD[23]. Singapore which is a developed country has a 1.38 HD to PD ratio and the PD fluid is manufactured locally[32]. In developing countries where there are inexpensive labor costs and high imported equipment and solution costs, PD is more expensive than HD[23].

There are several limitations associated with this study. Inflation could slightly alter the prices and values of the different variables since data was collected from more than a natural year. The centres participating in the study were major MOH hospitals which perhaps have the maximum economies of scale for both HD and PD and they should be working at the lowest cost that can be achieved. The smaller HD and PD units were not included in this study. Hence, the total cost in HD and CAPD could be underestimated if the results are generalized to other MOH dialysis centres (e.g. district hospitals). The costs of access surgeries could have been overestimated since they probably could be apportioned to a longer duration on dialysis particularly in HD.

CONCLUSION

Finally, the results indicate that dialysis centres in Malaysia have to improve their efficiency for cost containment and optimize the number of dialysis patients treated at government settings. CAPD could be relatively a cheaper modality for the government's consideration to increase its provision throughout the country but subjected to its cost-effectiveness. This type of study is essential due to concern about the increase in healthcare expenditure and improves decision-making processes for healthcare policies.

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COMPETING INTEREST

The authors declare that they have no competing interests.

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