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Economic costs of automated and continuous ambulatory peritoneal dialysis in Taiwan: a combined survey and retrospective cohort analysis

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ABSTRACT

Objectives: Taiwan succeeded in raising the proportion of peritoneal dialysis (PD) usage after the National Health Insurance (NHI) payment scheme introduced financial incentives in 2005. This study aims to compare the economic costs between automated PD (APD) and continuous ambulatory PD (CAPD) modalities from a societal perspective.

Design and setting: A retrospective cohort of patients receiving PD from the NHI Research Database was identified during 2004–2011. The 1:1 propensity score matched 1749 APD patients and 1749 CAPD patients who were analysed on their NHI-financed medical costs and utilisation. A multicentre study by face-to-face interviews on 117 APD and 129 CAPD patients from five hospitals located in four regions of Taiwan was further carried out to collect data on their out-of-pocket payments, productivity losses and quality of life with EuroQol-5D-5L.

Outcome measures: The NHI-financed medical costs, out-of-pocket payments and productivity losses of APD and CAPD patients.

Results: The total NHI-financed medical costs per patient-year after 5 years of follow-up were significantly higher with APD than CAPD (US$23 005 vs US $19 237; p<0.01). In terms of dialysis-related costs, APD had higher costs resulting from the use of APD machines (US$795) and APD sets (US$2913). Significantly lower productivity losses were found with APD (US$2619) than CAPD (US$6443), but the out-of-pocket payments were not significantly different. The differences in NHI-financed medical costs and productivity losses between APD and CAPD remained robust in the bootstrap analysis. The total economic costs of APD (US$30 401) were similar to those of CAPD (US$29 939), even after bootstrap analysis (APD, US$28 399; CAPD, US$27 960). No discernable differences were found in the results of mortality and quality of life between the APD and CAPD patients.

Conclusions: APD had higher annual dialysis-related costs and lower annual productivity losses than CAPD, which made the economic costs of APD very close to those of CAPD in Taiwan.

Strengths and limitations of this study

- This is the first study to evaluate the overall economic costs of automated peritoneal dialysis (APD) and continuous ambulatory peritoneal dialysis (CAPD) modalities.
- This study comprises a retrospective cohort of patients receiving APD and CAPD from the National Health Insurance Research Database and a multicentre study by face-to-face interviews of APD and CAPD patients.
- The information about out-of-pocket payments and productivity losses collected from patient interviews, which were rarely assessed in previous studies, adds important economic data to the overall evaluation of the costs associated with patients undergoing APD and CAPD.
- The unidentified laboratory data from the database and other potential confounding factors such as patient preference, self-care ability and physician selection are drawbacks of this study.
- Productivity losses related to presentism (impaired productivity or reduced effectiveness at work associated with APD or CAPD) are not included in this study.

INTRODUCTION

Given that both the incidence and prevalence rates of end-stage renal disease (ESRD) in Taiwan are among the highest in the world, this particular disease has become an increasing burden on the Taiwan National Health Insurance (NHI) system's finances; indeed, by 2011, the cost of dialysis accounted for an astonishing 7.2% of the total annual NHI expenditure.[1 2] In an attempt to contain the total costs of dialysis, in addition to applying a blanket budget cap on dialysis expenditure, a series of strategies were implemented by the NHI administrators to change the incentives relating to the choices of dialysis modalities.

Since peritoneal dialysis (PD) has an all-cause mortality rate similar to that of haemodialysis (HD), but with lower medical costs,[3–6] from 2005 onwards administrators within the Taiwan NHI have been actively promoting the use of PD, including automated PD (APD) and continuous ambulatory PD (CAPD), as a viable alternative treatment for dialysis. This is being achieved by a reduction in reimbursements for HD and a corresponding increase in those for PD, as well as the NHI payment scheme covering the APD machine costs. As a result, the use of PD in Taiwan has been gradually increasing, from 6.5% in 2003 to 8.5% in 2007 and 10.3% in 2009.[7] In terms of the global trend, Taiwan has now succeeded in raising the proportion of PD usage to the average level within developed countries.[8]

With the increasing usage of PD, the costs of the APD and CAPD modalities have become an important issue. Although there appears to have been very limited analysis of the costs involved in APD and CAPD, two specifically focused studies have revealed that APD has higher medical costs than CAPD, with the greatest differences being the costs of the dialysis machines and disposables.[9–11] The prior studies have not, however, examined the differences between APD and CAPD in terms of the non-dialysis-related medical utilisation, which may be attributable to complications and clinical outcomes brought about by APD or CAPD; neither did they report differences in the out-of-pocket payment, including expenses on caregivers, as well as productivity losses from patients and family. Therefore, we set out in this study, from a societal perspective, to compare economic costs between APD and CAPD patients in Taiwan using population-based NHI claims data and face-to-face interviews.

METHODS

Data sources, study design, setting and population

The joint institutional Review Board of Taipei Medical University approved this study (No. 201 503 057). The first part of this study was a nationwide retrospective cohort study covering the years 2004 to 2011 based on the claims data obtained from the National Health Insurance Research Database (NHIRD). Taiwan's mandatory-enrolment, single-payer NHI programme was launched on 1 March 1995, with the programme now covering more than 23 million enrollees, representing over 99% of the entire population. The NHIRD contains registration files and original claims data for the reimbursement of medical services by enrollees, potentially making it one of the largest and most comprehensive administrative healthcare databases worldwide. The NHIRD has been utilised for previous epidemiologic research, and the results have been validated for HD and PD patients.[12 13] Comprehensive details on the files used from the NHIRD in this study have already been provided in our previous work.[14] ESRD patients requiring long-term dialysis in Taiwan are identified as patients with a catastrophic illness, as confirmed by two nephrologists, who may then be exempted from co-payments within the NHI system. The cohort of incident patients receiving long-term PD in the present study (new ESRD patients) were identified from the registry for catastrophic illness (International Classification of Diseases, 9th Revision, Clinical Modification, (ICD-9-CM), 585) within the NHIRD. These PD patients were in receipt of long-term PD therapy for at least three consecutive months between 1 January 2006 and 31 December 2010. Clinical characteristics were collected on the sample patients, with these patients subsequently being followed-up by referring to the NHIRD database covering the period from 1 January 2004 to 31 December 2011. We further categorised the patients into two types, APD or CAPD, according to whether they were receiving PD via a cycler for at least 90 days after the initiation of PD. A total of 1801 patients receiving APD therapy, and 4205 patients receiving CAPD therapy, were included in this study. A schematic illustration of the inclusion and exclusion criteria of the study sample is provided in figure 1. The second part of this study was a multicentre study by cross-sectional interviews on patients over 18 years old, carried out at the nephrology outpatient clinics of five hospitals located in northern, central, southern and eastern Taiwan from April 2015 to March 2016. The patient interviews were performed face to face by well-trained nurses from the site or graduate students from Taipei Medical University. All the interviewers had attended interviewer training before they performed the interview. In total, there were 117 APD patients and 129 CAPD patients available for analysis.

Outcome measurement

The NHI-financed medical costs and utilisation during the 5-year period after the index date are the main outcomes of interest in the national cohort study. The 'index date' is defined in this study as the first day on which the corresponding patient started receiving their APD or CAPD therapy for a period of at least 90 days. The patients were then followed-up for a period of up to 5 years until 31 December 2011, when the data were censored, or until the occurrence of: (1) the change from APD to CAPD modality for at least 60 days, or vice versa (to evaluate the pure therapeutic period of APD or CAPD); (2) the change from PD to HD for at least 90 days; (3) the receipt of a kidney transplant; or (4) the death of the patient. The medical costs that had been incurred by each patient were traced back, starting from the index date to the last day of the follow-up period, after which we then calculated the total medical costs classified by the 'outpatient', 'emergency' and 'inpatient' departments. The total medical costs were divided on the basis of whether they were 'dialysis-related' or 'non-dialysis related'. The 'dialysis-related' costs were defined as: (1) costs of the APD machine and set; (2) costs of erythropoietin and PD solution; (3) administration, physician and nursing fee; and (4) intubation and extubation cost of the PD catheter. The total

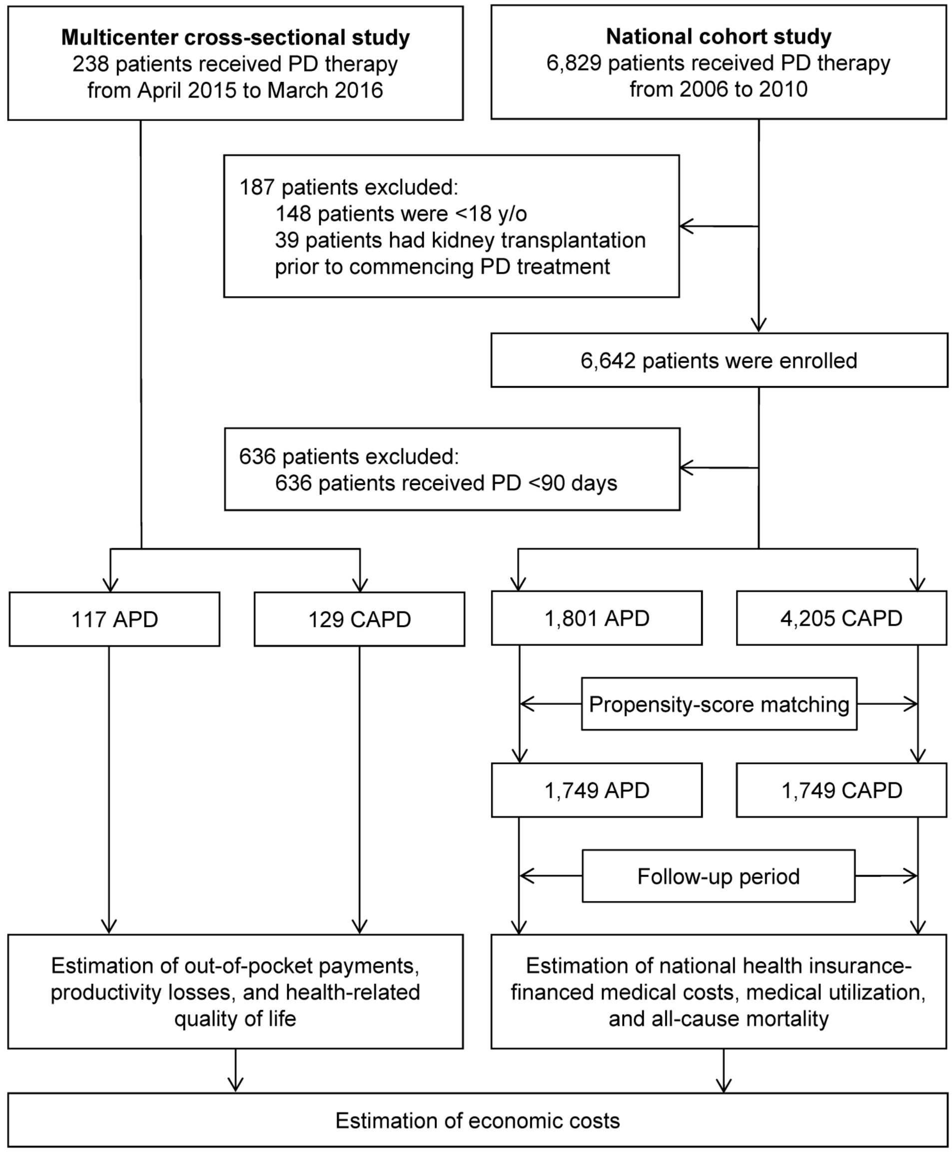

Figure 1 Study sample selection process. Automated peritoneal dialysis (APD) or continuous ambulatory peritoneal dialysis (CAPD) patients were further categorised according to whether they were receiving peritoneal dialysis (PD) via a cycler for at least 90 days after the initiation of PD. Clinical characteristics of the national cohort study were collected and followed-up covering the period from 2004 to 2011.

medical utilisation was subsequently calculated from the index date to the last day of the follow-up period, with all utilisation being classified by specific departments. The total medical costs and number of medical visits per patient-year were defined as the total medical costs and number of medical visits within the follow-up period divided by the number of days in the same period. There were no differences in terms of administration, physician and nursing fees between the APD and CAPD patients. There were also no regional differences in the amount reimbursed for medical services in Taiwan.

The secondary outcomes examined the differences in out-of-pocket payments, productivity losses and health-related quality of life (QoL) between APD and CAPD patients. There were two sources of time loss evaluated: patients' and caregivers' time spent in seeking care, and time spent in operating dialysis apparatus at home. Productivity losses were valued using the 'human capital-cost approach',[15] and were measured by multiplying the loss of time in hours or days with average hourly/daily wage rate reported by the Directorate-General of Budget, Accounting, and Statistics, Taiwan (see online supplementary table S1). Out-of-pocket payments included all expenses related to ESRD paid by the patient/family and not reimbursed by the NHI, such as expenses for medicines, medical materials and devices, herbal and complementary medicines, and nutritional supplements. QoL was elicited using the visual analogue scale, and the EuroQol-5D-5L (EQ-5D-5L) with five levels of severity. The EQ-5D-5L index score was calculated based on a scoring algorithm representing the preferences of Japanese residents because there is no population-based preference weight available in Taiwan.[16]

Statistical analysis

A logistic regression analysis was carried out on the APD versus CAPD patients using the variables listed in online supplementary table S2. We then used the propensity score analysis to match the APD patients with the CAPD patients.[17] Further analyses began with a comparison of those patients who were in receipt of either the APD or CAPD therapy at the baseline. Second, an independent paired t-test was then carried out to analyse the normally-distributed continuous variables, as well as a Wilcoxon rank sum test to analyse the non-normally distributed continuous variables by their median level. In addition, χ^2 tests were carried out on the categorical variables. Third, the log-rank test and the Kaplan-Meier method were used to examine the mortality and chart the survival curves. Then a Cox proportional hazard regression was performed to examine the differences in patient survival. Fourth, in analysing the patient interview survey data, the Mann-Whitney U test and Wilcoxon rank sum test were performed to assess the differences between the APD and CAPD patients. Finally, a bootstrap analysis was further performed on NHI-financed medical costs, as well as on out-of-pocket payments and productivity losses, by forming 1000 bootstrap samples of APD and CAPD patients of equal size (1749 vs 1749 the in national cohort study, and 117 vs 129 in the patient interview survey) with replacement. The difference between the groups was considered to be significant if the two-sided p value was <0.05. All of the analyses in this study were undertaken using the SAS 9.3 software (SAS Institute, Cary, North Carolina, USA).

Additionally, the PD patients, who have a catastrophic illness, may receive lower wage rates than the general population, resulting in lower productivity losses. In order to assess the impact of productivity losses on the total economic costs, we adjusted the productivity losses for the mean Taiwan unemployment rate during the interview period[18] and then set the productivity losses with a 20%, 30% or 40% decrement of wages as different scenarios to calculate the total economic costs.

RESULTS

Demographic characteristics

Figure 1 shows the study sample selection process. A total of 1749 APD patients and 1749 CAPD patients were enrolled in the national cohort study, and a total of 117 APD patients and 129 CAPD patients were interviewed in the multicentre cross-sectional study. Demographic characteristics are shown in online supplementary tables S2 and S3. There were 265 patients who were put on HD (15.2%) among the APD patients during the 45 192 patient-months of follow-up. The result was greater than the 206 patients (11.8%) among the CAPD patients during the 47 272 patient-months of follow-up (APD: 70.4 per 1000 patient-years, CAPD: 52.3 per 1000 patient-years; p<0.01). There were 324 deaths (18.5%) among the APD patients during the 45 192 patient-months of follow-up. This was greater than the 311 deaths (17.8%) among the CAPD patients during the 47 272 patient-months of follow-up (APD: 86.0 per 1000 patient-years, CAPD: 78.9 per 1000 patient-years; p=0.22). The survival rates at 60 months for the APD and CAPD patients were 61.5% and 62.3%, respectively (see online supplementary figure S1). The result of Cox proportional hazard regression showed the APD and CAPD patients had a similar risk of death after adjusting for age, Charlson comorbidity index score, diabetes and cardiovascular diseases (p=0.13).

The NHI-financed medical costs and utilisation

The NHI-financed medical costs per patient-year for both the APD and CAPD patients are reported in table 1. The median total medical costs were found to be US$3769 higher among the APD patients than the CAPD patients (US$23 005 vs US$19 237, p<0.01). Following further classification of the medical costs based on the various departments, the APD patients were found to have significantly higher median costs than the CAPD patients in both the outpatient care (US $20 158 vs US$16 883, p<0.01) and the inpatient care (US$1197 vs US$992, p=0.01). If classified based on dialysis-related or non-dialysis-related costs, the APD patients had higher median costs than the CAPD patients (US$19 235 vs US$16 050, p<0.01), with the largest difference between the two groups being in the outpatient care (US$18 579 vs US$15 594, p<0.01). Non-dialysis-related medical costs were also found to be higher among the APD patients than the CAPD patients (US$2975 vs US$2639, p<0.01), with the largest difference between the two groups being in the inpatient care (US$1007 vs US$863, p=0.03). In the bootstrap analysis, the mean total medical costs were found to be US$3589 higher among the APD patients than the CAPD patients (US$23 488 vs US$19 899, p<0.001).

Expenditure on the PD solution was found to be the highest cost item among all of the categories in both patient groups. Although the PD solution costs of the APD patients were significantly lower than those of the CAPD patients (US$9762 vs US$10 107, p<0.01), the APD patients were found to require significantly higher quantities of the PD solution than the CAPD patients (3700 L vs 2706 L, p<0.01).

The greatest differences in the dialysis-related costs were found to be the costs of the APD machines (US$795 vs US$0, p<0.01), and those of the APD sets (US$2913 vs US$0, p<0.01). No discernible differences were found in the costs and the defined daily dosage (DDD) of erythropoietin between the APD and CAPD patients.

The annual NHI-financed medical utilisation rates for both the APD and CAPD patients are reported in table 2, whereas no differences were found in the all items between the two patient groups.

Multicentre cross-sectional study for out-of-pocket payments and productivity losses

Results of the out-of-pocket payment, productivity losses and QoL are reported in table 3. There were no discernable differences between the APD and CAPD patients in the out-of-pocket payments (US$1075 vs US$855, p=0.62), although the APD patients had significantly

Table 1 NHI-financed medical costs per patient-year for PD patients

Variables	APD (n=1749)			CAPD (n=1749)			Median difference	p Value
	Mean	Median	SD	Mean	Median	SD		
Total medical costs (US$)*	25 498	23 005	10 646	21 879	19 237	16 635	3769	<0.01
Classified by departments								
Outpatient department	20 010	20 158	3607	16 918	16 883	7419	3275	<0.01
Emergency department	263	100	524	237	85	470	15	0.14
Inpatient department	5225	1197	10 766	4724	992	12 423	206	0.01
Classified by non-dialysis or dialysis								
Non-dialysis-related	6296	2975	9703	5964	2639	16 013	336	<0.01
Outpatient department	1574	1258	1505	1595	1207	6900	51	<0.01
Emergency department	256	99	510	232	84	463	14	0.15
Inpatient department	4466	1007	9338	4137	863	11 210	144	0.03
Dialysis-related (by department)	19 202	19 235	3340	15 914	16 050	2917	3185	<0.01
Outpatient department	18 436	18 579	3344	15 323	15 594	2885	2985	<0.01
Emergency department	7	0	43	4	0	26	0	0.04
Inpatient department	759	91	1720	587	41	1610	51	<0.01
Dialysis-related (by items)	19 202	19 235	3340	15 914	16 050	2917	3185	<0.01
APD set	2391	2913	1089	48	0	213	2913	<0.01
APD machine	813	795	208	16	0	61	795	<0.01
Cost of erythropoietin	1622	1763	654	1618	1736	620	27	0.80
PD-related costs†	3390	3466	416	3407	3470	409	–4	0.02
PD solution	9609	9762	2464	9887	10 107	2178	–346	<0.01
Others	1377	811	1873	938	503	1627	308	<0.01
Dialysis-related (by quantities)								
Quantity of PD solution (L)	3653	3700	740	2651	2706	629	994	<0.01
PRBC transfusion (unit)	3.7	0	13.5	3.3	0	8.7	0	0.15
Oral iron supply (mg)	2956	0	10 357	2155	0	8787	0	0.40
Erythropoietin (DDD)‡	145.2	5.1	86.2	145.1	5.2	85.5	0	0.96
Extubation of PD catheter	0.06	0	0.29	0.05	0	0.24	0	0.35
After bootstrap analysis								
Total medical costs (US$)*	23 488		783	19 899		173		<0.001
Non-dialysis-related	4723		629	4340		168		<0.001
Dialysis-related	18 859		157	15 768		76		<0.001

*US$1=30 New Taiwan Dollars.
†Costs include: (1) administration, physician and nursing fee; and (2) intubation and extubation cost of peritoneal dialysis catheter.
‡1 DDD=1000 IU epoetin alfa=1000 IU epoetin beta=5 μg darbepoetin alfa=4 μg methoxy polyethylene glycol-epoetin beta.
APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; DDD, defined daily dose; NHI, National Health Insurance; PD, peritoneal dialysis; PRBC, packed red blood cell.

Table 2 Annual NHI-financed medical utilisation per patient-year of peritoneal dialysis patients

Variables	APD (n=1749)			CAPD (n=1749)			Median difference	p Value
	Mean	Median	SD	Mean	Median	SD		
Total no. of visits/hospitalisations	44.58	40.63	18.86	44.51	40.50	20.09	0.13	0.53
Visits classified by department								
Outpatient visits	41.56	38.13	17.77	41.59	37.89	18.90	0.24	0.68
Dialysis-related visits	14.35	12.43	4.39	13.49	12.40	3.48	0.03	0.24
Non-dialysis-related visits	27.22	23.73	17.54	28.11	24.38	18.67	−0.65	0.25
Emergency room visits	1.66	0.90	2.47	1.60	0.87	2.33	0.04	0.51
Hospitalisations	1.36	0.79	1.69	1.31	0.76	1.75	0.03	0.23

APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; NHI, National Health Insurance.

higher co-payment for outpatient visits than the CAPD patients (US$60 vs US$48, p=0.03). Compared with the CAPD patients, the APD patients had lower annual productivity losses (US$2619 vs US$6443, p<0.001), resulting from less time spent seeking care (APD, 45.0 hours vs CAPD, 59.9 hours, p<0.001), and less time spent operating dialysis apparatus (APD, 330.4 hours vs CAPD, 821.3 hours, p<0.001). In terms of QoL, there were no significant differences between the APD and CAPD patients in each dimension of EQ-5D-5L. Details of EQ-5D-5L by

Table 3 Per patient-year out-of-pocket payments and productivity losses as well as quality of life by interview survey of peritoneal dialysis patients

	APD (n=117)				CAPD (n=129)					
Variables	Mean	Median	SD	Reporting moderate to extreme problems (%)	Mean	Median	SD	Reporting moderate to extreme problems (%)	Median difference	p Value
Out-of-pocket payments (US$)	2012	1075	2861		2170	855	3182		220	0.62
Co-payment to outpatient visits	165	60	283		126	48	274		12	0.03
Co-payment to hospitalisations	417	0	920		381	0	816		0	0.66
Medicine not covered by NHI	424	67	861		374	0	667		67	0.22
Medical equipment	188	120	265		165	67	312		53	0.19
Chinese medication	149	0	1247		4	0	25		0	0.12
Traditional medicine	36	0	311		6	0	70		0	0.02
Nutritional supplements	184	0	561		246	0	1214		0	0.52
Caregiver costs	381	0	1697		783	0	2438		0	0.35
Transportation costs	68	39	94		84	58	89		–19	0.12
Productivity losses (US$)*	3006	2619	2159		6125	6443	3234		–3824	<0.001
Seeking outpatient care										
From patients	274	214	211		341	333	254		–118	0.04
From family caregivers	125	0	235		192	0	352		0	0.19
Seeking inpatient care										
From patients	402	0	600		426	0	588		0	0.75
From family caregivers	254	0	489		334	0	539		0	0.16
Time spent operating dialysis apparatus	1952	2020	1626		4831	5059	2780		–3039	<0.001
Visual analogue scale	72.8	75.0	15.6	–	69.0	70.0	17.9	–		0.05
Utility from EuroQol-5D-5L index†	0.82	0.87	0.19		0.82	0.87	0.21			0.68
Mobility	–	–	–	7.7	–	–	–	13.2		0.16
Self-care	–	–	–	9.4	–	–	–	9.3		0.98
Usual activities	–	–	–	7.7	–	–	–	13.2		0.16
Pain/discomfort	–	–	–	12.8	–	–	–	16.3		0.44
Anxiety/depression	–	–	–	11.1	–	–	–	14.7		0.40
After bootstrap analysis										
Out-of-pocket payments (US$)	2019		261		2171		272			<0.001
Productivity losses (US$)	3007		200		6125		285			<0.001
EuroQol-5D-5L index	0.82		0.02		0.82		0.02			0.52

*US$1=30 New Taiwan Dollars.
†Using tariffs from Japanese version of EuroQol-5D-5L.
APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; NHI, National Health Insurance.

five severity levels are shown in online supplementary table S4. The results of the mean out-of-pocket payments, productivity losses and EQ-5D-5L index remained unchanged in the bootstrap analysis.

Economic costs

The total economic costs per patient-year, including the direct medical costs by NHI, out-of-pocket payments and productivity losses, are reported in table 4. NHI-financed medical costs comprised of a higher proportion of the total economic costs among the APD patients than those of the CAPD patients; in contrast, productivity losses contributed to a higher proportion of the total economic costs among the CAPD patients than among the APD patients. The total economic costs of APD (US$30 401) were similar to those of CAPD (US $29 939), even after bootstrap analysis (APD, US$28 399; CAPD, US$27 960). After considering the productivity losses under various scenarios, the differences in total economic costs between the APD and CAPD patients slightly increased in models 2–4.

DISCUSSION

The main results of this study using Taiwan's population-based claims data and interview survey data demonstrate that total economic costs of APD (US$29 977) were close to the costs of CAPD (US$30 750). The annual medical costs for the APD patients were US$3769 higher than those of the CAPD patients, with the greatest difference (US$2985) being found in the costs of outpatient care for dialysis, accounting for 80% of the difference in the total costs. The main source of the differences between the APD patients and CAPD patients in terms of dialysis-related costs were those of the APD machines and APD sets. As regards the medical utilisation rates, no significant differences were discernible between the APD and CAPD patients. The results from the interview survey demonstrated lower productivity losses in the APD patients than the CAPD patients, but no differences were detected in the out-of-pocket payments among the two patient groups. The differences in direct medical costs paid by NHI and productivity losses between APD and CAPD remained robust in the bootstrap analysis.

The NHI-financed medical utilisation between the APD and CAPD patients are quite similar; however, a significantly higher total of the NHI-financed medical costs were discernible among the APD patients than among the CAPD patients. This would seem to indicate that the costs per outpatient or emergency room visit are higher among the APD patients. Furthermore, while the APD patients were found to have similar numbers of hospitalisation to the CAPD patients (0.79 vs 0.76, p=0.23), the APD patients were found to have higher inpatient costs

Table 4 Total economic costs per patient-year of APD and CAPD patients

Variables	APD	CAPD
Direct medical costs by NHI (US$)*	25 498	21 879
Out-of-pocket payments (US$)	2012	2170
Productivity losses (US$)	3006	6125
Adjusted for unemployment rate†	2891	5890
Adjusted for unemployment rate and a 20% decrement in wages	2312	4712
Adjusted for unemployment rate and a 30% decrement in wages	2023	4123
Adjusted for unemployment rate and a 40% decrement in wages	1734	3534
Total costs, model 1‡	30 401	29 939
Total costs, model 2‡	29 822	28 761
Total costs, model 3‡	29 533	28 172
Total costs, model 4‡	29 244	27 583
After bootstrap analysis		
Direct medical costs by NHI (US$)	23 488	19 899
Out-of-pocket payments (US$)	2019	2171
Productivity losses (US$)	3007	6125
Adjusted for unemployment rate†	2892	5890
Adjusted for unemployment rate and a 20% decrement in wages	2313	4712
Adjusted for unemployment rate and a 30% decrement in wages	2024	4123
Adjusted for unemployment rate and a 40% decrement in wages	1735	3534
Total costs, model 1‡	28 399	27 960
Total costs, model 2‡	27 820	26 782
Total costs, model 3‡	27 531	26 193
Total costs, model 4‡	27 242	25 604

*US$1=30 New Taiwan Dollars.
†Adjusted for mean Taiwan unemployment rate (3.82%) between April 2015 and March 2016.
‡Models 1–4: Total costs include direct medical costs financed by NHI, out-of-pocket payments, and productivity losses adjusted for unemployment rate (model 1); adjusted for unemployment rate and a 20% decrement in wages (model 2); adjusted for unemployment rate and a 30% decrement in wages (model 3); adjusted for unemployment rate and a 40% decrement in wages (model 4).
APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; NHI, National Health Insurance.

than the CAPD patients, particularly those relating to non-dialysis inpatient treatment. This would seem to indicate that the costs per hospitalisation are again higher or the hospital stays are longer among the APD patients than the CAPD patients, possibly owing to the higher incident rate of patients changed to HD among the APD patients (APD: 70.4 per 1000 patient-years, CAPD: 52.3 per 1000 patient-years; p<0.01).

The NHI-financed dialysis-related costs of the APD patients are approximately 1.2 times higher than those of the CAPD patients, which is in line with the results of several related studies carried out in other countries.[9 19–21] The major sources of the higher dialysis-related costs for the APD patients were found to be the APD machines (4.2%), APD sets and PD solution (62.5%), and erythropoietin (8.4%), while those for the CAPD patients were PD solution (62.4%) and erythropoietin (10.2%). The differences between the dialysis-related costs for the APD patients and the CAPD patients were mainly attributable to the costs of the APD machines and APD sets (table 1). These costs were US $3708 higher among the APD patients than the CAPD patients. When compared to CAPD, APD involves the use of a cycler and extra line sets, which explains the higher dialysis costs involved in the APD treatment. The results of a related UK study also indicated that the greatest differences in costs between APD and CAPD were attributable to the APD machines and disposables.[9] In addition, APD patients had the lower costs and higher quantities of PD solutions. The most likely reasons were that the per-litre cost of the commonly used 5 L bag PD solution for APD is much cheaper than that of the commonly used 2 L bag PD solution for CAPD, and that the APD patients usually received shorter dwell time but more exchanges than the CAPD patients to reach adequate dialysis.[22]

The present study features an overall evaluation of the costs associated with patients undergoing APD and CAPD, with out-of-pocket payments and productivity losses incorporated into the analysis, which were rarely assessed in previous studies. From the payer's perspective, the NHI-financed medical costs of the CAPD seems to be a more cost-saving modality than those of the APD; however, from a societal perspective, the annual economic costs of APD were close to those of CAPD although differences exist in the proportion of key cost components. Based on the human capital-cost approach,[15] the productivity losses were estimated as the reduced future gross income, including reduced paid or unpaid production, due to PD related mortality and/or morbidity and contributed to a lower proportion of the total economic costs for APD rather than that of CAPD. On the other hand, NHI-financed medical costs made up a larger portion of the total economic costs for APD than that of CAPD. This is reflected in the fact that the costs of the productivity losses, resulting from the time spent seeking care and operating dialysis apparatus, were significantly lower in the APD than CAPD patients. With the help of the APD machine, the APD modality spent less time in operating dialysis so as to decrease the productivity losses; however, it correspondingly increases the costs of the APD machines and APD sets.

The mortality rates of the APD and CAPD patients were similar and the result did not differ from most of the previous findings of multicentre or nationwide cohort studies.[13 19 23 24] In terms of QoL, the results of the visual analogue scale and EQ-5D-5L were quite similar in the APD and CAPD patients (table 3 and online supplementary table S4), which were consistent with the findings published from the literature.[25–28]

The results of the present study also have some limitations. First, the major drawbacks are those commonly found in administrative database research. Although comorbidities and medications were matched at cohort entry, the patient's weight, peritoneal equilibration test and dialysis clearance, and their level of residual renal function are not available from the NHIRD. These unidentified data are potentially confounding factors in the prescriptions of the peritoneal dialysate dose. Other potential confounding factors that are not available from the claims database when computing the propensity scores were patient preference, self-care ability and physician selection. Second, the productivity losses estimated in this study were the value of time lost by patients and their family caregivers when seeking care/operating dialysis apparatus. Productivity losses related to presentism (impaired productivity or reduced effectiveness at work associated with ESRD) were not included in this study and thus may have led to an underestimation of the economic costs. Finally, the ED-5D-5L index score was calculated based on a scoring algorithm representing the preferences of Japanese residents which may not perfectly represent those of Taiwanese people.

Although NHI-financed annual medical costs of CAPD had a greater reduction in expenses than those of the APD, CAPD had higher annual productivity losses than APD. To extend the generalisability of our findings to other national health systems, our results highlight that the APD modality may appear to be more desirable in terms of its substantially lower productivity losses for countries with a higher value of time (hourly wage or daily wage), or with a younger dialysis patient population.

In this study, we present a national cohort study to analyse NHI-financed medical utilisation and medical costs and a cross-sectional study to survey the out-of-pocket payments and productivity losses for APD and CAPD patients. From a societal perspective, although APD had higher annual dialysis-related costs financed by NHI, the overall economic costs of APD were very close to those of CAPD because CAPD had higher annual productivity losses than APD.

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