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LIFETIME COSTS FOR PERITONEAL DIALYSIS AND HEMODIALYSIS IN PATIENTS IN TAIWAN

Tze-Wah Kao,[1,2] Yu-Yin Chang,[3] Pau-Chung Chen,[2,4] Chih-Cheng Hsu,[5] Yu-Kang Chang,[6,7] Yu-Hung Chang,[8] Lukas Jyuhn-Hsiarn Lee,[3,2,4] Kwan-Dun Wu,[1] Tun-Jun Tsai,[1] and Jung-Der Wang[2,9]

Department of Internal Medicine,[1] National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei; Institute of Occupational Medicine and Industrial Hygiene,[2] National Taiwan University, College of Public Health, Taipei; Division of Environmental Health and Occupational Medicine,[3] National Health Research Institutes, Taipei; Department of Environmental and Occupational Medicine,[4] National Taiwan University Hospital, Taipei; Division of Health Policy Research and Development,[5] and Division of Health Services and Preventive Medicine,[6] Institute of Population Health Sciences, National Health Research Institutes, Taipei; [7]Department of Public Health, China Medical University and Hospital, Taichung; Division of Health Policy Translation,[8] Institute of Population Health Sciences, National Health Research Institutes, Taipei; and Department of Public Health,[9] National Cheng Kung University College of Medicine, Tainan, Taiwan

♦ ***Background:*** **This study compared the lifetime costs for peritoneal dialysis (PD) and hemodialysis (HD) patients in Taiwan.**

♦ ***Methods:*** **Using the National Health Insurance (NHI) database of all end-stage renal disease patients on maintenance dialysis registered from July 1997 to December 2005, we matched eligible PD patients with eligible HD patients on age, sex, and diabetes status. The matched patients were followed until 31 December 2006. Patients were excluded if they were less than 18 years of age, had been diagnosed with cancer before dialysis, or had been dialyzed at centers or clinics other than hospitals. Outcomes—including life expectancy, total lifetime costs, and costs per life-year paid by the NHI—were estimated and compared.**

♦ ***Results:*** **The 3136 pairs of matched PD and HD patients had a mean age of 53.2 ± 15.4 years. The total lifetime cost for PD patients (US$139 360 ± US$8 336) was significantly lower than that for HD patients (US$185 235 ± US$9 623, $p < 0.001$). Except for patients with diabetes (who had a short life expectancy), the total lifetime cost was significantly lower for PD patients than for HD patients regardless of sex and age ($p < 0.01$).**

♦ ***Conclusion:*** **In Taiwan, the total lifetime costs paid by the NHI were lower for PD than for HD patients.**

Correspondence to: J.D. Wang, Department of Public Health, National Cheng Kung University College of Medicine, No. 1 University Road, Tainan 701 Taiwan.
jdwang121@gmail.com or jdwang@ntu.edu.tw
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The prevalence and incidence of end-stage renal disease (ESRD) have not only increased worldwide (1), but have also imposed a great financial burden on many countries (2,3). How to provide cost-effective treatment for ESRD patients has therefore become a priority for governments, insurance carriers, and health care providers.

In Taiwan, dialysis costs for all patients with ESRD have been fully reimbursed by the National Health Insurance (NHI) since 1995. The NHI is the only funding source for dialysis providers. It covers the costs of almost all medications and materials needed for dialysis; it does not pay physician or transportation expenses for the patients. Because Taiwan has the highest ESRD prevalence among all countries, with 68 940 patients undergoing dialysis in 2010 (1,4), and because the survival time of dialysis patients in Taiwan is relatively long, with a lower cardiovascular mortality rate than is seen in Western countries (5), ESRD is an enormous financial burden on the country (6).

Hemodialysis (HD) is more popular than peritoneal dialysis (PD) in Taiwan, probably for three reasons. First,

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older patients in Taiwan tend to depend on medical staff rather than on themselves (especially when facing a devastating disease), and hence, they avoid PD, a more self-dependent treatment. Second, many patients are afraid of developing peritonitis, which has been one of the major causes of death among PD patients in Taiwan (7). Third, because the NHI payments are higher for HD than for PD, HD is chosen as the first-line modality of renal replacement therapy by many nephrologists not practicing in hospitals.

In addition to practicing ESRD prevention by prohibiting the use of herbs that contain aristolochic acid (8), the Taiwanese government has been trying to promote PD because of underutilization (less than 10%) and a lower monthly cost than that for HD (9,10). However, because of ethics concerns and feasibility, the lifetime costs for PD and HD have never been fairly compared using a randomized controlled trial. Thus, in the present study, we used a matching method to compare lifetime survival and direct medical costs paid by the NHI for PD and HD in Taiwan and to provide clinically relevant evidence-based data for policymakers to make the best use of limited resources for ESRD patient care. Dialysis patients in Taiwan usually experience long survival, and so our study also quantified the lifetime medical costs of ESRD dialysis patients for the stakeholders who are concerned about the long-term sustainability of the NHI system.

METHODS

STUDY SUBJECTS

Using the database of ESRD patients registered in the NHI program from July 1997 to December 2005, we identified a study cohort. To secure the comparability of the populations to be examined, patients who were less than 18 years of age, who had been diagnosed with cancer before the initiation of dialysis, who had received maintenance dialysis for less than 3 months (90 days), or who had been dialyzed at centers or clinics other than hospitals were excluded. The study was approved by the Institutional Review Board of National Taiwan University Hospital (201107040RC).

ESTIMATION OF LIFE EXPECTANCY

Using an intention-to-treat design, all eligible patients were followed until 31 December 2006. Patients who had stopped using NHI subsidies for more than 3 months were considered deceased.

Life expectancy estimates (long-term survival) of PD and HD patients calculated using the Monte Carlo method were extrapolated to 50 years (lifetime) from a logit-transformed curve of the survival ratio between PD and HD patients and their respective age- and sex-matched reference populations (referents) using a semiparametric method based on the assumption of a constant excess hazard model (11,12). This method has been successfully applied to study the life expectancy of various kinds of patients having a relatively long survival (13–15). The iSQoL software that was used to estimate life expectancy can be freely downloaded from http://www.stat.sinica.edu.tw/jshwang.

ESTIMATION OF TOTAL LIFETIME COST AND COST PER LIFE–YEAR

"Total lifetime cost" refers to all outpatient and inpatient medical expenses paid by the NHI for a patient from the start of maintenance dialysis to death, regardless of any modality changes. In other words, "total lifetime cost" equals the sum of lifetime costs for outpatient and inpatient care. The total lifetime cost of dialysis treatment was estimated by summing, for an entire lifetime, the products of the mean survival probability for a dialysis patient in a time period t and the average cost during that period. The mean cost for a patient during a particular time period t_1 was calculated by dividing the sum of the costs incurred by each living patient within t_1 by the total number of living patients within t_1. Cost per patient per year was first adjusted to 2010 monetary values and then summed for the lifetime, after adjustment using the survival probability for each year (that is, total lifetime cost / life expectancy).

STATISTICAL ANALYSIS

Comparisons of demographic characteristics and diabetes status for all eligible PD and HD patients were performed using either the independent t-test or the chi-square test, as appropriate. Each eligible PD patient was then randomly matched with an eligible HD patient on age, sex, and diabetes status. Comparisons of demographic characteristics and diabetes status between the matched PD and HD patients were performed using the same statistical methods.

Life expectancies, total lifetime costs, and costs per life–year for PD and HD patients, assuming an annual 3% discount rate, were then compared using the z-test both before and after matching. Comparisons of the foregoing parameters, stratified by age, sex, and diabetes status, were also performed between the matched PD and HD patients. A series of one-way sensitivity analyses that assumed a 5% discount rate

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or that included the health care expenses of 1 – 3 months before dialysis start were then evaluated. All analyses were performed using the SAS software application (version 9.1: SAS Institute, Cary, NC, USA), and a two-sided p of 0.05 was set as the cut-off value for statistical significance.

RESULTS

The cohort included 3137 PD patients and 36 539 HD patients (Table 1). Most of the patients, especially those who chose PD, lived in the northern part of Taiwan. Patients on HD, about half of whom were men and had diabetes mellitus, were older and thus had a shorter life expectancy. Before matching, the total lifetime cost was similar for PD patients and for HD patients.

There were 3136 pairs of matched PD and HD patients [Table 2(A)]. Their mean age was 53.2 ± 15.4 years (range: 18 – 99 years). Life expectancies of these PD and HD patients after the start of maintenance dialysis were 7.9 ± 0.5 years and 8.7 ± 0.4 years respectively (p = 0.128). Figure 1 shows similar probabilities of survival across time for these PD and HD patients matched on age, sex, and diabetes status. After matching, the total lifetime cost for a PD patient (US$139 360 ± US$8 336) was noted to be significantly lower than that for a HD patient (US$185 235 ± US$9 623, $p < 0.001$).

When the matched patients were separated into groups by diabetes status [Table 2(B)], diabetic patients, whether receiving PD or HD, were found, compared with nondiabetic patients, to be older (mean age: 60.9 ± 12.4 years vs 49.2 ± 15.3 years) and to have a shorter life expectancy (about 4 years vs about 9 – 10 years). In the group with diabetes, PD and HD patients had similar total lifetime costs and costs per life-year (p = 0.0836); in the group without diabetes, PD patients (compared with HD patients) had a significantly lower total lifetime cost and cost per life-year (p =0.0004). Sensitivity analyses assuming annual discount rates of either 3% or 5% showed the same trend (data not shown).

Figure 2 shows the average monthly health care expense adjusted by survival probability and stratified by dialysis type (PD or HD) and diabetes status, plotted across time after starting dialysis. The area under the curve represents the sum of lifetime costs. Based on the intention-to-treat analysis, the curves representing the survival-adjusted monthly costs for diabetic PD and HD patients cross after 7 – 8 years of follow-up. If the analysis is limited to patients treated with one modality only, that phenomenon disappears.

When the matched patients were stratified by sex [Table 2(C)], life expectancy did not seem to be significantly different. However, the total lifetime cost for men on PD was significantly lower than that for men on HD (US$123 617 vs US$158 887, p = 0.0065). Similarly, the total lifetime cost for women on PD was significantly lower than that for women on HD (US$150 373 vs US$202 696, p = 0.0021).

The matched patients were also stratified by age into those less than 65 years of age and those 65 years of age or older [Table 2(D)]. The results showed that the lifetime cost for a PD patient was significantly lower

TABLE 1
Characteristics of the Peritoneal Dialysis (PD) and Hemodialysis (HD) Patients in Taiwan Before Matching

Characteristic	PD	HD	p Value
Patients (n)	3 137	36 539	
Age (years)			
Mean	53.1±15.4	61.4±13.9	0.0088
Range	18–99	18–101	
Sex [n (%) men]	1 272 (40.6)	17 161 (47.0)	<0.001
Diabetes mellitus [n (%)]	1 059 (33.8)	17 823 (48.8)	<0.001
Geographic distribution [n (%)]			
Northern Taiwan	1 570 (50.1)	14 797 (40.5)	<0.001
Central Taiwan	838 (26.7)	8 541 (23.4)	
Southern Taiwan	674 (21.5)	12 195 (33.4)	
Eastern Taiwan	55 (1.8)	998 (2.7)	
Life expectancy (years)	7.9±0.4	6.2±0.1	0.0002
Costs (US$)[a]			
Total lifetime	139 538±7 749	139 768±3 329	0.9836
Per life-year	17 723	22 708	

[a] Estimated from the start of dialysis. Exchange rate on 31 December 2010: US$1 = TW$29.32200.

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TABLE 2
Characteristics of the Matched Peritoneal Dialysis (PD) and Hemodialysis (HD) Patients in Taiwan

Characteristic	PD	HD	*p* Value
A. Overall group			
Patients (*n*)	3 136	3 136	
Age (years)			
Mean	53.2±15.4	53.2±15.4	1.000
Range)	18–99	18–99	
Sex [*n* (%) men]	1 272 (40.6)	1 272 (40.6)	1.000
Life expectancy (years)	7.9±0.5	8.7±0.4	0.128
Costs (US$)[a]			
Total lifetime	139 360±8 336	185 235±9 623	<0.001
Per life-year	17 723	21 367	
B. Stratified by diabetes			
Patients with diabetes (*n*)	1 058	1 058	
Age (years)			
Mean	60.9±12.4	60.9±12.4	1.000
Range	19–99	19–99	
Sex [*n* (%) men]	485 (45.8)	485 (45.8)	1.000
Life expectancy (years)	4.0±0.3	4.4±0.2	0.248
Costs (US$)[a]			
Total lifetime	90 945±10 935	112 516±5 318	0.0836
Per life-year	22 732	25 519	
Patients without diabetes (*n*)	2 078	2 078	
Age (years)			
Mean	49.2±15.3	49.2±15.2	1.000
Range	18–95	18–95	
Sex [*n* (%) men]	787 (37.9)	787 (37.9)	1.000
Life expectancy (years)	9.2±0.6	10.4±0.5	0.148
Costs (US$)[a]			
Total lifetime	157 374±10 531	216 457±12 853	0.0004
Per life-year	17 163	20 724	
C. Stratified by sex			
Male patients (*n*)	1 272	1 272	
Age (years)			
Mean	53.9±15.2	53.9±15.2	1.000
Range	18–95	18–95	
Sex [*n* (%) men]	1 272 (100)	1 272 (100)	1.000
Life expectancy (years)	7.0±0.6	7.1±0.3	0.867
Costs (US$)[a]			
Total lifetime	123 617±9 421	158 887±8 099	0.0065
Per life-year	17 651	22 303	
Female patients (*n*)	1 864	1 864	
Age (years)			
Mean	52.6±15.5	52.6±15.5	1.000
Range	18–99	18–99	
Sex [*n* (%) men]	0 (0)	0 (0)	1.000
Life expectancy (years)	8.4±0.5	9.7±0.5	0.0974
Costs (US$)[a]			
Total lifetime	150 373±10 192	202 696±12 590	0.0021
Per life-year	17 822	20 862	

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TABLE 2 (cont'd)

Characteristic	PD	HD	*p* Value
D. Stratified by age			
Patients < 65 years (*n*)	2 350	2 350	
Age (years)			
Mean	46.5±11.1	46.5±11.1	1.000
Range	18–64	18–64	
Sex [*n* (%) men]	928 (39.5)	928 (39.5)	1.000
Life expectancy (years)	9.3±0.6	10±0.5	0.904
Costs (US$)[a]			
Total lifetime	164 774±10 785	212 381±11 548	0.0023
Per life-year	17 692	21 220	
Patients ≥ 65 years (*n*)	786	786	
Age (years)			
Mean	73.2±6.5	73.2±6.5	1.000
Range	65–99	65–99	
Sex [*n* (%) men]	344 (43.8)	344 (43.8)	1.000
Life expectancy (years)	3±0.1	3.9±0.2	0.0004
Costs (US$)[a]			
Total lifetime	55 043±3 018	91 679±5 070	<0.001
Per life-year	18 206	23 664	

[a] Estimated from the start of dialysis. Exchange rate on 31 December 2010: US$1 = TW$29.32200.

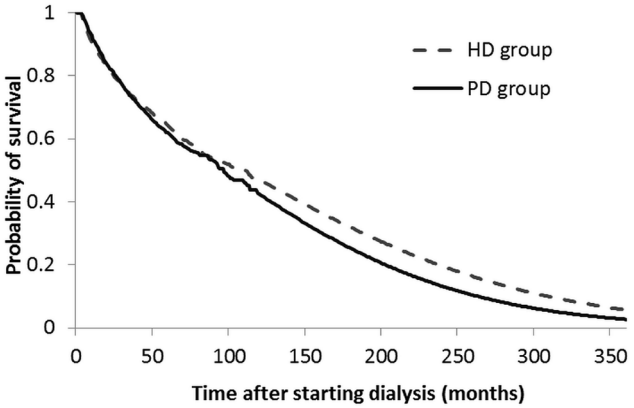

Figure 1 — Comparison of the probability of survival across time for 3136 peritoneal dialysis (PD) and hemodialysis (HD) patients in Taiwan, matched for age, sex, and diabetes status.

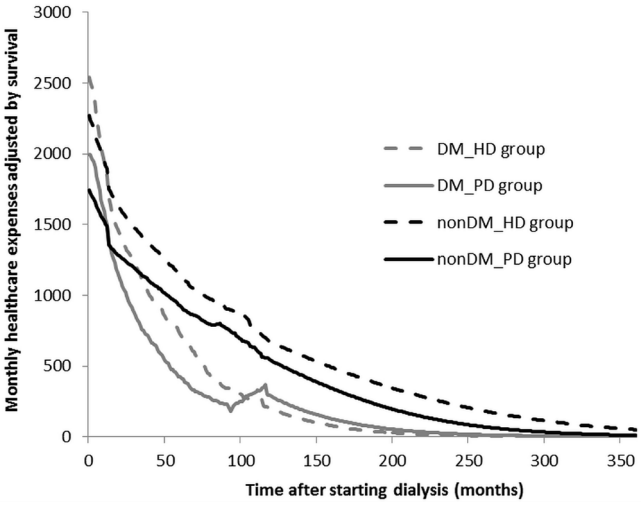

Figure 2 — Average monthly health care expenses adjusted by survival probability, stratified by dialysis type and diabetes status, and plotted across time since dialysis start. DM = patients with diabetes mellitus; HD = hemodialysis; PD = peritoneal dialysis; nonDM = patients without diabetes mellitus.

than that for a HD patient in both groups: US$164 774 versus US$212 381 for those less than 65 years of age ($p = 0.0023$), and US$55 043 versus US$91 679 for those 65 years of age and older ($p < 0.001$). Comparisons of the cost per life-year for PD and HD patients in the various age groups yielded similar results.

DISCUSSION

Table 1 shows the characteristics of ESRD patients in Taiwan. It can be seen that a larger proportion of PD patients live in Northern Taiwan. The fact that older patients in Taiwan are more dependent on medical staff and are thus more likely to avoid PD (which is a more self-dependent treatment) probably explains why the PD population is younger. As might be expected, the life-expectancy of a PD patient was longer than that of a HD patient. Because, compared with men, women generally have a smaller body size and need fewer daily exchanges

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to achieve adequate dialysis, the PD population included more women. In contrast, fewer patients with diabetes mellitus were found in the PD population, because glucose-containing PD fluids might affect glycemic control in diabetic patients (16). To be able to fairly compare PD and HD patients in Taiwan, we matched them on age, sex, and diabetes status (Table 2).

One conclusion from this nationwide hospital-based study is that the lifetime cost and the cost per life-year are, in general, both lower for PD patients than for HD patients in Taiwan [Table 2(A)]. A series of one-way sensitivity analyses that assumed a 5% discount rate or that included the health care expenses for 1 – 3 months before dialysis start showed the same trend. In other words, the differences in lifetime cost between PD and HD do not seem to be affected by changes in the discount rate or inclusion of costs from the immediate pre-dialysis phase. The following additional arguments support this finding:

- Copayment was waived for all dialysis patients under the NHI scheme.
- All patients diagnosed with cancer before dialysis were excluded to prevent any confounding from a comorbidity of this kind.
- Every patient receiving PD was matched with a patient receiving HD based on age, sex, and diabetes status—risk factors that may potentially influence survival (17) and health care expenses (18).

Berger *et al.* (19) also showed that, compared with HD patients, PD patients in America had significantly lower total health care costs over 12 months of treatment. Similarly, in Sweden, the cost per quality-adjusted life year was lower for PD than for HD among all analyzed age groups after 5 years of follow-up (20).

Although most previous studies have focused mainly on the annual cost or cost per life-year (19–21), we analyzed lifetime cost for PD and HD (Tables 1 and 2) to address the long-term sustainability of our NHI system. According to Table 1, the lifetime cost was about the same for PD and HD before matching on various risk factors. However, the results after matching, as summarized in Table 2, consistently reveal a lower lifetime cost for PD, except for patients having comorbid diabetes. This analysis indicates that the long-term financial burden of the NHI can be lowered if PD is chosen as initial treatment for ESRD.

The total lifetime cost of PD and HD for patients with diabetes was, respectively, only about 42% and 48% of the cost for patients without diabetes because of the much shorter life expectancy for diabetic patients [Table 2(B)]. In fact, the cost per life-year of ESRD care was higher for patients with diabetes than for nondiabetic patients. Because diabetes mellitus, the most common cause of ESRD (22,23), has been increasing worldwide, the issue of whether patients with diabetes should receive PD or HD deserves special attention. If, as demonstrated in our study, the life expectancy of matched PD and HD patients is the same, then choosing PD first for diabetic patients appears to be more cost-effective. Still, "prevention is better than cure" is a well-known axiom, and there are methods to retard the ESRD incidence among diabetic patients—for example, optimal control of blood glucose (23,24), hypertension (24), and hyperlipidemia (25), and early referral of chronic kidney disease patients to nephrology care (25,26), among others. Yet, how to promote PD initiation remains a great challenge in Taiwan and in other countries that have higher HD penetration.

Life expectancy was not different for men on PD and HD or for women on PD and HD [Table 2(C)]. Given that the total lifetime cost for men or women on HD was significantly higher than the cost for men or women on PD, our suggestion for choosing PD first in ESRD patients without contraindications seems reasonable.

In patients 65 years of age and older, life expectancy was slightly but significantly greater for those on HD than for those on PD. The reason may be that older patients generally have more comorbid conditions and that undergoing HD enables them to receive more intensive care from the dialysis staff. Given that the lifetime cost was significantly lower for PD patients than for HD patients, initiating home visits (27,28) for elderly patients might be a better way to reduce the NHI financial burden without compromising the quality of care during implementation of a "PD First" policy.

Our study has two noteworthy limitations. First, patients who had stopped using NHI subsidies for at least 3 months were considered deceased, meaning that patients who had gone abroad or emigrated were also censored. However, the effect was probably negligible, given that ESRD patients in Taiwan are eligible for dialysis free of charge, and few patients undergoing dialysis would choose to emigrate. Second, neither the lifetime expenses not paid by the NHI (for example, monthly transportation fees and costs for caregivers employed) nor the work status of the patients [the employment rate in PD patients is generally higher (29)] was included in the study. Transportation expenditures incurred by a family member or members accompanying a patient during HD may also directly or indirectly affect the cost of care. If such costs were to be carefully evaluated, the difference in lifetime cost for PD and HD patients might be even greater.

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CONCLUSIONS

Our study found that both the total lifetime cost and the cost per life-year paid by the NHI were lower for PD patients than for HD patients in Taiwan. At present, more than 65 000 people are receiving long-term dialysis in Taiwan, among whom more than 90% are treated with HD (4). To make more cost-effective use of NHI resources, we recommend a policy of sequential dialysis care with PD first and then HD as required for incident ESRD patients (30–32). Strategies to control diabetes should also be encouraged and implemented.

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DISCLOSURES

None of the authors has any financial conflict of interest associated with the contents or publication of this manuscript. The first author had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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