Cost Comparison of Peritoneal Dialysis Versus Hemodialysis in End-Stage Renal Disease

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Objective: To compare healthcare utilization and costs in patients with end-stage renal disease (ESRD) beginning peritoneal dialysis (PD) or hemodialysis (HD).

Study Design: Retrospective cohort study.

Methods: Using a US health insurance database, we identified all patients with ESRD who began dialysis between January 1, 2004, and December 31, 2006. Patients were designated as PD patients or as HD patients based on first-noted treatment. Patients with less than 6 months of pretreatment data and those with less than 12 months of data following initiation of dialysis ("pretreatment" and "follow-up," respectively) were dropped from the study sample. The PD patients were matched to HD patients using propensity scoring to control for differences in pretreatment characteristics. Healthcare utilization and costs were then compared over 12 months between propensity-matched PD patients and HD patients using paired *t* tests and Wilcoxon signed rank tests for continuous variables and using Bowker and McNemar tests for categorical variables, as appropriate.

Results: A total of 463 patients met all study entrance criteria; 56 (12%) began treatment with PD, and 407 (88%) began treatment with HD. Fifty PD patients could be propensity matched to an equal number of HD patients. The HD patients were more than twice as likely as matched PD patients to be hospitalized over the subsequent 12 months (hazard ratio, 2.17; 95% confidence interval, 1.34-3.51; $P < .01$). Their median healthcare costs over the 12-month follow-up period were $43,510 higher ($173,507 vs $129,997 for PD patients, $P = .03$).

Conclusions: Among patients with ESRD, PD patients are less likely than HD patients to be hospitalized in the year following initiation of dialysis. They also have significantly lower total healthcare costs.

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For author information and disclosures, see end of text.

Hemodialysis (HD) and peritoneal dialysis (PD) are the main dialysis modalities for patients with end-stage renal disease (ESRD). Hemodialysis is typically performed 3 times weekly at a dialysis center, with each treatment taking 3 to 5 hours[1]; nocturnal HD and short daily home HD are also available.[2] In contrast, PD uses the lining of the abdomen (the peritoneal membrane) instead of a dialyzer to filter the blood. The abdomen is filled with dialysis solution (a combination of minerals and sugar designed to draw wastes and excess fluids from the body into the solution) and is then drained several hours later (a process known as "exchange"). There are 3 different types of PD: continuous ambulatory PD (CAPD), automated PD (APD), and combination CAPD and APD.[1] In CAPD, patients undergo the exchange process usually 4 to 5 times during a 24-hour period; no machine is required. In APD, the patient uses an automated cycler to perform 3 to 5 exchanges during the night while sleeping (the abdomen remains filled with dialysis solution throughout the day).[3]

In the United States, the cost of dialysis is largely borne by the Medicare ESRD system, which accepts all patients previously enrolled in Medicare on initiation of dialysis (principally, persons ≥65 years) and those otherwise not eligible for Medicare benefits after they have received a minimum of 3 months of dialysis (for these latter patients, there is an additional 30-month "coordination of benefits" period during which Medicare remains the secondary payer, while the private insurer is the primary payer).[4] Persons 65 years or older who are still working or who have a spouse who is still working also may have their costs borne (in part or in full) by private health insurers. It has been estimated that 25% of all patients with ESRD beginning HD and 37% of all such patients beginning PD are privately insured.[5]

There is a wealth of information about healthcare utilization and costs among patients with ESRD who are insured through the Medicare program. Comparatively little is known about the use and cost of healthcare services among patients with ESRD who are privately insured and, in particular, those beginning treatment with PD versus HD.

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METHODS

Data were obtained from the PharMetrics Patient-Centric Database, which is composed of facility, profes-

Take-Away Points

Using a large US healthcare claims database, we compared healthcare utilization and costs in patients beginning renal replacement therapy with peritoneal dialysis (PD) versus hemodialysis (HD), matching PD patients to HD patients based on pretreatment characteristics.

- The PD patients were significantly less likely to be hospitalized during the year following initiation of dialysis.
- The PD patients also had significantly lower total healthcare costs over this period.

sional service, and retail (ie, outpatient) pharmacy claims from more than 85 US health plans (PharMetrics, Watertown, MA). The plans provide healthcare coverage to approximately 14 million persons annually throughout the United States (35% in the Midwest, 21% in the Northeast, 31% in the South, and 13% in the West). All patient identifiers in the database are fully encrypted, and the database is fully compliant with the Health Insurance Portability and Accountability Act of 1996.

Information available for each facility and professional service claim includes the date and place of service, diagnoses (in *International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] format), procedures (in *ICD-9-CM* [selected plans only] and Health Care Financing Administration Common Procedural Coding System formats), provider specialty, and charged and paid amounts. Data available for each retail pharmacy claim include the drug dispensed (in National Drug Code format), dispensing date, and quantity dispensed and number of days of therapy supplied (selected plans only). All claims include a charged amount; the database also provides the paid amounts (ie, total reimbursed, including patient deductible, copayment, and coinsurance).

Selected demographic and eligibility information is also available, including age, sex, geographic region, coverage type, and the dates of insurance coverage. All patient-level data can be arrayed chronologically to provide a detailed longitudinal profile of all medical and pharmacy services used by each insured person. Because this study was retrospective in nature, used completely anonymized data, and did not involve patient contact, institutional review board approval was neither required nor sought.

Using the PharMetrics database, we identified all patients with 1 or more medical encounters for PD or HD between January 1, 2004, and December 31, 2006 ("study period"), irrespective of whether they had any claims with a diagnosis of renal failure (*ICD-9-CM* diagnosis codes 403.X1, 404.X2, 404.X3, 585, 585.X, and 586) (additional criteria, listed herein, were used to exclude patients receiving dialysis for reasons other than ESRD). For each such patient, we then identified the first-noted claim for dialysis (either PD or HD) during the study period; the date of this claim was designated the "index date," and patients were stratified into 2 groups ("PD patients" or "HD patients") based on the treatment received on this date. All patients were required to be continuously enrolled for 6 months before their index date ("pretreatment") and for 12 months after this date ("follow-up"). Identification of patients who received PD versus HD was based on algorithms developed by us (**eAppendix A** and **eAppendix B** available at **www.ajmc.com**). Patients with claims for both PD and HD on their index date were excluded, as were patients enrolled in a Medicaid program and those 65 years or older who were enrolled in Medicare supplemental or capitated plans (because of incomplete claims histories). Additional exclusion criteria were taken from prior studies[6-8] that identified patients receiving dialysis based on electronic claims databases and included the following: (1) any claims encounters with dialysis-related codes (ie, diagnostic, procedural, or equipment) during the pretreatment period, (2) less than 3 months of continuous enrollment following the index date, (3) evidence of initiation of dialysis for reasons other than ESRD (eg, because of trauma), and (4) patients who underwent renal transplantation during the first month of follow-up.

We examined the prevalence of several (medically attended) comorbidities among PD patients and HD patients, including the following: (1) diabetes mellitus (*ICD-9-CM* diagnosis code 250.XX or receipt of α-glucosidase inhibitors, insulin, metformin hydrochloride, nonsulfonylurea insulin secretagogues, sulfonylurea, or thiazolidinedione); (2) coronary artery disease (codes 410.XX-414.XX); (3) congestive heart failure (code 428.XX); (4) anemia (codes 280.XX-285.XX or receipt of darbepoetin alfa or epoetin alfa); (5) renal osteodystrophy (code 588.0); (6) sleep disorders (codes 307.4X, 780.5X, and V69.4); (7) amyloidosis (code 277.3); and (8) hypertension (codes 401.XX-405.XX, 459.10, 459.30, 459.31, 459.32, 459.33, and 459.39 or receipt of antihypertensives). Patients were deemed to have these conditions if they had 2 or more outpatient claims (medical or pharmacy) on different days or 1 or more inpatient claims (medical only) meeting the aforementioned criteria.

To control for potentially important differences in pretreatment characteristics between PD patients and HD patients, we matched the latter to the former using techniques of propensity scoring.[9-11] Briefly, multivariate logistic regression analysis was used to generate a probability ("propensity score") that each subject was a PD patient; covariates entered into the model included age, sex, comorbidities, and pretreatment healthcare utilization and costs. Once a propensity score was generated for each patient in the study sample, HD patients were matched to PD patients in a stepwise fashion that minimized the absolute difference in propensity scores for each match. Once a pair was matched, both subjects were removed from the pool of potential pairs, and the process was repeated until all possible pairs for which the absolute difference in propensity scores was less than 0.01 were matched (ie, caliper matching was used). All analyses were then undertaken on the propensity-matched sample.

Once the matched sample was created, we examined the use and cost of healthcare services during the 12-month follow-up period, including the following: (1) prescription medications, (2) physician office visits, (3) other outpatient visits, (4) emergency department (ED) visits, and (5) hospitalizations. The use of healthcare services was examined in terms of the percentage of patients receiving each service, as well as the number of times each service was rendered; for hospitalizations, length of stay also was examined. The total reimbursed amount (ie, the amount paid by the insurer plus the amount of patient liability [eg, copayment and deductible]) was used as a proxy for cost.

Kaplan-Meier methods were used to examine the incidence of and the time to hospitalization during follow-up among patients in the matched

Table 1. Pretreatment Demographic and Clinical Characteristics of All Patients Initiating Peritoneal Dialysis (PD) or Hemodialysis (HD)

Characteristic	PD (n = 56)	HD (n = 407)	*P*
Age, mean, (SD) y	43.9 (19.6)	55.2 (15.4)	<.01
Sex, No. (%)			
Male	29 (51.8)	260 (63.9)	.08
Female	2 (48.2)	147 (36.1)	
Comorbidity, No. (%)			
Cancer	1 (1.8)	17 (4.2)	.39
Diabetes mellitus	20 (35.7)	165 (40.5)	.49
Coronary artery disease	9 (16.1)	87 (21.4)	.36
Congestive heart failure	6 (10.7)	92 (22.6)	.04
Anemia	28 (50.0)	189 (46.4)	.62
Renal osteodystrophy	6 (10.7)	6 (1.5)	<.01
Sleep disorders	3 (5.4)	26 (6.4)	.77
Amyloidosis	0	0	—
Depression	3 (5.4)	17 (4.2)	.68
Hypertension	27 (48.2)	258 (63.4)	.03
Pretreatment healthcare utilization			
Erythropoietin-stimulating agents			
Darbepoetin alfa			
No. (%) with ≥1 claims	2 (3.6)	30 (7.4)	.29
Mean (SD)	0.1 (0.6)	0.3 (1.5)	.29
Median (IQR)	0 (0-0)	0 (0-0)	.29
Epoetin alfa			
No. (%) with ≥1 claims	7 (12.5)	43 (10.6)	.72
Mean (SD)	0.3 (0.9)	0.4 (1.9)	.72
Median (IQR)	0 (0-0)	0 (0-0)	.72
Any of above			
No. (%) with ≥1 claims	9 (16.1)	72 (17.7)[a]	.68
Mean (SD)	0.4 (1.1)	0.8 (2.4)	.68
Median (IQR)	0 (0-0)	0 (0-0)	.68
Physician office visits			
No. (%) with ≥1 visits	45 (80.4)	329 (80.8)	.93
Mean (SD)	7.8 (8.6)	8.4 (13.9)	.60
Median (IQR)	6 (3-10)	5 (1-11)	.60
Other outpatient visits			
No. (%) with ≥1 visits	35 (62.5)	274 (67.3)	.47
Mean (SD)	6.6 (8.4)	4.8 (7.0)	.46
Median (IQR)	2 (0-13)	2 (0-6)	.45
Emergency department visits			
No. (%) with ≥1 visits	14 (25.0)	115 (28.3)	.61
Mean (SD)	0.7 (1.5)	0.8 (1.6)	.67
Median (IQR)	0 (0-1)	0 (0-1)	.67
Hospitalizations			
No. (%) with ≥1 hospitalizations	15 (26.8)	111 (27.3)	.94
Total No. of hospitalizations during pretreatment			
Mean (SD)	0.3 (0.6)	0.4 (82.0)	.85
Median (IQR)	0 (0-1)	0 (0-1)	.85
Pretreatment healthcare costs, $			
Mean (95% confidence interval)	41,324 (21,263-66,611)	21,830 (17,178-27,183)	
Median (IQR)	10,794 (1892-25,540)	7005 (1395-18,629)	

IQR indicates interquartile range.
[a]One patient received both products.

sample. Cox proportional hazards models were used to identify potential predictors of hospitalization; predictors in these models included age, sex, pretreatment comorbidities, pretreatment healthcare utilization and costs, and initial dialysis modality (ie, PD vs HD).

For variables that were not approximately normally distributed, 95% confidence intervals (CIs) were constructed by drawing 1000 samples (with replacement) from the source population, calculating the values for the relevant variables within each sample, and taking the 2.5 and 97.5 percentile values (ie, the bootstrap method).[12] The statistical significance of differences between propensity-matched PD patients and HD patients was ascertained using paired *t* tests (age) and Wilcoxon signed rank tests (all others) for continuous variables and using Bowker and McNemar tests for categorical variables, as appropriate. All analyses were conducted using PC SAS version 9.1 (SAS Institute, Cary, NC).

RESULTS

We identified 56 PD patients and 407 HD patients who met all study entrance criteria. On average, PD patients were younger than those receiving HD, and fewer of them had a history of congestive heart failure (**Table 1**). The total healthcare costs during pretreatment were higher (albeit not significantly) among PD patients than among HD patients. Fifty PD patients were matched to an equal number of HD patients; 6 PD patients could not be matched. After matching, PD patients and HD patients were similar in terms of the pretreatment characteristics we considered (**Table 2**).

On a per-patient basis, those initiating dialysis with HD averaged 20 more outpatient visits over 12 months compared with matched patients in the PD group: the mean (95% CI) was 68.4 (57.3-82.1) versus 48.4 (41.0-57.1), and the corresponding median (interquartile range [IQR]) was 60 (38-90) versus 43 (29-70) (P = .01 for both) (**Table 3**). The HD patients also had nominally more ED visits (mean [95% CI], 3.3 [2.1-5.0] vs 2.3 [1.3-3.5] for PD; P = .28). Over the 12-month period of follow-up, more HD patients were hospitalized (80% vs 50% for PD, P <.01).

The incidence of hospitalization during follow-up is shown in the **Figure**. In Cox proportional hazards models, HD was associated with more than a 2-fold increased risk of hospitalization relative to PD (hazard ratio, 2.17; 95% CI, 1.34-3.51; P <.01) (**Table 4**). Other significant predictors of hospitalization included congestive heart failure (hazard ratio, 2.56; 95% CI, 1.56-4.22; P <.01) and hypertension (hazard ratio, 2.22; 95% CI, 1.13-4.36; P = .02).

The median (IQR) total per-patient healthcare costs were $43,510 higher among HD patients than among PD patients over 12 months ($173,507 [$98,706-$335,719] vs $129,997 [$73,212-$207,578], P = .03). The median (IQR) per-patient inpatient costs were $39,851 ($6089-$140,125) for HD patients versus $651 ($0-$40,591) for PD patients (P <.01); the corresponding values for other services were $73,392 ($24,087-$101,992) versus $70,642 ($17,652-$96,770) for outpatient office visits (P = .53), $360 ($0-$1340) versus $0 ($0-$135) for ED visits ($P$ = .29), $2454 ($0-$6483) versus $2750 ($0-$8591) for outpatient (ie, retail) pharmacy (P = .28), and $14,097 ($6987-$49,320) versus $16,229 ($4192-$37,867) for all other services (P = .47). The difference in the total per-patient healthcare costs over 12 months was $80,709 (mean [95% CI], $263,001 [$200,925-$334,588] vs $182,292 [$129,942-$253,090]; P = .04). The mean (95% CI) per-patient inpatient costs were $140,633 ($81,752-$211,574) for HD patients and $79,175 ($28,522-$144,682) for PD patients (P = .08); the corresponding values for other services were $81,046 ($62,626-$101,583) versus $70,798 ($55,490-$86,781) for outpatient visits (P = .48), $1395 ($731-$2204) versus $848 ($380-$1491) for ED visits ($P$ = .27), $4196 ($2774-$5805) versus $6679 ($4036-$10,133) for outpatient pharmacy (P = .15), and $35,731 ($24,054-$47,886) versus $24,792 ($17,152-$33,701) for all other services (P = .17).

DISCUSSION

In the absence of head-to-head clinical trials, which may never be conducted, observational studies such as ours may be the only means of comparing healthcare utilization and costs in patients beginning dialysis with HD versus PD. Findings from our study suggest that privately insured patients who initiate dialysis with PD have significantly lower risks of hospitalization and lower total costs of care over 12 months than HD patients of similar demographic and clinical characteristics. While comparatively few dialysis patients began therapy with PD (only about 12% in our study), it has been estimated that 76% to 93% of patients beginning dialysis have no contraindications and could receive either modality.[13] Our study results suggest that expanded use of PD in lieu of HD may yield substantial economic benefits to private payers.

Prior analyses of Medicare enrollees have consistently reported lower healthcare costs among patients who initiated dialysis with PD rather than HD, although the magnitude of differences reported by others is less than we observed. (Medicare typically pays less for services than private insurers because of the ability [ie, market power] of the former to dictate payment rates.) The 2006 US Renal Data System Annual Data Report[14] noted that the mean annual per-patient costs of dialysis (all modalities) were $67,000 for Medicare patients and $180,000 for patients covered by private health

Table 2. Pretreatment Demographic and Clinical Characteristics of Propensity-Matched Patients Initiating Peritoneal Dialysis (PD) or Hemodialysis (HD)

Characteristic	PD (n = 50)	HD (n = 50)	*P*
Age, y			
Group, No. (%)			
<18	8 (16.0)	2 (4.0)	.92
18-29	1 (2.0)	7 (14.0)	
30-39	5 (10.0)	9 (18.0)	
40-49	10 (20.0)	7 (14.0)	
50-59	16 (32.0)	14 (28.0)	
60-64	3 (6.0)	5 (10.0)	
65-74	5 (10.0)	3 (6.0)	
75-84	2 (4.0)	3 (6.0)	
≥85	0	0	
Mean (SD)	46.3 (18.8)	46.4 (17.6)	.98
Median (IQR)	50 (35-56)	50 (34-57)	.82
Minimum	7	15	
Maximum	82	82	
Sex, No. (%)			
Male	27 (54.0)	26 (52.0)	.85
Female	23 (46.0)	24 (48.0)	
Comorbidity, No. (%)			
Cancer	1 (2.0)	3 (6.0)	.32
Diabetes mellitus	20 (40.0)	17 (34.0)	.56
Coronary artery disease	8 (16.0)	11 (22.0)	.41
Congestive heart failure	6 (12.0)	8 (16.0)	.56
Anemia	24 (48.0)	26 (52.0)	.67
Renal osteodystrophy	5 (10.0)	5 (10.0)	>.99
Sleep disorders	2 (4.0)	4 (8.0)	.41
Amyloidosis	0	0	—
Depression	2 (4.0)	1 (2.0)	.56
Hypertension	26 (52.0)	33 (66.0)	.14
Pretreatment healthcare utilization			
Erythropoietin-stimulating agents			
Darbepoetin alfa			
No. (%) with ≥1 claims	1 (2.0)	2 (4.0)	.56
Total No. of claims during pretreatment			
Mean (SD)	0.0 (0.3)	0.2 (1.2)	.55
Median (IQR)	0 (0-0)	0 (0-0)	.55
Epoetin alfa			
No. (%) with ≥1 claims	6 (12.0)	7 (14.0)	.78
Total No. of claims during pretreatment			
Mean (SD)	0.2 (0.8)	0.5 (1.8)	.69
Median (IQR)	0 (0-0)	0 (0-0)	.69
Any of above			
No. (%) with ≥1 claims	7 (14.0)	9 (18.0)	.59
Total No. of claims during pretreatment			
Mean (SD)	0.3 (0.9)	0.8 (2.1)	.47
Median (IQR)	0 (0-0)	0 (0-0)	.69

(Continued)

■ **Table 2.** Pretreatment Demographic and Clinical Characteristics of Propensity-Matched Patients Initiating Peritoneal Dialysis (PD) or Hemodialysis (HD) *(Continued)*

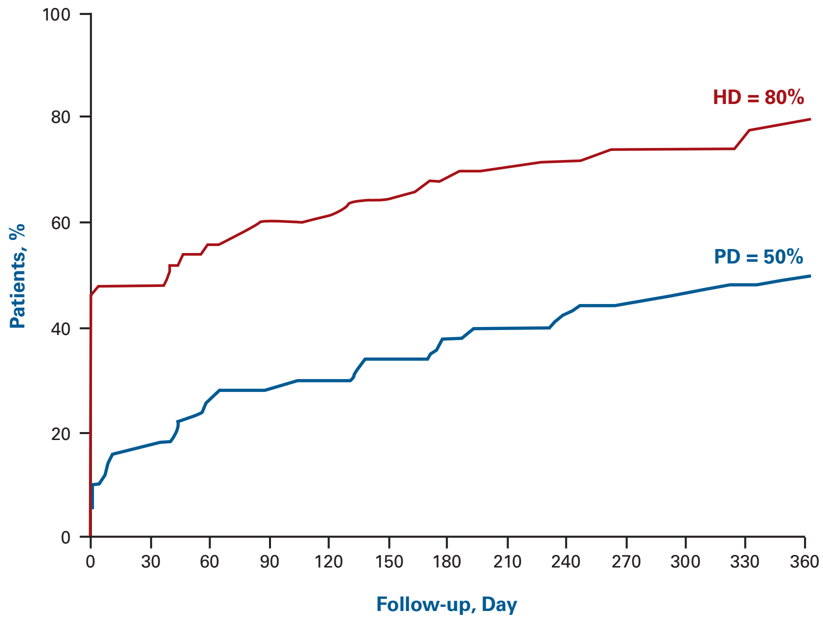
Characteristic	PD (n = 50)	HD (n = 50)	*P*
Pretreatment healthcare utilization *(Continued)*			
Physician office visits			
No. (%) with ≥1 visits	39 (78.0)	40 (80.0)	.82
Total No. of visits during pretreatment			
Mean (SD)	7.4 (8.4)	6.0 (6.3)	.55
Median (IQR)	6 (2-10)	5 (1-9)	.55
Other outpatient visits			
No. (%) with ≥1 visits	31 (62.0)	38 (76.0)	.18
Total No. of visits during pretreatment			
Mean (SD)	6.5 (8.2)	7.1 (8.8)	.43
Median (IQR)	2 (0-12)	4 (1-11)	.43
Emergency department visits			
No. (%) with ≥1 visits	12 (24.0)	17 (34.0)	.25
Total No. of visits during pretreatment			
Mean (SD)	0.8 (1.6)	1.0 (2.1)	.38
Median (IQR)	0 (0-0)	0 (0-1)	.38
Hospitalizations			
No. (%) with ≥1 hospitalizations	13 (26.0)	17 (34.0)	.45
Total No. of hospitalizations during pretreatment			
Mean (SD)	0.3 (0.6)	0.6 (1.0)	.27
Median (IQR)	0 (0-1)	0 (0-1)	.26
Pretreatment healthcare costs, $			
Mean (95% confidence interval)	27,928 (12,564-47,858)	49,846 (24,648-83,157)	.21
Median (IQR)	9426 (1426-20,413)	10,757 (2716-36,230)	.26

HD indicates hemodialysis; IQR, interquartile range; PD, peritoneal dialysis.
Note: Patients matched within a tenth of their propensity score (eg, 0.1X matched to 0.1X).

insurance ("Employer Group Health Plans"). In 2005, for example, annual per-patient Medicare expenditures related to vascular access were $52,734 for patients with PD catheters and approximately $65,509 for patients with HD access points ($58,294, $67,479, and $74,963 for patients with arteriovenous fistulas, grafts, and catheters, respectively).[4] Shih and colleagues[15] examined Medicare expenditures over a 3-year period following initiation of dialysis among 3423 patients with incident ESRD identified in the US Renal Data System. After adjustment for differences in patient characteristics (eg, age, sex, race/ethnicity, comorbidities, and primary cause of ESRD), the estimated total annual Medicare expenditures were reported to be $11,446 lower for PD patients than for HD patients ($56,807 vs $68,253, *P* <.001). Bruns and colleagues[16] identified 148 patients receiving PD (n = 35) or HD (n = 113) at the University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, between July 1, 1994, and June 30, 1995. The unadjusted mean annual per-patient costs were $17,920 lower among those who received PD ($45,420 vs $63,340 for HD, significance not reported). Peritoneal dialysis has also been reported to be less expensive than HD in non-US populations with ESRD.[17-22]

Historically, patients beginning dialysis with PD have been described as healthier on average than those initiating treatment with HD in terms of the number and severity of reported comorbidities.[23,24] In our study, PD patients were younger than HD patients, and fewer of them had a history (based on attributable healthcare encounters) of congestive heart failure or hypertension. We attempted to control for differences in patient characteristics by propensity matching patients on the basis of pretreatment comorbidities and healthcare utilization and costs. Although no significant pretreatment differences were noted between PD patients and HD patients in the matched sample, the database is limited in terms of the clinical information it contains. Accordingly, the degree to which our findings may reflect residual confounding is unknown (ie, factors that continue to differ between the 2 groups, despite matching, other than initial dialysis modality that also are related to study outcomes).

■ **Figure.** Time to Hospitalization in Propensity-Matched Patients Initiating PD or HD



	Follow-up, Month						
	0	2	4	6	8	10	12
Index Therapy				**Number at Risk**			
PD	50	37	35	31	29	27	21
HD	50	22	20	16	14	13	8

PD indicates peritoneal dialysis; HD, hemodialysis.
Note: Follow-up spanned 12-month period following dialysis initiation.

Differences in the total healthcare costs between PD patients and HD patients in our study were largely attributable to differences in the cost of inpatient care. Although HD patients typically have higher medication costs than PD patients because of their increased use of erythropoietin-stimulating agents (ESAs) (in 2005, the Medicare ESRD program spent about $2 billion on ESAs, most of which was received by HD patients[4,25]), we did not observe a similar difference in our study, most likely because claims for ESAs administered in office or clinic settings may be bundled with other services and not explicitly noted. To the extent that bundling actually occurs, we would not be able to determine the services (including ESA administration) that were actually rendered in the office and clinic settings. Unfortunately, the extent to which bundling actually occurs—and its possible effect on our findings—is unknown. However, the percentage of patients in our study who received ESAs in the period before dialysis (ie, 16%-17%) falls within the range (11%-31%) reported in prior studies[6,26] of a similar nature that also were based on healthcare claims data.

As already noted, PD was the initial dialysis modality for only about 12% of patients in our study. In prior research, 7% to 27% of patients with ESRD in the United States have been reported to initiate dialysis with PD.[2,14-16,23,24,27] Using data from the US Renal Data System, Mehrotra and colleagues[13] reported that the use of PD among patients with incident ESRD declined from 11% during 1996-1997 to 7% during 2002-2003; the use of PD has continued to decline and was reported to be 6.7% in 2005.[4] Several reasons have been postulated for these low rates of use, including lack of nephrologist training on PD techniques, late patient referral to nephrologists, economic incentives associated with HD (eg, reimbursement mechanisms for iron supplementation and ESAs), lack of investment in infrastructure related to PD, poor patient education concerning dialysis options before initiation of therapy, and increased availability of HD during the early morning, late evening, and overnight hours.[2,5,13,18,28,29] Unfortunately, we could not address these issues in our study.

Our study has some additional limitations. First, given limitations of the database, we were unable to validate the algorithms that we used to identify PD patients and HD patients. By requiring that patients have at least claims with codes specific to PD or HD, we believe that the possibility of misclassification based on coding error was limited. Furthermore, we limited the possibility that patients who receive dialysis on a temporary basis only (eg, for acute renal failure) were inadvertently included in our study sample by requiring that patients have evidence of receipt of dialysis or a kidney transplant (indicative of ESRD) over a period of at least 3 months following the index date for dialysis. Nonetheless, the precise magnitude of misclassification bias is unknown.

Second, we tallied healthcare utilization and costs using an "intent-to-treat" approach (ie, in relation to the first treatment received). Therefore, patients who switched from HD to PD or, more likely, from PD to HD would have lev-

■ **Table 3.** Number of Patients Receiving Selected Healthcare Services Ascertained During the 12-Month Follow-up Period Among Propensity-Matched Patients Initiating Peritoneal Dialysis (PD) or Hemodialysis (HD)

Variable	PD (n = 50)	HD (n = 50)	*P*
Prescription medications			
No. (%) with ≥1	35 (70.0)	37 (74.0)	59
No. of prescriptions during follow-up			
Mean (95% CI)	43.6 (32.7-54.8)	39.3 (28.8-50.0)	.54
Median (IQR)	39 (0-69)	27 (0-69)	.51
Outpatient visits			
Physician office visits			
No. (%) with ≥1	48 (96.0)	49 (98.0)	.56
No. of physician's office visits during follow-up			
Mean (95% CI)	23.3 (18.2-29.6)	35.7 (28.0-46.0)	.03
Median (IQR)	20 (9-28)	30 (16-43)	.02
Other outpatient visits			
No. (%) with ≥1	48 (96.0)	49 (98.0)	.56
No. of other outpatient visits during follow-up			
Mean (95% CI)	25.1 (20.9-29.5)	32.8 (26.1-40.4)	.07
Median (IQR)	22 (16-35)	28 (17-45)	10
Any of above			
No. (%) with ≥1	50 (100.0)	49 (98.0)	>.99
Total No. of outpatient visits during follow-up			
Mean (95% CI)	48.4 (41.0-57.1)	68.4 (57.3-82.1)	.01
Median (IQR)	43 (29-70)	60 (38-90)	.01
Emergency department visits			
No. (%) with ≥1	22 (44.0)	34 (68.0)	.01
No. of emergency department visits during follow-up			
Mean (95% CI)	2.3 (1.3-3.5)	3.3 (2.1-5.0)	.28
Median (IQR)	0 (0-4)	2 (0-4)	.33
Hospitalizations			
No. (%) with ≥1	25 (50.0)	40 (80.0)	<.01
No. of hospitalizations during follow-up			
Mean (95% CI)	1.3 (0.8-1.8)	2.5 (1.8-3.3)	<.01
Median (IQR)	1 (0-2)	1 (1-4)	<.01
Inpatient days during follow-up			
Mean (95% CI)	23.1 (8.6-42.4)	41.6 (25.0-61.4)	.16
Median (IQR)	1 (0-12)	13 (3-56)	<.01

CI indicates confidence interval; IQR, interquartile range.

els of utilization and cost that presumably would be reflective of both modalities. Prior research has indicated that 25% to 33% of PD patients switch to HD compared with only 3% to 5% of HD patients who switch to PD.[15,30] In their analyses of patients beginning dialysis with PD versus HD, Shih et al[15] reported that PD patients who did not switch to HD averaged $48,446 in multivariate-adjusted annual Medicare expenditures versus $68,531 for all PD patients combined (ie, irrespective of switching status); similar figures for HD were $68,209 versus $72,189 (all values are in 2004 US dollars). Therefore, our findings may represent an underestimate of the true difference in cost between the 2 modalities; however, the magnitude of underestimation is unknown.

Additional benefits have been hypothesized for PD versus HD, including flexible scheduling, fewer needlesticks (preserving arteriovenous access sites for future HD and minimizing the risk of blood-borne infections), and better preservation of residual renal function.[2] Moreover, PD has been associated with greater patient satisfaction with dialysis care and with a reduced burden of kidney disease.[31-33] However, limitations of the database precluded us from addressing any of these issues in our study.

Table 4. Univariate Cox Proportional Hazards Models of Predictors of Hospitalization During Follow-up in Propensity-Matched Patients Initiating Peritoneal Dialysis (PD) or Hemodialysis (HD)

Variable	Hazard Ratio (95% Confidence Interval)	*P*
Initial dialysis modality, vs PD		
PD	1 [Reference]	—
HD	2.17 (1.34-3.51)	<.01
Age group, vs <18 y		
<18	1 [Reference]	—
18-29	1.26 (0.55-2.91)	.59
30-39	0.92 (0.47-1.79)	.80
40-49	1.09 (0.60-1.99)	.78
50-59	0.80 (0.47-1.35)	.40
60-64	0.76 (0.31-1.89)	.56
65-74	1.01 (0.44-2.34)	.98
75-84	2.34 (0.93-5.87)	.07
≥85	—	—
Sex, vs female		
Male	0.61 (0.38-0.98)	.04
Pretreatment comorbidity, yes vs no		
Cancer	1.38 (0.66-2.88)	.39
Diabetes mellitus	1.14 (0.71-1.81)	.59
Coronary artery disease	1.32 (0.80-2.17)	.28
Congestive heart failure	2.56 (1.56-4.22)	<.01
Anemia	1.22 (0.62-2.38)	.57
Renal osteodystrophy	1.61 (0.80-3.25)	.19
Sleep disorders	1.68 (0.67-4.19)	.27
Amyloidosis	—	—
Depression	1.99 (1.06-3.74)	.03
Hypertension	2.22 (1.13-4.36)	.02
Receipt of erythropoietin-stimulating agents during predialysis, yes vs no	1.00 (0.54-1.87)	>.99
Pretreatment healthcare costs, vs <median	1.61 (1.00-2.58)	.05

In conclusion, after matching our patient groups on several pretreatment characteristics, we found that patients beginning PD were significantly less likely than those initiating treatment with HD to be hospitalized over 12 months and that they had significantly lower total healthcare costs over this period. To the extent that our findings reflect differences in outcomes associated with choice of dialysis modality rather than differences in patient characteristics that we could not account for, the results may be of significant interest to private-sector insurers.

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