



Impact of the End Stage Renal Disease Prospective Payment System on the Use of Peritoneal Dialysis

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Introduction: The End Stage Renal Disease (ESRD) Prospective Payment System (PPS), implemented by the Centers for Medicare and Medicaid Services in January 2011, encouraged use of peritoneal dialysis (PD) through various financial incentives. Our goal was to determine whether PPS effectively increased PD use in incident dialysis patients.

Methods: Our study used the United States Renal Data System (USRDS) to identify 430,927 adult patients who initiated dialysis between 2009 and 2012. The interrupted time series method was used to evaluate the association Centers for Medicare and Medicaid Services of PPS with PD use at dialysis initiation. We further stratified by patient demographics, predialysis care, and facility chain and profit status.

Results: Interrupted time series analysis indicated PPS was associated with increased PD use in the 2-year period after PPS (change in slope = 0.04, $P < 0.0001$), although there was no immediate change in the level of PD use at the beginning of PPS ($P = 0.512$). Stratified analyses indicated PPS led to increased PD use across all age, race, and sex groups ($P < 0.05$) although marginally among females ($P = 0.09$). Notably, small dialysis organizations and nonprofit organizations appeared to increase use of PD faster compared to large dialysis organizations and for-profit units, respectively.

Discussion: Implementation of the Centers for Medicare and Medicaid Services ESRD payment reform was associated with an increased use of PD in the 2 years after PPS. Our findings highlight the role of financial incentives in changing practice patterns to increase use of a dialysis modality considered to be both more cost-effective and empowering to ESRD patients. However, even after PPS, rates of PD use remain low among the dialysis population in the USA.

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KEYWORDS: end-stage renal disease; interrupted time series; peritoneal dialysis; prospective payment system

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The choice of dialysis modality is one of the most important decisions for dialysis patients and their families. Research has demonstrated that home-based peritoneal dialysis (PD), compared to in-center hemodialysis (HD), has significant clinical advantages. Specifically, PD treatment preserves residual renal function better,¹ requires a lower dose of erythropoiesis-stimulating agent (ESA) to treat anemia² and avoids the need for a vascular access, thus reducing infections, which are the leading cause of hospitalization and mortality among end-stage renal disease (ESRD) patients.^{3,4} Studies have also shown favorable effects of PD compared to HD in health-related quality of life,⁵ treatment satisfaction,⁶ and survival in the first 1 to 2 years

of dialysis among ESRD patients when age, diabetes, and cardiovascular disease are considered.^{7–9} In addition, PD is less costly than HD, as home-based dialysis saves costs on staff overhead and dialysis supplies.¹⁰ The average per-treatment costs for delivering HD and PD, estimated by the United States Government Accounting Office (GAO), were \$251 and \$94, respectively.¹¹

Despite clinical benefits and economic advantages, the present use of PD in the USA is low, being approximately 6.8% among prevalent dialysis patients in 2013,¹² which is far less than the optimal rate (35%) recommended by nephrologists,¹³ as well as PD use in other industrialized countries (20%–81%).¹⁴ It has been suggested that nonmedical factors—especially financial incentives—contribute to the low use of PD in the USA.^{14,15} Prior to the development of the End Stage Renal Disease (ESRD) Prospective Payment System (PPS), Medicare paid separately for injectable medications based on dose administered. HD patients received

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ESAs i.v. compared to PD patients, who received ESAs subcutaneously, requiring 2 to 4 times more ESA dose.¹⁶ Therefore, dialysis facilities were able to increase their profits by having a majority of patients on HD.^{17,18} The new PPS bundled routine dialysis services including injectable drugs into an equivalent Medicare payment for both PD and HD, and thus removed the financial barrier to the use PD. To further promote home dialysis, the Centers for Medicare and Medicaid Services (CMS) imposed additional reforms in PPS such as raising payment for home dialysis training by 60%.¹⁹

Rigorous studies have not been conducted to examine whether PPS has effectively increased PD use. In this study, we evaluated whether PPS is associated with increased PD use among incident dialysis patients in the USA using a quasi-experimental design that examined dialysis modality choice among all Medicare ESRD patients initiating treatment 2 years before and 2 years after PPS implementation.

METHODS

Data Sources

We used data from United States Renal Data System (USRDS) from January 2009 to December 2012, 2 years before and 2 years after PPS, to conduct this study. The variables included in the USRDS Standard Analytical Files (SAFs), as well as the data source, collection methods, and validation studies, are described on the USRDS website (<http://www.usrds.org>). As a special data request, USRDS gave us the provider number for each patient at dialysis initiation, thereby allowing us to conduct subgroup analysis by provider characteristics. By cross-referencing facility data and patient-level data, a patient–provider file was constructed for analysis.

Study Measures

Our primary study measure was the rate of monthly PD use, calculated as a percentage of total continuous ambulatory PD (CAPD) and continuous cycling PD (CCPD) among all dialysis modalities for each month in the 48-month study period. Choice of modality at dialysis initiation was determined from the Medical Evidence Form (CMS-2728), mandatory for every new ESRD patient at initiation of renal replacement therapy in the USA. The modality variable in the MEF has been widely used in previous studies.^{7,9} Because our focus was difference in in-center HD versus continuous PD after PPS, home HD or intermittent PD patients (~3%) were excluded from this study. As a secondary analysis, we used the USRDS definition to ascertain dialysis modality; PD was determined by identifying PD use on day 90 after dialysis initiation with continuous

treatment using PD in the subsequent 60 days (known as the 60-day rule).

Patient demographics, comorbid conditions, and laboratory values including hemoglobin, serum albumin, and glomerular filtration rate (GFR) were collected at dialysis initiation. Patients who were unable to ambulate or to transfer, those who needed assistance with daily activities, and those who lived in a nursing home, assisted living, or other institutions were categorized as “inability to ambulate or institutionalized.” Chain and profit status associated with the facility in which the patient initiated dialysis were also determined using USRDS Facility file.

Interrupted Time Series Analysis

We used interrupted time series (ITS) regression models (segmented regression analysis)^{20,21} with maximum likelihood method to evaluate changes in rate of PD use that occurred after PPS, controlling for the baseline pre-PPS period. The ITS model in this study was the following:

$$Y[t] = \beta_0 + \beta_1 * \text{time before PPS} + \beta_2 * \text{PPS} + \beta_3 * \text{time after PPS} + e_t$$

where β_0 estimates PD rate at the beginning of the study period; β_1 estimates the change in PD rate each month before PPS; β_2 estimates the level change in PD rate immediately after PPS; and β_3 estimates the change in the trend in PD rate after PPS.

Serial autocorrelation was tested by the Durbin–Watson (DW) statistic by using backward elimination. Heteroscedasticity was tested by the Q statistic in the regression model. We also assessed seasonality by white noise test using the Fisher K and Bartlett Kolmogorov–Smirnov (BKS) statistic.²² We adjusted both seasonality and lagged intervention effects in our final factorial autoregressive models. We further stratified our analyses by patient demographics, clinical history, predialysis care, and dialysis facility chain and profit status to determine whether the effect of PPS differed among patient subgroups. Lagged effects and seasonality were assessed using stepwise autoregressive analyses. After adjustment, the Durbin–Watson statistic for our final factored autoregressive model was 1.803 (P value for hypothesis of positive autocorrelation = 0.127, P value for hypothesis of negative autocorrelation = 0.877) with R^2_{Autoreg} of 0.90, indicating no autocorrelation and good model fit. All analyses were conducted using SAS (SAS Institute Inc, Cary NC), mainly AUTOREG and SPECTEA procedures.

RESULTS

The study population across the 48 months ($N = 430,927$) comprised 57% male and 43% female

participants. Of the participants, 50% were aged ≥ 65 years; 66% were white; 56% were diabetic; 87% had hypertension; 54% had cardiovascular disease; 8% had cancer; 10% had chronic obstructive pulmonary disease; 8% were employed full time; and 18% were unable to ambulate or were institutionalized. Approximately 42% had no predialysis nephrology care, and 63% underwent dialysis in large dialysis organizations (LDOs). Although statistically significant because of our large sample size, there were only minor differences in patient age, sex, presence of comorbidities, laboratory values, and dialysis facility characteristics between the baseline pre-PPS and post-PPS periods (Table 1).

Unadjusted Analyses and Covariate Effects

Overall, the average PD use rate increased from 6.4% to 7.9% between the 2-year pre- and 2-year post-PPS periods for all dialysis patients (Table 2). Throughout the study, participants who were younger (18–44 years), female, white, employed full-time, and those with more than 12 months of nephrology care were more likely to start dialysis with PD compared to their counterparts ($P < 0.05$). Furthermore, healthier patients were more likely to start dialysis with PD ($P < 0.05$), including those without diabetes, cardiovascular disease, cancer, or chronic obstructive pulmonary disease, and those with higher values of hemoglobin (≥ 12 g/dl), serum albumin (≥ 3.5 g/dl), glomerular filtration rate (GFR) (≥ 8 ml/min/ 1.73 m²), and body mass index (BMI) (≥ 18.5 kg/m²). Patients who were unable to ambulate or who were institutionalized had the lowest rates of PD across the study period. Over the 4-year period, patients who had more than 12 months of predialysis care were more likely to start their dialysis with PD than those with 0 to 6 months of care or those without predialysis nephrology care. Patients who underwent dialysis in small dialysis organizations (SDOs) were more likely to start with PD as compared to those in nonchain facilities and LDOs (Table 2).

ITS Analysis of PD Rate

Figure 1 shows the actual, predicted, and mean rates of PD use for each month from January 2009 (4.8% use) to December 2012 (7.8% use), the end of the study period. ITS analysis indicated that PPS implementation resulted in increased use of PD in the 2-year period after PPS (change in slope = 0.04, 95% confidence interval [CI] = 0.03–0.06, $P < 0.0001$). The trend of increasing PD use began in the 2-year period prior to 2011 (trend [or slope] before bundling 0.04, 95% CI = 0.03–0.06, $P < 0.0001$) and accelerated in the 2-year follow-up. There was no immediate change in level of PD use after PPS ($P = 0.512$).

Table 1. Characteristics of patients initiating dialysis before and after the January 2011 Prospective Payment System (PPS)

Entire study period	Pre-PPS	Post-PPS	P value	
Number of patients	430,927	217,867	213,060	
Age group (yr)	%	%	%	
18–44	11.4	11.6	11.3	<0.0001
45–64	38.6	38.3	39.0	
≥ 65	49.9	50.1	49.7	
Sex				
Male	56.9	56.7	57.1	0.006
Female	43.1	43.3	42.9	
Race				
White	65.6	65.6	65.7	0.458
Nonwhite	34.4	34.4	34.3	
Ethnicity				
Hispanic	9.3	8.9	9.7	<0.0001
Non-Hispanic	86	86.3	85.7	
Employed full-time	8	8	8	0.739
Inability to ambulate/ institutionalized	17.8	17.6	18.1	<0.0001
Primary cause of renal failure				
Hypertension/large vessel disease	29.4	29.2	29.5	<0.0001
Diabetes	45.9	45.6	46.3	
Glomerulonephritis	5.8	5.8	5.8	
Other	18.9	19.4	18.4	
Diabetes	55.9	55.2	56.6	<0.0001
Hypertension	86.6	86.1	87.1	<0.0001
Cardiovascular disease	53.6	54.2	53.1	<0.0001
Atherosclerotic heart disease	20.1	21.1	19.2	<0.0001
Congestive heart failure	31.9	32.5	31.3	<0.0001
Other cardiac disease	18.3	18	18.6	<0.0001
Cerebrovascular disease	9.4	9.5	9.2	0.000
Peripheral vascular disease	13.3	13.7	12.8	<0.0001
Cancer	7.7	7.7	7.6	0.2575
Chronic obstructive lung disease	9.7	9.6	9.8	0.030
BMI (kg/m ² , mean \pm SD)	29.5 \pm 8.1	29.5 \pm 8.1	29.6 \pm 8.1	<0.0001
Hemoglobin (g/dl, mean \pm SD)	10.2 \pm 16.9	10.3 \pm 16.7	10 \pm 17.1	0.000
Serum albumin (g/dl, mean \pm SD)	3.2 \pm 4.4	3.2 \pm 4.7	3.2 \pm 4	0.201
GFR (ml/min/ 1.73 m ² , mean \pm SD) ^a	12 \pm 5.4	12.1 \pm 5.5	11.9 \pm 5.4	<0.0001
Nephrology care				
No care	41.7	42.9	40.6	<0.0001
0–12 mo	32.4	32.5	32.2	
>12 mo	25.9	24.6	27.2	
Facility chain status				<0.0001
LDO	63.2	61.8	64.6	
SDO	11.3	12.1	10.6	
Nonchain	25.5	26.2	24.8	
Facility profit status				<0.0001
For profit	83.6	82.7	84.4	
Nonprofit	16.4	17.3	15.6	

Pre-PPS period is from January 2009 to December 2010. Post-PPS period is from January 2011 to December 2012. P value for Pearson χ^2 test or t test was based on the difference between pre- and post-PPS periods. BMI, body mass index; GFR, glomerular filtration rate; LDO, large dialysis chain; SDO, small dialysis chain.

^aGFR was calculated using the Modification of Diet in Renal Disease Study (MDRD) equation.

Table 2. Rate of peritoneal dialysis (PD) use as proportion of all dialysis modality by patient characteristics from January 2009 to December 2012

Entire study period	%	Pre-PPS %	Post-PPS %
All	7.1	6.4	7.9
Demographics			
Age, yr			
18–44	11.8	10.4	13.3
45–64	8.2	7.5	9.0
65+	5.2	4.6	5.7
Sex			
Male	7.0	6.2	7.7
Female	7.3	6.6	8.0
Race			
White	7.6	6.9	8.3
Nonwhite	6.2	5.4	6.9
Employed full-time			
Yes	19.2	17.3	21.0
No	6.1	5.4	6.7
Comorbid conditions			
Cardiovascular disease			
Yes	4.7	4.3	5.2
No	9.9	8.8	10.9
Diabetes			
Yes	6.3	5.6	7.0
No	8.1	7.3	9.0
Hypertension			
Yes	7.3	6.6	8.0
No	6.0	5.2	6.8
Cancer			
Yes	4.7	4.1	5.3
No	7.3	6.6	8.1
Chronic obstructive lung disease			
Yes	3.4	3.1	3.6
No	7.5	6.7	8.3
Inability to ambulate/institutionalized			
Yes	2.0	1.7	2.2
No	8.2	7.4	9.1
Laboratory values			
BMI (kg/m ²)			
<18.5	4.4	3.8	5.0
18.5 to <30	7.2	6.5	8.0
≥30	7.2	6.4	7.9
Hemoglobin (g/dl)			
<10	4.8	4.0	5.5
10 to <12	9.6	8.6	10.7
≥12	11.4	10.8	12.2
Serum albumin (g/dl)			
<3.5	4.1	3.6	4.6
≥3.5	13.5	12.2	14.9
GFR (ml/min/1.73 m ²) ^a			
<5	4.2	3.5	4.9
5 to <8	6.4	5.6	7.1
≥8	7.7	6.9	8.5
Dialysis care			
Nephrology care			
No care	2.3	2.0	2.6
0–6 mo	9.6	8.8	10.4
>12 mo	11.9	10.9	12.7
Facility chain status			

(Continued)

Table 2. (Continued)

Entire study period	%	Pre-PPS %	Post-PPS %
LDO	6.9	6.1	7.7
SDO	8.0	6.9	9.4
Nonchain	7.3	6.9	7.7
Facility profit status			
For-profit	7.1	6.4	7.9
Nonprofit	7.0	6.3	7.8

Pre-PPS period is from January 2009 to December 2010. Post-PPS period is from January 2011 to December 2012. *P* value for Pearson χ^2 test or *t* test was based on the difference between pre- and post-PPS periods. BMI, body mass index; GFR, glomerular filtration rate; LDO, large dialysis chain; PPS, Prospective Payment System; SDO, small dialysis chain.

^aGFR was calculated using the Modification of Diet in Renal Disease Study (MDRD) equation.

Stratified ITS analyses indicated PPS led to an increased PD use across all age, race, and sex groups ($P < 0.05$) except in females ($P = 0.086$) after PPS (Table 3). Increased PD use was also found regardless of employment status, dialysis chain, or profit status. It appears that SDOs had a higher rate of PD increase compared to LDOs (change in slope = 0.12, 95% CI = 0.07–0.17, vs. 0.03, 95% CI = 0–0.05, respectively) (Figure 2). Similarly, it appears that nonprofit organizations had a higher rate of PD increase compared to for-profit organizations (change in slope = 0.08, 95% CI = 0.04–0.12 vs. 0.04, 95% CI = 0.02–0.06, respectively). The extent of nephrology care before dialysis had a unique pattern in terms of influencing PD use after PPS; no care and ≥ 12 months of pre-dialysis nephrology care resulted in similar changes in slope after PPS (0.05, with 95% CI = 0.04–0.07, and

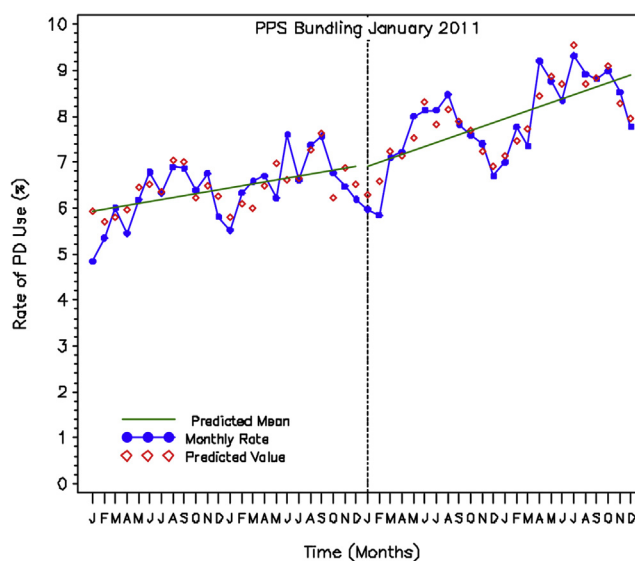


Figure 1. Time series of monthly peritoneal dialysis (PD) use from January 2009 to December 2012. Fitted trend line shows predicted values from the segmented regression analysis. PPS, Prospective Payment System.

Table 3. Changes in rate of peritoneal dialysis (PD) use after PPS assessed using interrupted time series stratified by selected characteristics

	Trend before bundling		Change in level after PPS		Change in trend after PPS	
	β_1	<i>P</i> value	β_2	<i>P</i> value	β_3	<i>P</i> value
All	0.04 (0.03–0.06)	<0.0001	-0.09 (-0.38 to 0.19)	0.512	0.04 (0.03–0.06)	<0.0001
Age, yr						
18–44	0.05 (-0.01 to 0.11)	0.085	0.49 (-0.68 to 1.67)	0.393	0.10 (0.03–0.17)	0.007
45–64	0.05 (0.03–0.08)	0.0001	-0.24 (-0.77 to 0.29)	0.354	0.04 (0.01–0.07)	0.020
≥ 65	0.04 (0.02–0.06)	<0.0001	-0.22 (-0.55 to 0.11)	0.186	0.03 (0.01–0.05)	0.009
Sex						
Female	0.05 (0.02–0.08)	0.001	0.02 (-0.55 to 0.60)	0.934	0.03 (0–0.07)	0.086
Male	0.04 (0.02–0.06)	<0.0001	-0.21 (-0.59 to 0.18)	0.286	0.05 (0.03–0.07)	<0.0001
Race						
White	0.03 (0.02–0.05)	<0.0001	-0.06 (-0.44 to 0.31)	0.729	0.05 (0.03–0.07)	<0.0001
Nonwhite	0.06 (0.04–0.07)	<0.0001	-0.14 (-0.51 to 0.23)	0.454	0.03 (0.01–0.05)	0.016
Employed full-time						
No	0.04 (0.03–0.05)	<0.0001	-0.16 (-0.39 to 0.08)	0.192	0.03 (0.02–0.05)	<0.0001
Yes	0.10 (0.04–0.17)	0.001	0.26 (-1.01 to 1.52)	0.683	0.08 (0.001–0.16)	0.04
Nephrology care						
No care	0.01 (0–0.02)	0.204	-0.20 (-0.44 to 0.03)	0.090	0.05 (0.04–0.07)	<0.0001
0–12 mo	0.08 (0.05–0.11)	<0.0001	0.07 (-0.47 to 0.62)	0.786	-0.03 (-0.06 to 0.01)	0.122
>12 mo	0.05 (0.01–0.09)	0.008	-0.35 (-1.12 to 0.42)	0.358	0.07 (0.02–0.11)	0.005
Chain status						
LDO	0.05 (0.03–0.07)	<0.0001	0.07 (-0.29 to 0.44)	0.684	0.03 (0–0.05)	0.020
SDO	0.03 (0–0.07)	0.071	0.23 (-0.54 to 0.99)	0.549	0.12 (0.07–0.17)	<0.0001
Nonchain	0.037 (0.01–0.06)	0.01	-0.91 (-1.49 to 0.33)	0.003	0.06 (0.03–0.10)	0.001
Profit/nonprofit						
For profit	0.05 (0.03–0.06)	<0.0001	-0.17 (-0.49 to 0.16)	0.296	0.039 (0.02–0.06)	0.0002
Nonprofit	0.01 (-0.02 to 0.04)	0.486	0.263 (-0.37 to 0.90)	0.407	0.078 (0.04–0.12)	0.0002

LDO, large dialysis chain; PPS, Prospective Payment System; SDO, small dialysis chain.

0.07, with 95% CI = 0.02–0.11, respectively), but PD use in patients with 0 to 12 months of nephrology care did not change (-0.03 with 95% CI = -0.06 to 0.01) (Table 3 and Figure 2). The rate of PD use significantly increased after PPS among ESRD patients with diabetes and hypertension as well as those whose with BMI ≥ 30 or GFR ≥ 5 ml/min at dialysis initiation (Supplementary Table S1).

In a secondary analysis ascertaining PD modality at month 3 versus at initiation of dialysis, the total PD population in the ITS analysis was 199,937 (less than one-half of the PD population identified using the 2728 form). Because “claims data” are required to identify PD patients at month 3, patients who were Medicare Secondary Payor (MSP) and those enrolled in health maintenance organization plans were not included in this secondary analysis. However, results from this secondary analysis are similar to the results reported above. The ITS analysis indicated that PPS implementation resulted in increased use of PD in the 2-year period after PPS (change in slope = 0.03, 95% CI = 0.02–0.05, $P < 0.003$). The trend of increasing PD use also began in the 2-year period prior to 2011 (trend [or slope] before bundling = 0.07, 95% CI = 0.05–0.09, $P < 0.0001$). There was no immediate

change in level of PD use after PPS ($P = 0.902$) (Supplementary Figure S1).

DISCUSSION

Our study confirmed the previously unexamined hypothesis that implementation of the CMS ESRD Prospective Payment System is associated with an increase in PD use in incident dialysis patients in the USA. This trend started prior to 2011 (implementation of PPS) but accelerated in the 2 years after PPS was launched. Our findings are consistent with USRDS Annual Data Report,²³ and recent studies^{24–26} showing an increase in rate of PD use over time. However, these previous studies and reports were descriptive in nature, whereas our study, using the census of dialysis patients initiating PD therapy in the USA was the first to use a causal, quasi-experimental design to demonstrate that PPS itself was effective in increasing PD use.

Historically, financial considerations have played an important role in many clinical decisions among ESRD patients.²⁷ In this case, choice of PD shifted from a financial disincentive before PPS to an incentive after PPS. Specifically, under the past payment structure, injectable medications such as ESAs were paid based on the total amount administered; because a PD patient

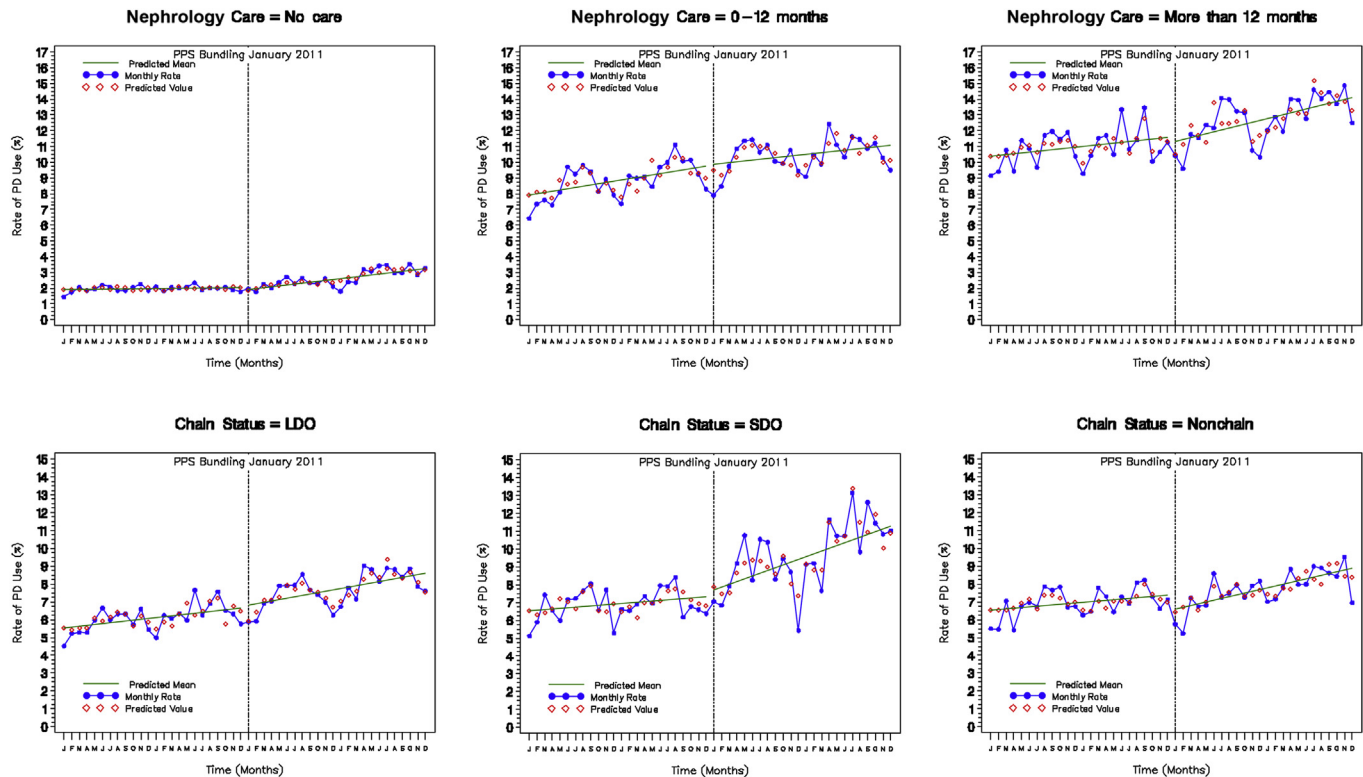


Figure 2. Time series of monthly peritoneal dialysis (PD) use by predialysis nephrology care or dialysis facility chain status from January 2009 to December 2012. Fitted trend line shows predicted values from the segmented regression analysis. LDO, large dialysis organization; SDO, small dialysis organization.

tended to use less i.v. medication than an HD patient, potential revenues and profits generated from larger dosage of injectable drugs given at HD treatment outweighed the less costly PD use.²⁸ Consequently, providers might have been discouraged to prescribe PD as a dialysis treatment option. Conversely, PPS applies a fixed payment covering all dialysis services including injectable drugs. Given the equal payments for both HD and PD modalities, savings from significantly fewer requirements of expensive ESA doses makes delivery of PD treatment more profitable to the provider compared to HD treatment. Combined with fewer staffing requirements and less expensive supplies, providers could administer more PD care with less use of resources and could take advantage of the inherent profitability of PD under the new bundle.

In addition to injectable medications, other factors were important in the growth of home dialysis before and after PPS. According to Mark Neumann, Editor-in-Chief at *Nephrology News & Issues* (NN&I), who conducted an annual ranking of dialysis providers in the USA,²⁹ the percentage of patients on home therapies, particularly PD, has been growing since 2010. Incentives offered by Medicare such as the Comprehensive ESRD Care Initiative demonstration played an important role in helping patients choose PD therapy. Educational efforts, such as the NN&I-produced

webinar “Home Dialysis: Next Steps” have also been touted as increasing visibility and decreasing barriers associated with home dialysis. Numerous courses made available by universities, the American Society of Nephrology (ASN), the National Kidney Foundation (NKF), the International Society for Peritoneal Dialysis (ISPD), and other renal organizations were designed to expand the knowledge base and comfort level of physicians to perform PD. A movement to offer patients “urgent” PD therapy instead of the traditional route from the emergency department of an HD catheter and in-center HD has garnered interest and increased initiation of PD.³⁰ Other home dialysis programs have succeeded using a Web-based project funded by Baxter that offers expertise on setting up a home program. Finally, increasing emphasis on predialysis education paid by Medicare—the Kidney Disease Education (KDE) benefit—has helped more patients learn about PD.

During the past 2 decades, the ESRD industry has undergone tremendous market structural changes, with an influx of large, for-profit, multi-unit dialysis chains. Our finding that SDOs and nonprofit organizations appear to have increased use of PD after PPS compared to their LDO and for-profit counterparts may have been anticipated given their PD use prior to PPS; that is, historically, PD use has been significantly lower

in for-profit units compared with not-for-profit units,³¹ and lower in large dialysis chain facilities (mostly for-profit) than in smaller units. Although the potential profitability of PD after PPS is anticipated to increase its use in all facilities, studies have shown that for-profit facilities appear to use fewer resources^{32,33} to deliver hemodialysis services and therefore might not benefit financially to the same extent as nonprofit organizations and SDOs.

Although PPS has increased rates of PD use, these rates remain low compared to other industrialized countries and the National Kidney Foundation (NKF) goals. Several significant barriers might need to be addressed in order to promote PD use in the future. First, long-existing HD facilities in practice may impede investing in construction of PD infrastructure.³⁴ As a matter of fact, lack of PD supplies might be a bottleneck limiting PD use as reported, a plunge in PD rate in 2014 due to dialysate shortage.³⁵ Rising of PD also calls upon adequate training of personnel to prepare them to implement PD. Currently, PD training during nephrology fellowship in the USA is very limited because it is not required by the Accreditation Council for Graduate Medical Education (ACGME).³⁶ One study revealed 29% of nephrology training programs in the USA had fewer than 5 PD patients for 1 fellow; 14% of these programs spent less than 5% of the training time on PD training.³⁷ Consequently, when surveyed, only one-half of nephrologists felt prepared to use PD and comfortable using it.³⁸ Moreover, our study showed that length of predialysis care is associated with increased PD use, which is consistent with previous results that patient misconception and lack of knowledge of PD are strong barriers to PD use.³⁹ and patients who are referred early to a nephrologist are more likely to choose PD.⁴⁰ Referring patients in the late stages of chronic kidney disease to a nephrologist is an important key to improving patient PD use.

A previous systematic review of 58 studies on Medicare's use of Prospective Payment Systems by the Agency for Healthcare Research and Quality (AHRQ) concluded that bundled payment programs have successfully reduced costs without incurring major compromises on quality of care.⁴¹ Other studies, similar to ours, that have examined changes in practice patterns after implementation of ESRD PPS have shown that dialysis providers are now motivated to adopt less expensive strategies given bundling for injectable medications; for example, using less expensive oral and i.v. iron to substitute for ESA to treat anemia, increasing use of subcutaneous ESA route of administration (which requires a one-third to one-half the dose of i.v. ESA administration), and using less expensive oral vitamin D versus i.v. vitamin D.^{42,43}

Overall Medicare spending for dialysis drugs has been estimated to be reduced by \$25 per dialysis session per patient after PPS.²⁴ However, it might be too early to conclude that ESRD PPS represents a successful policy reform, without evidence that these substantial changes in care patterns have not adversely affected survival among dialysis patients.

Our study has several limitations. First, we were unable to include a comparable control group to investigate effects of other factors on PD use during the 4 years of the study, as PPS is a universal payment reform affecting ~95% of dialysis patients in the USA enrolled in the Medicare ESRD Program. However, use of a quasi-experimental interrupted time series design enabled us to adjust for baseline trend and autocorrelation to improve internal validity.⁴⁴ Moreover, the large sample size and tight indicator trend lines used in this study provide compelling evidence for the association of PPS with increased PD use. Future studies will determine whether this trend of increasing PD use is sustained by PPS and whether it will ameliorate the high mortality rates (nearly 17% annually) found among the dialysis population in the USA.¹²

It is hoped that our results will inform policymakers inside and outside of the ESRD community regarding the possible effects of changes in financial incentives. We used an innovative time series model that uses Medicare ESRD payment reform as a "natural experiment" to study the impact of PPS on PD modality. Information provided herein is useful as Medicare continues to implement payment reforms that shift reimbursement from fee-for-service toward episode-based or capitated payments. With the passage of the Patient Protection and Affordable Care Act (ACA), policymakers face the challenge of minimizing health care costs while maintaining or improving quality of care.

In conclusion, the CMS PPS has led to an increase in the use of PD among incident ESRD patients. Our findings highlight the role of financial incentives in changing practice patterns, in this case to increase the use of a dialysis modality considered by many to be both more cost-effective and empowering to ESRD patients.

DISCLOSURE

All the authors declared no competing interests.

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SUPPLEMENTARY MATERIAL

Figure S1. Time series of monthly peritoneal dialysis (PD) use at month 3 after dialysis initiation from January 2009 to December 2012. Fitted trend line shows predicated values from the segmented regression analysis. PPS, Prospective Payment System.

Table S1. Changes in rate of peritoneal dialysis (PD) use after Prospective Payment System (PPS) assessed using interrupted time series stratified by comorbidities.

Supplementary material is linked to the online version of the paper at <http://www.kireports.org>.

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