

Trends in Peritoneal Dialysis Use in the United States after Medicare Payment Reform

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Supplemental Statistical Model Information

Model fit and specification: Multiple logistic regression models were fit to examine changes in outcomes between the pre-prospective payment system (PPS) and post-PPS periods, adjusting for patient and regional characteristics. We modeled time of dialysis initiation in years (2006-2013), with the PPS beginning in 2011, using discontinuity regression models. For modeling time in years (2006-2013) with PPS in 2011, we examined three different types of discontinuity regression models:

- 1) intercept shift at 2011 with constant slope across all years;
- 2) no intercept shift in 2011 but separate slopes for pre-PPS (2006-2010) and post-PPS (2011-2013); and
- 3) intercept shift in 2011 with separate slopes as noted above for the pre- and post-PPS periods.

In these models, we examined different functional forms for slopes of time that included linear, quadratic, cubic and quartic terms. Model selection criteria (Akaike Information Criteria)¹ was used to select the best model mean structure and functional form for time.

Model estimates: To estimate the PPS effect (odds ratio) for all outcomes, we averaged over the pre-PPS years (2006-2010) using estimates of the intercept and slope parameters and averaged over the post-PPS years (2011-2013) using estimates of the intercept, intercept shift at 2011, and slope parameters from the logistic regression models. Predicted probabilities over the pre-PPS and post-PPS periods, as well as for individual years, were estimated using the appropriate intercept and slope parameters with fixed values of all covariates centered at means. Caution should be used when inferring these probabilities to population parameters.

Reference

Akaike H. A new look at the statistical model identification. *IEEE. Trans Automat Contr.* 1974;19:716-2

Supplemental Table 1. Incident ESKD patient and market characteristics by policy period

Patient characteristics at dialysis initiation	Pre-Policy: 2006-2010 (n=387,115)	Post-Policy: 2011-2013 (n=232,011)
<i>Demographic characteristics</i>		
Age, mean (SD)	61 (16)	61 (15)
Male, N (%)	219,504 (57)	134,223 (58)
Race, N %		
White	246,687 (64)	150,305 (65)
Black	117,920 (31)	67,373 (29)
Other	22,508 (6)	14,333 (6)
Hispanic ethnicity, N (%)	53,031 (14)	34,383 (15)
Employed, full or part-time, N (%)	48,576 (13)	29,021 (13)
Urban residential status, N (%)	307,561 (79)	185,169 (80)
Distance to nearest dialysis facility ^a , mean miles (SD)	4 (7)	4 (7)
Relative distance to nearest PD facility ^b , mean miles (SD)	5 (12)	4 (11)
Region, N (%)		
South	163,112 (42)	98,550 (43)
Midwest	84,397 (22)	48,949 (21)
Northeast	66,128 (17)	38,221 (17)
West	73,478 (19)	46,291 (20)
Insurance coverage, N (%) ^c		
Medicare	198,294 (51)	127,693 (55)
Medicaid	106,632 (28)	66,481 (29)
Department of Veterans Affairs	8,276 (2)	5,900 (3)
Private	107,788 (28)	56,256 (24)
Other	78,968 (20)	42,933 (19)
None	35,009 (9)	20,406 (9)
<i>Clinical characteristics</i>		
Cause of ESKD, N (%)		
Diabetes	180,245 (47)	109,419 (47)
Hypertension	110,058 (28)	69,199 (30)
Glomerulonephritis	35,915 (9)	20,171 (9)
Other	47,433 (12)	27,102 (12)
Unknown	13,464 (4)	6,120 (3)

Comorbidities, N (%) ^d		
Hypertension	333,392 (86)	204,615 (88)
Diabetes	210,057 (54)	131,726 (57)
Congestive heart failure	119,401 (31)	65,693 (28)
Coronary artery disease	76,952 (20)	37,918 (16)
Peripheral vascular disease	50,442 (13)	25,534 (11)
Pre-ESKD nephrology care, N (%)		
Yes	231,527 (60)	144,115 (62)
No	111,636 (29)	59,757 (26)
Unknown	43,952 (11)	28,139 (12)
BMI, mean (SD)	29 (8)	30 (8)
eGFR, mL/mn/1.73m ² ^e , mean (SD)	10 (6)	10 (6)

Market Characteristics (Hospital Referral Region, HRR)

Dialysis facility composition, mean (SD)		
% offering PD ^f , 2006	38 (16)	38 (16)
% Freestanding facilities	89 (16)	91 (13)
% For-profit owned	81 (20)	85 (18)
% Chain affiliated	83 (17)	87 (15)
% Urban location	77 (24)	78 (23)
Dialysis market competition ^g , mean (SD)	39 (18)	39 (18)
Hospital density ^h , mean (SD)	306 (120)	293 (112)
% urban general population, mean (SD)	81 (16)	81 (16)
Per capita income, \$1000s, mean (SD)	38,700 (8,400)	43,000 (8,900)

BMI: body mass index; ESKD: end-stage kidney disease; eGFR: estimated glomerular filtration rate (eGFR), PD: peritoneal dialysis, SD: standard deviation

^a Distance to nearest dialysis facility, which may or may not offer PD.

^b Difference between distance to nearest dialysis facility and distance to nearest dialysis facility that offers PD.

^c Insurance status is not mutually exclusive. Patients can have multiple sources of insurance coverage.

^d Other comorbidities include chronic obstructive pulmonary disease, cerebrovascular disease, inability to ambulate, inability to transfer, other cardiac disease, cancer, drug dependence, tobacco use.

^e Calculation of eGFR is based on the CKD EPI formula.

^f PD includes continuous ambulatory PD, continuous cycler PD, and other PD.

^g Measured using the Herfindahl-Hirschman Index of dialysis market competition, which is equal to the sum of the square of each dialysis facility's market share, based on the number of dialysis patients unique to each facility. Index values range from 0 to 100, where a value of 0 reflects unconcentrated, competitive markets and values approaching 100 characterize concentrated, monopolistic markets.

^h Hospital density is defined as the number of community hospital beds per 100,000 people in a hospital referral region.

Supplemental Table 2. Odds ratio estimates from logistic regression models for all covariates for outcomes early PD experience, late PD use, HD to PD switches and PD to HD switches

	Full sample Pre-PPS period N=387,115 Post-PPS period N=232,011		Subgroup with no Early PD experience pre-PPS period N=350,619 post-PPS period N=202,837	Subgroup with early PD Experience pre-PPS period N=36,496 post-PPS period N= 29,174
	Early PD experience OR (95% CI)	Late PD use OR (95% CI)	Switch from HD to PD ^a OR (95% CI)	Switch from PD to HD ^b OR (95% CI)
Post-PPS*	1.51 (1.47-1.55)	1.47 (1.45-1.50)	1.59 (1.52-1.66)	0.92 (0.87-0.98)
<i>Demographic characteristics</i>				
Age – 5 year increase	0.89 (0.89-0.89)	0.88 (0.87-0.88)	0.87 (0.86-0.87)	0.98 (0.98-0.99)
Male	0.86 (0.85-0.88)	0.85 (0.84-0.86)	0.83 (0.81-0.85)	1.12 (1.08-1.16)
Race				
White	--	--	--	--
Black	0.59 (0.57-0.60)	0.58 (0.57-0.60)	0.61 (0.59-0.63)	1.17 (1.12-1.23)
Other	0.97 (0.93-1.00)	0.88 (0.85-0.91)	0.67 (0.62-0.71)	0.73 (0.67-0.79)
Hispanic ethnicity	1.28 (1.24-1.31)	1.41 (1.37-1.45)	1.75 (1.67-1.84)	1.12 (1.05-1.19)
Employed, full or part-time	1.69 (1.65-1.73)	1.62 (1.59-1.66)	1.29 (1.24-1.35)	0.92 (0.88-0.97)
Urban residential status	0.94 (0.92-0.97)	0.93 (0.91-0.95)	0.91 (0.87-0.95)	1.01 (0.96-1.06)
Distance to nearest dialysis facility ^c	1.02 (1.02-1.02)	1.02 (1.02-1.03)	1.02 (1.02-1.02)	1.00 (0.99-1.00)
Relative distance to nearest PD facility ^d	1.00 (1.00-1.00)	1.00 (0.99-1.00)	0.99 (0.99-0.99)	1.00 (1.00-1.00)
Region				
South	--	--	--	--
Midwest	0.91 (0.89-0.93)	0.92 (0.90-0.94)	0.93 (0.89-0.97)	0.92 (0.87-0.97)
Northeast	0.71 (0.69-0.73)	0.73 (0.71-0.75)	0.80 (0.76-0.84)	0.99 (0.92-1.06)
West	1.03 (1.00-1.06)	1.06 (1.03-1.09)	1.13 (1.07-1.18)	1.02 (0.96-1.09)
Insurance coverage ^e				
Medicare	0.96 (0.93-0.98)	0.92 (0.90-0.94)	0.89 (0.95-0.92)	1.09 (1.03-1.15)
Medicaid	0.61 (0.60-0.63)	0.60 (0.59-0.62)	0.63 (0.60-0.66)	1.16 (1.08-1.24)
Department of Veterans Affairs	0.70 (0.65-0.75)	0.80 (0.76-0.85)	1.06 (0.96-1.17)	1.12 (0.97-1.30)

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Private	1.41 (1.37-1.45)	1.39 (1.35-1.43)	1.25 (1.19-1.31)	0.88 (0.82-0.94)
Other	1.10 (1.07-1.13)	1.11 (1.08-1.14)	1.13 (1.07-1.18)	0.90 (0.85-0.96)
None	1.05 (1.01-1.10)	1.02 (0.99-1.06)	1.01 (0.95-1.08)	1.21 (1.11-1.32)
<i>Clinical characteristics</i>				
Cause of ESKD				
Diabetes	--	--	--	--
Hypertension	0.98 (0.96-1.01)	1.01 (0.99-1.04)	1.07 (1.03-1.12)	0.90 (0.84-0.95)
Glomerulonephritis	1.22 (1.18-1.26)	1.30 (1.26-1.34)	1.42 (1.35-1.50)	0.83 (0.77-0.89)
Other	0.92 (0.89-0.95)	0.93 (0.90-0.96)	0.96 (0.91-1.02)	0.81 (0.75-0.87)
Unknown	1.06 (1.01-1.12)	1.06 (1.01-1.11)	1.06 (0.97-1.15)	0.79 (0.70-0.89)
Comorbidities ^f				
Hypertension	1.04 (1.01-1.07)	1.03 (1.01-1.06)	1.02 (0.98-1.06)	1.10 (1.04-1.17)
Diabetes	0.85 (0.83-0.87)	0.88 (0.86-0.90)	0.97 (0.93-1.01)	1.21 (1.15-1.28)
Congestive heart failure	0.66 (0.64-0.67)	0.72 (0.70-0.73)	0.91 (0.88-0.95)	1.05 (1.00-1.11)
Coronary artery disease	0.96 (0.94-0.99)	1.00 (0.98-1.02)	1.10 (1.06-1.15)	0.92 (0.87-0.98)
Peripheral vascular disease	0.89 (0.87-0.92)	0.93 (0.90-0.96)	1.03 (0.98-1.08)	1.06 (0.99-1.13)
Pre-ESKD nephrology care	3.01 (2.94-3.09)	2.09 (2.04-2.13)	0.96 (0.93-1.00)	0.89 (0.84-0.94)
BMI	0.99 (0.98-0.99)	0.99 (0.99-0.99)	1.00 (0.99-1.00)	1.02 (1.02-1.02)
eGFR ^g	1.01 (1.01-1.01)	1.01 (1.00-1.01)	0.99 (0.99-0.99)	0.99 (0.99-0.99)
<i>Market Characteristics (Hospital Referral Region, HRR)</i>				
Dialysis facility composition -10% increase				
% offering PD ^h , 2006	1.08 (1.07-1.08)	1.08 (1.07-1.08)	1.07 (1.06-1.08)	0.99 (0.98-1.00)
% Freestanding facilities	1.04 (1.03-1.05)	1.04 (1.03-1.05)	1.02 (1.01-1.04)	0.99 (0.97-1.01)
% For-profit owned	1.01 (1.00-1.02)	1.00 (0.99-1.01)	0.99 (0.98-1.00)	1.00 (0.99-1.02)
% Chain affiliated	1.00 (0.99-1.01)	1.01 (1.00-1.01)	1.03 (1.02-1.04)	1.00 (0.99-1.02)
% Urban location	1.03 (1.02-1.04)	1.03 (1.02-1.03)	1.01 (0.99-1.02)	0.99 (0.97-1.00)
Dialysis market competition ⁱ – 10% increase	1.00 (1.00-1.00)	1.00 (1.00-1.01)	1.00 (0.99-1.01)	0.99 (0.98-1.00)
Hospital density ^j -100 bed increase	1.38 (1.28-1.49)	1.30 (1.22-1.40)	1.06 (0.94-1.20)	0.91 (0.77-1.06)
Percent urban population	0.89 (0.87-0.90)	0.90 (0.89-0.91)	0.92 (0.90-0.94)	0.98 (0.96-1.01)
Per capita income – \$10K increase	0.98 (0.97-1.00)	0.96 (0.95-0.97)	0.92 (0.90-0.94)	1.01 (0.98-1.04)

BMI: body mass index; ESKD: end-stage renal disease; eGFR: estimated glomerular filtration rate (eGFR), PD: peritoneal dialysis, PPS: Medicare prospective payment system for dialysis, SD: standard deviation

* To assess the overall PPS effect (odds ratio) for each of the outcomes, we exponentiated the estimated the difference in PD outcomes between the pre-PPS and post-PPS periods, averaging over the years in each of the periods.

^a Fewer than 0.3% of these patients (n=631 pre-PPS, n=699 post-PPS) actually did try PD in the first 90 days but switched to HD prior to day 90 and then switched back to PD after day 90.

^b One patient in the pre-PPS period actually initiated dialysis with HD, but switched to PD prior to day 90, and then switched back to HD after day 90.

^c Distance to nearest dialysis facility, which may or may not offer PD.

^d Difference between distance to nearest dialysis facility and distance to nearest dialysis facility that offers PD.

^e Insurance status is not mutually exclusive. Patients can have multiple sources of insurance coverage.

^f Other comorbidities included chronic obstructive pulmonary disease, cerebrovascular disease, inability to ambulate, inability to transfer, other cardiac disease, cancer, drug dependence, tobacco use.

^g Calculation of eGFR is based on the CKD EPI formula.

^h PD includes continuous ambulatory PD, continuous cycler PD, and other PD.

ⁱ Measured using the Herfindahl-Hirschman Index of dialysis market competition. Higher values correspond to less competition, i.e. more monopolistic markets.

^j Hospital density is defined as the number of community hospital beds per 100,000 people in a hospital referral region.

Supplemental Table 3. Estimated PPS effect and model parameters from logistic regression models for outcomes early PD experience, late PD use, HD to PD switch and PD to HD switch outcome

	Full sample Pre-PPS period N=387,115 Post-PPS period N=232,011				Subgroup with no Early PD experience pre-PPS period N=350,619 post-PPS period N=202,837		Subgroup with early PD Experience pre-PPS period N=36,496 post-PPS period N= 29,174	
	Early PD experience		Late PD use		Switch from HD to PD ^a		Switch from PD to HD ^b	
	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value
Post-PPS ^c	0.41	<.0001	0.39	<.0001	0.46	<.0001	-0.08	0.004
Intercept	-2.72	<.0001	-2.39	<.0001	-3.69	<.0001	-1.00	<.0001
Year	-0.08	<.0001	-0.08	<.0001	-0.04	0.20	0.00	0.96
Year*Year	0.04	<.0001	0.05	<.0001	0.06	<.0001	-0.01	0.56
Year*Year*Year	-0.00	<.0001	-0.00	<.0001	-0.01	<.0001	0.00	0.63
Post-PPS Intercept shift	-0.00	0.96	-0.02	0.31	-0.04	0.28	0.06	0.23
<i>Demographic characteristics</i>								
Age	-0.02	<.0001	-0.03	<.0001	-0.03	<.0001	0.00	<.0001
Male	-0.15	<.0001	-0.16	<.0001	-0.19	<.0001	0.11	<.0001
Race								
White	--	--	--	--	--	--	--	--
Black	-0.53	<.0001	-0.54	<.0001	-0.50	<.0001	0.16	<.0001
Other	-0.03	0.07	-0.12	<.0001	-0.41	<.0001	-0.32	<.0001
Hispanic ethnicity	0.24	<.0001	0.34	<.0001	0.11	0.56	0.11	0.00
Employed, full or part-time	0.53	<.0001	0.48	<.0001	-0.08	0.26	-0.08	0.00
Urban residential status	-0.06	<.0001	-0.07	<.0001	0.01	-0.10	0.01	0.81
Distance to nearest dialysis facility ^d	0.02	<.0001	0.02	<.0001	0.00	0.02	-0.00	0.00
Relative distance to nearest PD facility ^e	-0.00	<.0001	-0.01	<.0001	0.00	-0.01	-0.00	0.36
Region								
South	--	--	--	--	--	--	--	--
Midwest	-0.09	<.0001	-0.09	<.0001	-0.07	0.00	-0.09	0.00
Northeast	-0.34	<.0001	-0.32	<.0001	-0.23	<.0001	-0.01	0.74
West	0.03	0.08	0.06	<.0001	0.12	<.0001	0.02	0.47

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Insurance coverage ^f								
Medicare	-0.05	0.00	-0.08	<.0001	-0.12	<.0001	0.08	0.00
Medicaid	-0.49	<.0001	-0.51	<.0001	-0.47	<.0001	0.14	<.0001
Department of Veterans Affairs	-0.36	<.0001	-0.22	<.0001	0.06	0.23	0.11	0.13
Private	0.34	<.0001	0.33	<.0001	0.22	<.0001	-0.13	<.0001
Other	0.09	<.0001	0.10	<.0001	0.12	<.0001	-0.10	0.00
None	0.05	0.02	0.02	0.20	0.01	0.75	0.19	<.0001
<i>Clinical characteristics</i>								
Cause of ESKD								
Diabetes	--	--	--	--	--	--	--	--
Hypertension	-0.02	0.24	0.01	0.44	0.07	0.00	-0.11	0.00
Glomerulonephritis	0.20	<.0001	0.26	<.0001	0.35	<.0001	-0.19	<.0001
Other	-0.09	<.0001	-0.07	<.0001	-0.04	0.17	-0.21	<.0001
Unknown	0.06	0.03	0.06	0.02	0.06	0.19	-0.24	0.00
Comorbidities								
Hypertension	0.04	0.00	0.03	0.01	0.02	0.38	0.10	0.00
Diabetes	-0.17	<.0001	-0.13	<.0001	-0.03	0.15	0.19	<.0001
Congestive heart failure	-0.42	<.0001	-0.33	<.0001	-0.09	<.0001	0.05	0.06
Coronary artery disease	-0.04	0.01	0.00	0.88	0.09	<.0001	-0.08	0.01
Other heart disease	-0.14	<.0001	-0.09	<.0001	0.04	0.05	-0.01	0.81
Peripheral vascular disease	-0.11	<.0001	-0.07	<.0001	0.03	0.22	0.05	0.12
Cerebrovascular disease	-0.15	<.0001	-0.15	<.0001	-0.10	0.00	0.09	0.03
Chronic obstructive pulmonary disease	-0.37	<.0001	-0.30	<.0001	-0.11	0.00	0.00	0.92
Cancer	-0.27	<.0001	-0.22	<.0001	-0.08	0.01	0.07	0.14
Inability to ambulate	-0.85	<.0001	-0.78	<.0001	-0.56	<.0001	-0.19	0.06
Inability to transfer	-0.54	<.0001	-0.58	<.0001	-0.54	<.0001	-0.50	0.01
Drug abuse	-0.93	<.0001	-0.92	<.0001	-0.79	<.0001	0.37	0.00
Tobacco abuse	-0.05	0.01	-0.03	0.05	0.00	0.99	0.23	<.0001
Pre-ESKD nephrology care								
Yes	--	--	--	--	--	--	--	--
No	-1.10	<.0001	-0.74	<.0001	0.04	0.02	0.12	<.0001
Unknown	-1.10	<.0001	-0.79	<.0001	-0.10	<.0001	0.07	0.10
BMI	-0.02	<.0001	-0.01	<.0001	-0.01	<.0001	0.02	<.0001
eGFR ^g	0.01	<.0001	0.01	<.0001	-0.01	<.0001	-0.01	<.0001

<i>Market Characteristics (Hospital Referral Region, HRR)</i>									
Dialysis facility composition									
% offering PD ^h , 2006	0.01	<.0001	0.01	<.0001	0.01	<.0001	-0.00	0.03	
% Freestanding facilities	0.00	<.0001	0.00	<.0001	0.00	0.01	-0.00	0.36	
% For-profit owned	0.00	0.02	0.00	0.75	-0.00	0.02	0.00	0.59	
% Chain affiliated	0.00	0.45	0.00	0.09	0.00	<.0001	0.00	0.72	
% Urban location	0.00	<.0001	0.00	<.0001	0.00	0.36	-0.00	0.24	
Dialysis market competition ⁱ	-0.00	0.64	0.00	0.56	0.00	0.46	-0.00	0.08	
Hospital density ^j	0.00	<.0001	0.00	0.00	-0.00	0.00	0.00	0.05	
Percent urban population	-0.01	<.0001	-0.01	<.0001	-0.01	<.0001	-0.00	0.20	
Per capita income	-0.00	0.01	-0.00	<.0001	-0.01	<.0001	0.00	0.46	

BMI: body mass index; ESKD: end-stage kidney disease; eGFR: estimated glomerular filtration rate (eGFR), PD: peritoneal dialysis, PPS: Medicare prospective payment system for dialysis, SD: standard deviation

^a Fewer than 0.3% of these patients (n=631 pre-PPS, n=699 post-PPS) actually did try PD in the first 90 days, but switched to HD prior to day 90 and then switched back to PD after day 90.

^b One patient in the pre-PPS period actually initiated dialysis with HD, but switched to PD prior to day 90, and then switched back to HD after day 90.

^c To assess the overall PPS effect for each of the outcomes, we estimated the difference in PD outcomes between the pre-PPS and post-PPS periods, averaging over the years in each of the periods^d Distance to nearest dialysis facility, which may or may not offer PD.

^d Absolute distance to nearest dialysis facility, agnostic to dialysis modality offering.

^e Difference between distance to nearest dialysis facility and distance to nearest dialysis facility that offers PD.

^f Insurance status is not mutually exclusive: patients can have multiple sources of insurance coverage.

^g Calculation of eGFR is based on the CKD EPI formula.

^h PD includes continuous ambulatory PD, continuous cycler PD, and other PD.

ⁱ Measured using the Herfindahl-Hirschman Index of dialysis market competition. Higher values correspond to less competition, i.e. more monopolistic markets.

^j Hospital density is defined as the number of community hospital beds per 100,000 people in a hospital referral region.

Supplemental Figure 1. Patient Sampling Frame

