Dialysis Modality Selection Among Patients Attending Freestanding Dialysis Facilities

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Persons with end stage renal disease (ESRD) are eligible to receive dialysis services under the Medicare program. An individual-level analysis was performed to determine the factors associated with the modality selected by patients; namely in-center hemodialysis, continuous ambulatory peritoneal dialysis (CAPD), continuous cycling peritoneal dialysis (CCPD), and home hemodialysis. Logistic regression equations were estimated using program data for 73,448 ESRD Medicare patients attending freestanding dialysis facilities. The results showed that CAPD, CCPD, and home hemodialysis were more likely to be selected by patients who were younger, had non-systemic precipitating causes of ESRD, had a shorter duration of ESRD, attended larger facilities, and were not ethnic minorities. There is no consistent evidence demonstrating the superiority of particular modalities. The policy goal should be to enable beneficiaries to use the modality for which they are best suited, which requires that the range of modalities be available to all ESRD beneficiaries.

INTRODUCTION

In 1972, Congress passed legislation extending Medicare coverage to persons with chronic renal failure; this legislation became effective July 1, 1973. At present, a variety of treatment modalities are available. The modality used by a particular patient may be influenced by clinical factors, convenience of use, availability in the patient's area, and other considerations. Medicare payment policy should not affect the modality used, since Medicare pays providers of renal dialysis services a flat rate for each dialysis session.[1]

The large majority (83 percent in 1993) of beneficiaries in the Medicare ESRD program undergoing dialysis in 1993 used in-center hemodialysis. This modality requires the patient to be intravenously connected to a dialysis machine for a session lasting 3 to 4 hours, and to receive about three such sessions per week. The dialysis machine performs the function of a kidney, whereby the patient's blood enters the machine, is purified and then is returned into the patient through the intravenous connection. In contrast to hemodialysis, another type of dialysis uses the patient's peritoneal cavity and peritoneal membrane. One form of this type of dialysis is CAPD. Under this modality, dialysate is introduced through a catheter into the peritoneal cavity. The peritoneal membrane allows the blood to be purified as it passes through the membrane into the dialysate. Once the concentration level of toxins on both sides of the membrane is in equilibrium, the patient drains the dialysate and replaces it with new fluid. A patient exchanges fluid four times a day, each exchange taking twenty to thirty minutes.

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[1] In 1993, during the first 18 months (increased to 30 months in the 1997 Balanced Budget Act) of dialysis, Medicare is the secondary payor. In this period, providers can charge private insurers amounts other than Medicare rates. There is no data on the amount of these charges. If these charges differ across modalities, this may affect the modality chosen during this Medicare secondary payor period, and subsequently after the 18-month window.

A similar modality is CCPD.[2] This modality also uses the peritoneal cavity and peritoneal membrane but the patient is connected to a machine, usually overnight, which continuously supplies and removes dialysate to the patient's peritoneal cavity. The patient may also supplement this modality with CAPD during the day. Another less common modality is home hemodialysis, which is the same as in-center hemodialysis, except the patient uses a machine in his or her own home.

Patients using CAPD, CCPD, or home hemodialysis, must possess a considerable degree of independence, since they perform dialysis without the help of trained medical staff. The advantage of these self-dialyzing modalities is that the patient does not have to attend three weekly sessions at a dialysis facility. This allows the patient more freedom, which improves the patient's employment opportunities and eliminates the need to travel three times a week between home and the dialysis facility. The latter is particularly important for patients in rural areas. There are disadvantages associated with CAPD, CCPD, and home hemodialysis that need to be weighed against the benefits. CAPD and CCPD are associated with significantly higher risk of infection (Nolph, Lindblad, and Novak, 1988), although for patients with vascular access difficulties, CAPD or CCPD may be preferable, despite the associated risk of infection. Not every patient is medically suitable for CAPD or CCPD. A patient needs a certain percentage of his body water cleared each day for adequate dialysis. Not all patients can be adequately dialyzed using CAPD or CCPD because of their large size, their inability to tolerate the volumes of fluid, or they lack the requisite transportation characteristics in their peritoneal membranes. A disadvantage of home hemodialysis is the need to have a partner or aid present to help connect and disconnect the patient from the machine.

This article examines patient, facility, and area characteristics that are associated with modality selection in the ESRD Medicare population.[3] The article does not include analyses of health outcomes or costs associated with the various modalities studied. In this study I used administrative data on more than 73,000 ESRD Medicare patients, who are treated in a freestanding facility with at least one patient receiving CAPD, CCPD, or home hemodialysis. The Medicare sample used in this study is more representative of the United States' ESRD population, compared with previous studies of relatively small national samples or small samples confined to a few specific geographic regions (Deber et al, 1985; Dunham, Mattern, and McGaghie, 1985; Mattern et al. 1989).

METHODS

The analysis applies standard economic ideas about individual and firm (facility) behavior. The choice of dialysis modality is assumed to result from a combination of the patient's preference and the physician's clinical advice. The relative weight of the patient and physician in the choice decision is likely to vary, according to such factors as the patient's health status, educational background, sociodemographic status, and

[2]The term CCPD used in this study is a mode of dialysis that comes under the general rubric of "automated peritoneal dialysis" (APD). CCPD is the most common category of APD, and implies the presence of dialysate in the abdomen during the day. APD without a daytime dwell has been termed nightly intermittent peritoneal dialysis (NIPD). CCPD supplemented by CAPD during the day can be described as CCPD with an additional daytime dwell. The data used for this study do not delineate between this sub-modalities; patients are categorized into hemodialysis, CAPD, CCPD, and other rarely used modalities. Patients using the latter were excluded from this study.

[3]This study refers to "selecting" a modality. For some patients, their physical condition or geographical location may limit their choice to a single modality (Hobson's choice). In effect, the study models the probability of "being in" a modality; for some patients this is the result of a choice among alternatives, others may have no real choice.

income. In addition, the patient's modality choice may be constrained due to geographic location, or the fact that the patient's physician works at a facility that provides a limited range of modalities. None of this process is observable from the Medicare claims data used in this article; only the actual modality chosen is known. Facilities are assumed to be run by efficient companies or persons, whose objective is to provide the best patient care, while making the best use of the resources at their disposal. Thus, the determinants of modality choice are a combination of patient, facility, and geographical characteristics.

Data and Study Population

The data bases used in this analysis include the program management and medical information system (PMMIS) to obtain modality, age, race, sex, duration of ESRD and precipitating cause of ESRD on all the Medicare ESRD beneficiaries as of April 1, 1993; the 1993 ESRD facility survey data base to obtain the number of patients in each facility; the area resource file (ARF) to obtain data to calculate facilities per square mile; the 1990 U.S. Census to obtain median household income for each ZIP code. The 1993 ESRD statistical cost report data base was used to obtain data on facilities' profit versus not-for-profit status. Chain membership was acquired from the individual chains' home office cost reports.

The sample of patients was restricted to those attending freestanding renal dialysis facilities because while hospital based facilities provide dialysis services to a significant proportion of the ESRD population, they have a different institutional structure.

Facilities do not necessarily offer the entire range of modalities. The analysis addressed this problem by placing patients in three, non-mutually exclusive groups, based on the type of modalities offered in a facility. In order to be included in group 1, a patient must have attended a facility that provided CAPD to at least one of its patients. To be included in group 2, patients must have attended a facility that provided CCPD to at least one patient. Group 3's inclusion criterion was that the patient attend a facility which provides home hemodialysis to at least one patient (refer to sidebar for a list of definitions for each group). The information establishing whether a patient is in included in groups 1, 2, and 3 was obtained from the PMMIS data as of April 1,1993.[4,5] (Health Care Financing Administration, 1994.)

Group 1 (N = 66,067) consists of all patients attending freestanding facilities that provide CAPD.

Group 2 (N = 39,352) consists of all patients attending freestanding facilities that provide CCPD.

Group 3 (N = 42,019) consists of all patients attending freestanding facilities that provide home hemodialysis.

[4]It should be noted that there are data indicating which modalities a facility is approved to provide, however, this data gives insight only into facilities' "potential" modality provision. The analysis in this article focuses only on "actual" modalities provided.

[5] A facility licensed to provide a particular set of modalities may not necessarily intend to provide them. A second reason for using actual modalities is to examine differences in service use between sociodemographic groups; for example, racial differences. Suppose one were to use "potential" provision as the grouping criterion, and fewer black persons were observed to use CAPD. A claim that black persons systematically use this modality less could be countered by an argument that black persons choose to attend those facilities that do not "actually" offer CAPD, or that those facilities actually offering CAPD are not located in areas with a high proportion of black ESRD patients. If, however, I observe a facility where white persons "actually" use CAPD but black persons do not, I can be more certain of our claims regarding differences in utilization across the races. In short, using actual modalities offered increases the validity of such claims. This methodology understates any bias against particular modalities, however, the objective is to identify differences in utilization as compellingly as possible and the methodology used here has the advantage of achieving this objective.

A number of metropolitan statistical area (MSA) level characteristics, created by aggregating data from the county level, were used in the analysis. Patients outside of an MSA were assigned a value according to their county of residence. Patients living in the same MSA (or county for non-MSA residents) were all assigned the same value for facilities-per-square-mile and the Herfindahl index covariates (defined as the sum of squares of each facility's market share in the MSA or county). A facility's market share was measured as the proportion of patients associated with it. Patients attending the hospital-based facilities were included in the calculation of this index, although patients attending hospital based facilities were excluded from the logistic regressions. Patients were assigned values for the characteristics of the facility each attended: total number of patients, for-profit versus not-for-profit status, and membership of a large chain. Income data were only available at the ZIP code level, therefore, the same value for median household income was assigned to all patients in a given ZIP code.

Statistical Analysis

The probability of modality selection was estimated using a polytomous logistic regression (Hosmer and Lemeshow, 1989). The probability that the i-th patient selects the j-th dialysis modality is

$$P_{ij} = \frac{\exp(\beta_j' x_i)}{\sum_{k=1}^{m} \exp(\beta_k' x_i)},$$

$$j = 1, 2, 3, 4; \; i = 1, 2, \ldots, N$$

where β_j is a vector of parameters to be estimated, N is the sample size, x_i is a vector of characteristics (race, age, sex, and the other covariates) for the i-th patient and m is the number of possible choices. The model in this article considers four dialysis modalities, thus m equals four. Each covariate is associated with m - 1 parameters. Each parameter measures the effect of the covariate upon the probability that the modality in question is selected, relative to the reference category, in-center hemodialysis. For example, the male dummy variable will have three parameters associated with it, the exponent of the first gives the odds ratio for CAPD, the second for CCPD and the third for home hemodialysis, relative to selecting in-center hemodialysis.

Separate regression equations were estimated for each group. Thus, regressions using group 1 produce results that are conditional on the event that the facility provides CAPD to at least one patient. Likewise, the group 2 and 3 regressions are conditional on the provision of CCPD and home hemodialysis, respectively. The dependent variable in the three regressions was the modality; in-center hemodialysis, CAPD, CCPD, or home hemodialysis.

The independent variables in each regression controlled for individual patient characteristics, area characteristics, and facility characteristics. The individual patient covariates were age; less than 20, 20 to 44, 65 to 74, and over 74 (45 to 64 was the reference category); ethnicity; black, Asian, Native American and persons of other or unknown race (white was the reference category); sex; male (female was the reference category); precipitating illness; diabetes, hypertension, polycystic kidney disease, interstitial nephritis, obstructive nephropathy, other, unknown and not reported (glomerulonephritis was the reference category); and the number of years since the onset of ESRD. The geographic area covariates were the median household income, the number of facilities per square mile, the Herfindahl index and the

census division in which the facility was located. The income covariate was assigned at the ZIP code level and the other area covariates were assigned at the MSA or county location for non-MSA facilities. The facility covariates were the facility's for-profit status, whether a facility was owned by one of the three largest chains, the number of patients, and the number of patients squared.

An assumption of the logit model is the independence from irrelevant alternatives (IIA). This assumes that adding to, or deleting from, the list of choices (in this case, modalities) will not affect the parameter estimates. A set of modified tests for IIA failed to show evidence of a violation of IIA (Hausman and McFadden, 1984).

RESULTS

Table 1 presents some basic analysis of the three sample groups; specifically, individual patient characteristics. There are no large differences between the groups. More males are in the sample. A larger proportion of black patients undergo in-center hemodialysis compared with white persons. The 20 to 44 age group contains a larger proportion of patients using home-based modalities. The most common precipitating cause of ESRD is diabetes and hypertension. A larger proportion of patients in these precipitating disease group categories use in-center hemodialysis. Table 2 presents an analogous set of values for the facility and geographic characteristics associated with each patient. The home modalities are more common in areas with fewer facilities per square mile. In-center hemodialysis is selected by patients residing in lower income areas, and CCPD is selected by patients in higher income areas. CCPD patients are more likely to attend facilities that belong to large chains or are for-profit facilities.

The multivariate analysis attempts to separate the impact of the different covariates. If there is a high degree of correlation among a pair, or pairs, of covariates, this may lead to high standard errors and thus, non-definitive results. A correlation matrix was calculated for the covariates in the model, for each of the three groups of data. There were no large differences in each group's correlation matrix, so the comments below pertain specifically to group 1, but also apply to groups 2 and 3. None of the correlation coefficients exceeded 0.50 in absolute value. The Herfindahl index and the number of facilities per square mile have a correlation coefficient of -0.48. Given that these both measured the concentration of facilities within an MSA or county, this collinearity is not surprising. In areas with few facilities, mostly rural locations, there is a tendency for single facilities to have a larger share of the patients; for example, the number of patients only warrant one or two facilities. The only other correlation coefficient in this range is that between the diabetes and hypertension dummy variables, which is -0.42. This is simply due to the fact that approximately one-fourth of the sample falls into each of these categories (Table 1), hence, a patient who does not have diabetes as his precipitating cause of ESRD is most likely to have hypertension as the cause. In summary, therefore, there are one or two pairs of covariates for which multicollinearity might be a problem but it does not appear to represent a problem for the analysis in general.

Table 3 reports the polytomous choice logit regression results. Each logit estimation produced three parameters associated with each covariate. The parameters reported for each estimation are those pertaining to the modality upon whose provision the group was conditioned. Thus, the group 1 results only reports the $_j$ for $j = 1$

Table 1
Sample Groups Used in the Logit Regressions: Patients Attending Freestanding Dialysis Facilities by Treatment Modality: By Sex, Race, Age, and Precipitating Disease Group

Item	Group 1 (N = 66,067)				Group 2 (N = 39,352)			
	CAPD	CCPD	Outpatient Hemodialysis	Home Hemodialysis	CAPD	CCPD	Outpatient Hemodialysis	Home Hemodialysis
Sex					Percent			
Male	51.5	52.3	51.0	56.2	51.0	52.1	50.8	55.1
Female	48.5	47.7	49.0	43.8	49.0	47.9	49.2	44.9
Race					Percent			
Native American	1.2	0.9	1.2	3.9	1.1	0.9	1.3	5.7
Asian	2.0	1.5	2.0	1.8	2.0	1.6	2.3	2.5
Black	26.6	26.2	41.1	25.3	27.3	26.0	40.7	22.0
White	68.8	70.4	54.0	66.7	68.4	70.6	54.2	67.5
Other/Unknown	1.4	1.0	1.6	2.2	1.3	1.0	1.6	2.3
Age					Percent			
Under 20 Years	0.8	3.7	0.2	0.5	0.6	3.6	0.3	0.5
20-44 Years	28.1	28.9	17.9	27.2	27.9	29.1	18.2	27.2
45-64 Years	37.9	36.5	34.7	40.0	37.9	36.3	34.4	40.5
65-74 Years	23.0	22.5	27.9	19.8	23.6	22.5	27.8	20.5
75 Years or Over	10.2	8.3	19.3	12.5	10.0	8.4	19.3	11.3
Disease Groups					Percent			
Diabetes	28.2	28.5	29.7	21.2	27.7	28.5	29.9	21.7
Glomerulonephritis	18.1	17.5	13.1	21.3	18.2	17.6	13.4	20.8
Hypertension	24.8	24.6	31.0	20.8	25.4	24.6	30.7	19.2
Polycystic Kidney Disease	4.7	6.0	3.4	7.1	4.5	6.1	3.2	7.4
Interstital Nephritis	3.5	3.3	3.3	3.7	3.5	3.3	3.2	3.4
Obstructive Nephropathy	1.7	1.4	2.2	2.7	1.8	1.3	2.3	2.8
Other	6.9	8.4	5.1	5.8	7.0	8.3	5.1	5.1
Unknown	6.1	5.4	5.8	5.5	6.4	5.4	6.1	7.1
Not Reported	5.9	4.9	6.5	12.0	5.5	5.0	6.1	12.5
Total Count for Each Modality	10,417	2,074	52,301	1,275	6,147	2,114	30,304	787
Percent of Group Using Modality	15.8	3.1	79.2	1.9	15.6	5.4	77.0	2.0

See Notes at end of table.

Table 1—Continued
Sample Groups Used in the Logit Regressions: Patients Attending Freestanding Dialysis by Treatment Modality: By Sex, Race, Age, and Precipitating Disease Group

	Group 3 (N = 42,019)				Other (N = 19,856)
Item	CAPD	CCPD	Outpatient Hemodialysis	Home Hemodialysis	Facilites Offering Only Outpatient Hemodialysis
Sex			Percent		
Male	51.6	50.7	50.7	55.0	48.3
Female	48.4	49.3	49.3	45.0	51.7
Race			Percent		
Native American	1.3	0.8	1.2	3.3	1.5
Asian	1.5	1.5	1.6	1.6	2.1
Black	27.4	25.7	43.7	29.3	43.4
White	68.7	71.6	52.1	63.8	50.7
Other/Unknown	1.1	0.5	1.4	2.0	2.3
Age			Percent		
Under 20 Years	0.8	4.4	0.3	0.5	0.2
20-44 Years	28.0	28.9	18.5	26.1	16.9
45-64 Years	38.4	36.4	35.2	40.7	36.1
65-74 Years	22.9	22.3	27.6	20.2	28.3
75 Years or Over	9.8	8.0	18.5	12.5	18.5
Disease Groups			Percent		
Diabetes	28.4	28.1	29.9	21.9	29.1
Glomerulonephritis	19.0	18.2	13.0	19.8	12.5
Hypertension	24.2	26.0	30.7	22.7	31.7
Polycystic Kidney Disease	4.6	5.9	3.3	6.7	3.4
Interstital Nephritis	3.5	3.8	3.3	3.6	2.7
Obstructive Nephropathy	1.8	1.2	2.1	2.6	1.9
Other	7.1	8.3	5.2	5.8	4.5
Unknown	5.8	4.6	6.0	5.6	6.2
Not Reported	5.5	4.0	6.5	11.3	7.9
Total Count for Each Modality	5,888	1,306	33,298	1,527	19,856
Percent of Group Using Modality	14.0	3.1	79.2	3.6	100

NOTES: Group 1 contains all patients attending freestanding facilities that provide CAPD. Group 2 contains all patients attending freestanding facilities that provide CCPD. Group 3 contains all patients attending freestanding facilities that provide home hemodialysis

SOURCE: Health Care Financing Administration, 1993

Table 2
Sample Groups Used in the Logit Regressions Patients Attending Freestanding Dialysis Facilities by Treatment Modality; By Facility and Geographic Characteristics

Item	Group 1 (N = 66,067)				Group 2 (N = 39,352)			
	CAPD	CCPD	Outpatient Hemodialysis	Home Hemodialysis	CAPD	CCPD	Outpatient Hemodialysis	Home Hemodialysis
				Mean				
Facilities per Square Mile	0.0064	0.0051	0.0073	0.0061	0.0057	0.0051	0.0069	0.0062
Herfindahl Index	0.364	0.340	0.336	0.369	0.338	0.339	0.321	0.362
Median Household Income in ZIP Code	$31,734	$32,918	$30,909	$32,007	$31,947	$32,926	$31,041	$32,845
Number of Patients in Facility	143.0	145.1	130.1	166.3	159.1	143.4	145.1	183.6
				Percent				
Attending Large Chain Facility	32.3	59.2	40.1	28.3	43.7	59.1	48.0	38.1
Attending a For-Profit Facility	81.8	78.6	84.6	64.2	79.9	78.8	80.8	65.3
Not Attending a For-Profit Facility	18.2	21.4	15.4	35.8	20.1	21.2	19.2	34.7
Census Division 1	3.7	6.8	3.9	3.0	5.8	6.9	5.1	3.4
Census Division 2	7.7	6.6	9.6	8.7	7.2	6.4	9.8	9.5
Census Division 3	11.3	6.9	10.1	7.5	12.8	7.1	10.6	8.0
Census Division 4	8.5	5.9	4.6	10.0	9.3	5.9	5.9	11.3
Census Division 5	27.3	34.1	29.8	19.8	26.7	33.6	27.1	19.2
Census Division 6	10.1	7.8	8.9	16.9	7.9	7.7	7.5	9.0
Census Division 7	12.4	12.8	12.2	15.0	13.2	13.0	13.6	18.4
Census Division 8	5.3	7.4	5.6	6.9	6.1	7.3	6.9	6.9

See Notes at end of table.

Table 2 —Continued
Sample Groups Used in the Logit Regressions Patients Attending Freestanding Dialysis by Treatment Modality; By Facility and Geographic Characteristics

Item	Group 3 (N = 42,019)				Other (N = 19,856)
	CAPD	CCPD	Outpatient Hemodialysis	Home Hemodialysis	Facilites Offering Only Outpatient Hemodialysis
			Mean		
Facilities per Square Mile	0.0058	0.0050	0.0065	0.0060	0.0112
Herfindahl Index	0.384	0.313	0.351	0.356	0.280
Median Household Income in ZIP Code	$31,206	$32,411	$30,482	$31,403	$31,019
Number of Patients in Facility	164.2	156.0	137.7	152.0	84.3
			Percent		
Attending Large Chain Facility	31.7	58.3	40.9	33.8	42.0
Attending a For-Profit Facility	79.5	80.6	82.9	64.6	84.0
Not Attending a For-Profit Facility	20.5	19.4	17.1	35.4	16.0
Census Division 1	2.9	4.2	3.3	2.6	1.6
Census Division 2	6.7	7.8	9.1	8.3	15.0
Census Division 3	12.9	5.2	9.5	6.6	14.8
Census Division 4	9.3	8.1	4.9	8.4	2.2
Census Division 5	30.4	34.6	30.5	22.7	27.0
Census Division 6	10.2	6.0	7.4	14.7	9.7
Census Division 7	15.4	17.6	21.6	19.4	10.3
Census Division 8	5.8	7.9	5.5	6.3	2.4

NOTE: Group 3 contains all patients attending freestanding facilities that provide home hemodialysis.

SOURCE: Health Care Financing Administration, 1993

Table 3

Association of Patient Characteristics and Selection of Dialysis Modalities for Medicare Beneficiaries With ESRD Attending Freestanding Facilities: Results of the Multivariate Polytomous Choice Logit Regressions

	Group 1: Patients Attending Facilities Providing CAPD				Group 2: Patients Attending Facilities Providing CCPD				Group 3: Patients Attending Facilities Providing Home Hemodialysis			
Item	Param.	s.e.		A.O.R.	Param.	s.e.		A.O.R.	Param.	s.e.		A.O.R.
Constant	-1.459	0.082	***		-2.733	0.175	***		-2.211	0.185	***	
Sex, Age, Race, and ESRD Duration												
Male	-0.075	0.022	***	0.93	-0.050	0.047		0.95	0.130	0.054	**	1.14
Under 20 Years	0.954	0.146	***	2.60	2.457	0.176	***	11.67	0.111	0.404		1.12
20-24 Years	0.379	0.029	***	1.46	0.481	0.059	***	1.62	0.082	0.070		1.09
65-74 Years	-0.411	0.029	***	0.66	-0.395	0.062	***	0.67	-0.351	0.073	***	0.70
74 Years or Over	-0.937	0.039	***	0.39	-1.088	0.088	***	0.34	-0.405	0.089	***	0.67
Native American	-0.328	0.103	***	0.72	-0.506	0.244	**	0.60	0.690	0.166	***	1.99
Asian	-0.318	0.082	***	0.73	-0.576	0.187	***	0.56	-0.221	0.221		0.80
Black	-0.870	0.028	***	0.42	-0.870	0.059	***	0.42	-0.688	0.067	***	0.50
Other/Unknown	-0.487	0.096	***	0.61	-0.914	0.239	***	0.40	-0.085	0.198		0.92
ESRD Duration in Years	-0.065	0.003	***	0.94	-0.093	0.008	***	0.91	0.086	0.006	***	1.09
Precipitating Cause of ESRD												
Polycystic Kidney Disease	-0.044	0.060		0.96	0.353	0.113	***	1.42	0.296	0.124	**	1.34
Diabetes	-0.357	0.035	***	0.70	-0.291	0.073	***	0.75	-0.301	0.088	***	0.74
Hypertension	-0.236	0.036	***	0.79	-0.156	0.075	**	0.86	-0.217	0.087	**	0.81
Interstitial Nephritis	-0.279	0.065	***	0.76	-0.256	0.139	*	0.77	-0.199	0.154		0.82
Obstructive Nephropathy	-0.488	0.089	***	0.61	-0.690	0.205	***	0.50	-0.176	0.180		0.84
Unknown	-0.175	0.053	***	0.84	-0.253	0.113	**	0.78	-0.407	0.128	***	0.67
Other	-0.116	0.051	**	0.89	0.001	0.101		1.00	-0.142	0.128		0.87
Not Reported	-0.265	0.055	***	0.77	-0.242	0.121	**	0.78	-0.014	0.106		0.99
Socioeconomic and Geographic Factors												
Facilities per Square Mile	-9.396	1.687	***	0.66	-24.00	4.528	***	0.35	-11.63	4.293	***	0.60
Herfindahl Index	0.082	0.037	**	1.08	-0.107	0.080		0.90	-0.165	0.090	*	0.85
Median Household Income	3.998E-06	1.030E-06	***	1.04	1.300E-05	2.123E-06	***	1.14	4.565E-06	2.46E-06	*	1.05
Census Division 1	0.192	0.067	***	1.21	0.232	0.117	**	1.26	0.023	0.196		1.02
Census Division 2	0.084	0.052		1.09	-0.011	0.116		0.99	-0.086	0.146		0.92
Census Division 3	0.387	0.046	***	1.47	0.055	0.112		1.06	-0.096	0.138		0.91
Census Division 4	0.695	0.053	***	2.00	0.171	0.119		1.19	0.514	0.132	***	1.67
Census Division 5	0.359	0.039	***	1.43	0.473	0.084	***	1.60	0.098	0.109		1.10
Census Division 6	0.515	0.050	***	1.67	0.183	0.114		1.20	0.849	0.121	***	2.34
Census Division 7	0.340	0.047	***	1.40	0.073	0.101		1.08	0.344	0.117	***	1.41
Census Division 8	-0.011	0.058		0.99	0.017	0.113		1.02	0.017	0.142		1.02

See Notes at end of table.

Table 3—Continued

Association of Patient Characteristics and Selection of Dialysis Modalities for Medicare Beneficiaries With ESRD Attending Freestanding Facilities: Results of the Multivariate Polytomous Choice Logit Regressions

Item	Group 1: Patients Attending Facilities Providing CAPD				Group 2: Patients Attending Facilities Providing CCPD				Group 3: Patients Attending Facilities Providing Home Hemodialysis			
	Param.	s.e.		A.O.R.	Param.	s.e.		A.O.R.	Param.	s.e.		A.O.R.
Facility Characteristics												
Large Chain	-0.345	0.025	***	0.71	0.416	0.052	***	1.52	-0.209	0.063	***	0.81
For-Profit	-0.079	0.031	**	0.92	-0.116	0.061	*	0.89	-0.680	0.068	***	0.51
Number of Patients	0.006	0.001	***		4.810E-03	1.150E-03	***		-7.930E-03	1.200E-03	***	
Number of Patients Squared	-8.98E-06	1.42E-06	***		-1.000E-05	3.024E-06	***		2.400E-05	2.924E-06	***	
Observations	66,067				39,352				42,019			

NOTES: Param. denotes parameter estimate. s.e. denotes standard error. *, **, *** denote significant at the 10 percent, 5 percent, and 1 percent level, respectively. ESRD is end stage renal disease. A.O.R. denotes adjusted odds ratio for a 1 unit change except for "Facilities per square mile" (A.O.R. is min. to max.) "Median household income" (A.O.R. is per $10,000). The parameter estimates reported are only those pertaining to the modality of interest for each logit regression. Thus, the "Group 1" results report only the parameters impacting directly on CAPD selection The "Group 2" and "Group 3" results are reported analogously, reporting the CCPD and home hemodialysis related parameters, respectively. The full set of results, incorporating all 102 covariates' parameter estimates, in all three logits, are available from the author upon request.

SOURCE: Health Care Financing Administration, 1993.

(CAPD). Analogously, the reported group 2 and 3 results contain only the parameter estimates for $j = 2$ (CCPD) and $j = 3$ (home hemodialysis), respectively.

I investigated whether the institutional differences between hospital-based and freestanding facilities were reflected in the data. Using our logit model, I conducted a log-likelihood test for pooling of the freestanding and hospital-based patients for groups 1, 2 and 3; in each case the data rejected pooling at the 0.001 percent level.

Results for Group 1—Patients Attending CAPD Facilities

Males were significantly less likely to select CAPD (odds ratio 0.93). There was a steady reduction in the probability of selecting CAPD with respect to the patient's age compared with the 45 to 64 year old reference category. Patients under age 20 were the most likely to select CAPD (odds ratio 2.6), age 20 to 44 (odds ratio 1.46), age 65 to 74 (odds ratio 0.66) and age over 74 (odds ratio 0.39). All minority ethnic groups were less likely than white persons to select CAPD; namely, black persons (odds ratio 0.42), Native Americans (odds ratio 0.72), Asians (odds ratio 0.73) and other races (odds ratio 0.61).

Patients with a longer duration of ESRD were less likely to select CAPD (odds ratio 0.94 for each additional year). Not all the categories of precipitating cause of ESRD were significant. Diabetes (odds ratio 0.7), hypertension (odds ratio 0.79), obstructive nephropathy (odds ratio 0.61), and the "unknown" and " not reported" categories (odds ratio 0.89 and 0.77, respectively) were significantly related to selecting CAPD compared with glomerulonephritis. Patients in areas with low facilities per square mile, were more likely to select CAPD (the odds ratio is 0.66 for the maximum value of facility-density relative to the minimum value). The Herfindahl index was positively associated with CAPD selection, indicating patients attending facilities in less competitive markets were more likely to select CAPD. Median household income was positively associated with the probability of selecting CAPD (odds ratio 1.04 for each $10,000 increment). Patients attending facilities belonging to large chains (odds ratio 0.71) or for-profit facilities (odds ratio 0.92), were less likely to select CAPD. Finally, the coefficients for the number of patients and the number of patients squared, were positive and negative, respectively.

Results for Group 2—Patients Attending CCPD Facilities

There was no significant effect of sex on the probability of selecting CCPD. The effect of age was stronger than for CAPD (under 20 (odds ratio 11.67), age 20 to 44 (odds ratio (1.62), age 65 to 74 (odds ratio 0.67) and over 74 (odds ratio 0.34)) and all of the ethnicity categories were significant at the 5 percent level. Minorities were less likely to select CCPD relative to white persons; "Other" (odds ratio 0.4), black persons (odds ratio 0.42), Asians (odds ratio 0.56) and Native Americans (odds ratio 0.6). The duration of ESRD was negatively associated with CCPD selection (odds ratio 0.91 for each additional year). The significant precipitating cause of ESRD categories were diabetes (odds ratio 0.75), hypertension (odds ratio 0.86), obstructive nephropathy (odds ratio 0.5), and the "unknown" and "unreported" categories (odds ratio 0.78 for both categories). Patients living in areas with low facilities per square mile were more likely to select CCPD (odds ratio is 0.35 for the maximum relative to the minimum value of facilities per square mile). The Herfindahl index was not significant for CCPD selection. Median

household income was significant and positively associated with CCPD selection (odds ratio 1.14 for each $10,000 increment). Patients attending facilities that were members of large chains were more likely to select CCPD (odds ratio 1.52); however, patients attending for-profit facilities were less likely to select CCPD (odds ratio 0.89). The parameter estimates for the number of patients and the number of patients squared were significant.

Results for Group 3—Patients Attending Home Hemodialysis Facilities

Males were significantly more likely to select home hemodialysis (odds ratio 1.14). Unlike group 1 and 2, the only age categories that were significant were age 65 to 74 (odds ratio 0.7) and age over 74 (odds ratio 0.67). Native Americans were significantly more likely to select home hemodialysis (odds ratio 1.99) and black persons were significantly less likely to select home hemodialysis (odds ratio 0.5). None of the other ethnic category covariates were significant. In contrast to CAPD and CCPD, patients with longer duration of ESRD were more likely to select home hemodialysis (odds ratio 1.09 for each additional year of ESRD duration). Precipitating causes of ESRD showed the same qualitative effect as for CAPD and CCPD. Patients with diabetes or hypertension as the precipitating cause of ESRD were less likely to select home hemodialysis (odds ratio 0.74 and 0.81, respectively). In contrast, patients with polycystic kidney disease as the precipitating cause, were more likely to select home hemodialysis (odds ratio 1.34). Patients in areas with fewer facilities per square mile were more likely to select home hemodialysis (odds ratio 0.85 for patients in the area with the lowest facilities per square mile relative to the highest). Median household income was significant at the 10 percent level (odds ratio 1.05 for each $10,000 increment). Patients attending facilities that belonged to large chains were less likely to select home hemodialysis (odds ratio 0.81). The same was true for patients attending for-profit facilities (odds ratio 0.51). The number of patients, and the number of patients squared, were positive and negative, respectively.

LIMITATIONS OF THE STUDY AND DISCUSSION

Limitations

Despite the large sample size and the attempt to control for as many modality determining characteristics as possible, the analysis contained a number of limitations.

First, the analysis excluded the set of patients who used hospital based facilities. There are some important differences between the sample used for this study and those patients attending hospital-based dialysis facilities; hospital-based facilities serve a smaller proportion of black patients (26.1 versus 38.5 percent); freestanding facilities have a higher proportion of patients with hypertension as their precipitating cause of ESRD (29.7 versus 22.7 percent). The freestanding facilities also have a larger proportion of CAPD (14.2 percent versus 12.4 percent), CCPD (2.9 percent versus 1.9 percent) and home hemodialysis (2.1 percent versus 1.5 percent) patients compared with hospital-based facilities. Freestanding facilities specialize in dialysis services while in a typical hospital, the chronic renal dialysis unit represents a small component of the whole institution and, as such, there is significant potential for cross-subsidization between the dialysis component and the remainder of the hospital. If dialysis units in hospitals have less fi-

nancial constraints (due to cross-subsidization) and some modalities are less expensive than others (although I do not know which ones), then hospital-based facilities may have a different mix of modalities. A detailed analysis of modality selection in hospital-based facilities is left for future research.

Second, the analysis attempts to control for patients' health; for example, through the precipitating cause of ESRD. There are a number of other health factors that determine modality selection, including, lack of vascular access and cardiovascular disease. No data for these are available for the sample used in this analysis. Third, ZIP code level income is a rough approximation of a patient's income. Although it is the best data available, its use can lead to problems due to the ecological fallacy. Fourth, the individual patient data were taken as of April 1, 1993. Thus, the dialysis modality is simply the modality for the patient, at that point in time. It is possible that the patient may have only used that modality for a few days, or that the patient changed modality a few days after that date. Fifth, there is no perfect method to calculate market share since some facilities may belong to the same chain and be located in the same area. There is no clear evidence as to whether facilities within the same chain, located in the same area, are in competition or collusion. The Herfindahl index calculation used in this article assumes that a facility is in competition with all the other facilities in its area.

The analysis in this article uses Medicare claims to examine utilization. Using these data, there is no means to determine whether rates of modality use are too high or too low. The analysis only estimates differences in rates of use, and then suggests whether these are meaningful. Thus, for example, there is a low probability of minorities using home-based modalities. There appears to be some clinical reasons (higher infection rates among black patients using CAPD) and social factors (income) that may help explain this but some of the differences remain to be explained in their entirety. Given the restrictions on the data used for this analysis, this article does not claim to have explained modality choice in the United States. Indeed, hospital-based facilities served 49 percent of the dialysis population, including 48 percent of CAPD patients, 40 percent of CCPD patients, and 42 percent of home hemodialysis patient. The results presented are conditional upon the assumptions made, the method of assigning facilities' patients to the different groups, and the omission of patients attending hospital based facilities.

Discussion

This study identified several important associations linking dialysis modality selection with patient characteristics, facility settings and geographic characteristics. First, non-white patients were considerably less likely to be on home dialysis therapy. This finding is consistent with other studies that used the PMMIS data (United States Renal Data System, 1995). The strongest effect is for black persons, who were less than half as likely to select the home dialysis modalities compared to white persons. The exception to this finding was the higher probability of selecting home hemodialysis among Native Americans.

There are a number of possible reasons for the low probability of selecting CAPD and CCPD among black persons. There is evidence that black persons have a significantly higher probability of peritonitis episodes when using CAPD, compared with white persons (Farias et al., 1994; Korbet, Vonesk, and Firanek). The higher peritonitis rate suggests that black persons starting CAPD may not remain on it as long as

white persons, leading to a lower observed rate of utilization among black patients. Further, given the higher risk of peritonitis, physicians may be less inclined to initiate CAPD for their black patients. This argument does not explain the lower rates of CAPD use among other ethnic minorities, since I could find no published evidence of a higher incidence of peritonitis among other ethnic minorities using CAPD. Another possible explanation for the low rate of CAPD use among black persons is that physicians may be less likely to recommend self-dialyzing modalities, such as CAPD, to low income patients. Patients with low incomes and limited housing space may not be able to store the necessary supplies and machines for CAPD, CCPD or home hemodialysis. Although the regressions contain a control variable for income, this covariate is a measure at the ZIP code level. Consequently, there is the possibility that black ethnicity partially captures the effects of income, although studies that have controlled for income when modeling modality selection find a lower use rate of peritoneal dialysis among black persons (Barker-Cummings et al., 1995).

Second, females are more likely to select CAPD and males are more likely to use home hemodialysis. The finding for CAPD concurs with other studies examining modality selection (Radecki et al., 1988).

Third, CAPD, CCPD, and home hemodialysis are more likely to be selected by healthier patients; that is, health status as proxied by age, ESRD duration and precipitating cause of ESRD. Older patients, and patients who have been sicker longer, are less likely to use these modalities. Patients with non-systemic precipitating causes of ESRD; specifically, polycystic kidney disease and glomerulonephritis, were more likely to select these modalities. In contrast, patients with systemic precipitating causes of renal failure; for example, diabetes and hypertension, are less likely to select CAPD and CCPD. The result showed a negative association between obstructive nephropathy and selecting CAPD and CCPD. This runs counter to the argument about non-systemic causes of renal failure being associated with CAPD and CCPD. A possible explanation for this is that patients with obstructive nephropathy might have experienced multiple abdominal surgeries for treatment of an obstruction in an earlier stage of their illness. Prior extensive surgery is a contraindication with respect to Tenckhoff catheter insertion (Bullmaster et al., 1985).

There is a strong positive association between income and the selection of CAPD, CCPD, and home hemodialysis. One possible explanation is that patients in higher income groups have a greater potential earnings loss by attending outpatient dialysis sessions and would, therefore, prefer dialysis modalities that make it easier for them to work. However, other researchers have shown that CAPD patients are not more likely to engage in work activity (Tucker et al., 1991). Another explanation is that discussed in relation to minorities; namely, that patients with low incomes are more likely to live in smaller houses, with less room to store dialysis equipment.

Facility characteristics were also associated with modality selection. Patients who attended facilities owned by large chains were less likely to select CAPD and home hemodialysis, but more likely to select CCPD. The growth in CAPD is only slightly above the growth in the total dialysis population and, as previously mentioned, training costs are significant (as they are for CCPD). It is possible, therefore, that large chains do not view the investment in CAPD training as worthwhile. On the other hand, since CCPD is a relatively recent mode of dialysis and has the fastest growth rate among the modalities,

large chains may be anticipating this as the "wave of the future" and substituting CAPD with CCPD.

Patients attending for-profit facilities are less likely to select either CAPD, CCPD, or home hemodialysis. It may be that these facilities are more conscious about profits, and may not view these modalities as sufficiently remunerative. Other studies have shown an association between for-profit status and a facility's propensity to raise profits by providing more services using less equipment and personnel (Griffiths et al., 1994). Given that there is not a substantive difference in reimbursement rates among modalities, it is possible that for-profit facilities are more inclined to seek lower cost dialysis modalities. If this is true, the lower probability of their patients using home modalities may indicate that these modalities are more expensive. There is no consensus in the literature as to which modalities are more expensive to provide. Data on the cost of producing dialysis services is available for each free-standing facility but since each facility may produce multiple types of services, it is difficult to definitively apportion components of total cost to each modality. An alternative to disentangling the costs of different modalities is to speculate by implication; namely, that the most profit-conscious facilities will tend to provide the less expensive modalities.[6]

There may be significant gains from specialization in in-center hemodialysis and unless there is a critical mass of patients using the other modalities, it is not worthwhile to provide them on a significant scale. This latter effect is a real possibility, given the significance of the parameter estimates for the number-of-patients covariate. The significant parameter estimates on the number of patient covariate suggests economies of scale in the provision of CAPD, CCPD, and home hemodialysis; that is, patients attending larger facilities are more likely to select these modalities. This result concurs with those studies using more aggregate data showing that larger facilities are more likely to offer patients CAPD, CCPD, or home hemodialysis (Kendix, 1995). The significant negative parameter estimates for the number of patients squared indicates that the increment in the scale economies is smaller, as the number of patients increases.

The results for groups 1, 2, and 3 showed a strong association between selecting the home-based modalities and areas with fewer facilities per square mile. Rural facilities have a small number of facilities per square mile, with each facility serving a large geographic area. Patients in these areas face high time and travel costs of attending a dialysis facility three times a week and are, therefore, more likely to prefer home modalities.

Other studies have shown evidence that the degree of competition between facilities has an impact on the delivery of ESRD service (Farley, 1993; Held and Pauly, 1983). The Federal Government sets payment rates for dialysis services; therefore, facilities may resort to non-price competition. One possibility is that greater competition among facilities improves the range and quality of services offered to patients. An example of an improvement is to offer patients a greater number of modalities from which to choose. Under this hypothesis, greater competition among facilities would lead to an increased probability of CAPD, CCPD, and home hemodialysis being selected. There is a countervailing effect, however, since these modalities all require the facility to devote significant

[6]Since charges may differ across modalities during the Medicare secondary payer period (footnote [5]), and for-profit facilities may be more concerned about costs, this may explain the observed difference in the probability of selecting these modalities.

resources to training patients to self-dialyze. If dialysis training is insufficiently remunerated, facility owners may regard their losses associated with training as an investment, which yields returns at a later date, when the patient can self-dialyze. This is particularly the case for CAPD, which is regarded as a less expensive modality after the patient is trained. If, however, there is a large number of facilities in the immediate vicinity, trained patients may be sought by competitors, thereby reducing the incentive for facilities to train patients. It should be noted that a trained CAPD patient is unlikely to change providers without careful consideration, and facilities are not permitted to offer patients monetary incentives to change providers. Nevertheless, if a competitor provides superior services to CAPD patients, this could outweigh any loyalty and other bonds that have formed between the patient and his current provider. In addition, if facilities make more money from CAPD (not CAPD training), a facility with a local monopoly may use its power to increase CAPD use. Thus, the qualitative effect of a higher concentration of facilities on modality selection is ambiguous for CAPD. The incentive to attract other facilities' patients undergoing CCPD or home hemodialysis may not be as great, since these are more expensive self-dialyzing modalities. The present analysis produced mixed results, possibly reflecting the ambiguous effect of market competition. There is a positive association between the probability of selecting CAPD and a less competitive market (high Herfindahl index), a negative relationship between selecting home hemodialysis and less market competition and no significant association for CCPD selection.

The large sample size allows a more accurate estimation of the covariates' impact on modality selection. Nevertheless, there is the issue of whether some of the statistically significant findings are clinically significant or have any policy significance. An excellent analysis and summary of this issue is presented by McCloskey and Ziliak (1996). First, the results show that among the group 1 sample, females have a significantly higher probability of using CAPD. The odds ratio is, however, fairly small (0.93) and it is unclear whether this has any clinical significance. Secondly, the results for the Herfindahl index are significant at the 5 percent level for the group 1 sample, but the odds ratio is only 1.08. Given the other results for this covariate in the group 2 and 3 samples, one cannot draw any significant policy conclusions from these results.

POLICY IMPLICATIONS

There is no consensus in the literature as to the relative efficacy of the different modalities. Some researchers claim that, in general, the survival rate between hemodialysis and CAPD patients has been equivalent (Blake, 1996). Another study using 1989-91 data showed superior survival for hemodialysis patients but could not rule out case-mix differences as a cause of differences in survival (U.S. Renal Data System, 1995). There is a debate as to whether CAPD and CCPD are efficacious. It is possible that CAPD and CCPD are not being performed optimally, and that they require more cyclers and fluid; thus, it is possible that the potential exists for increased survival. If there are deficiencies in the application of CAPD and CCPD, if these deficiencies are correctable, and if it can be shown that these are superior modalities for some categories of patients, then this study provides information about current practice, which may help direct future practice.

There are no definitive results regarding the relative cost-effectiveness of the mo-

dalities. There is some evidence that in-center hemodialysis is more cost-effective compared with CAPD and CCPD, however, this applied only for older patients (Held et al., 1992). Researchers have shown that the cost to Medicare, in terms of program reimbursement, is lower for CAPD and CCPD, compared with in-center hemodialysis, but, with the exception of age, these results did not control for differences in patient characteristics (U.S. Renal Data System, 1996). Assuming that coinsurance payments for Medicare covered services are correlated with Medicare reimbursement, this ranking of modality costs is likely to pertain to beneficiary out-of-pocket liability.

Given the absence of consistent evidence demonstrating the general superiority of particular modalities, the policy goal should be to enable beneficiaries to use the modality for which they are best suited. This requires that the entire range of modalities be readily available to all ESRD beneficiaries. The results in this study suggest systematic variation in modality selection with respect to income, with lower income associated with a lower probability of selecting CAPD and CCPD. In many cases, income and educational attainment are highly correlated. It is possible, therefore, that the availability of all modalities might be enhanced by directing informational and educational campaigns to both physicians and patients, since there is some evidence that well informed patients may *equibus paribus* select CAPD and CCPD (Ahlmen, Carlsson, and Schonborg, 1993).

This study provides insight into the factors explaining the choice of dialysis modality. Many of the results are reasonable; for example, the more common use of home based modalities in areas where facilities are far apart, the effect of age, duration of ESRD, and precipitating cause of ESRD. The detailed analysis does not suggest a pattern of modality selection that should give policymakers cause for concern. The ethnic variations bear continued observation, but there is no evidence that non-white persons are suffering poorer outcomes as a result of modality choice. Further, despite the results for large chain membership and for-profit status facilities, there is no clear indication that Medicare's policy of equal reimbursement for all modalities, has interfered with modality choice.

The lack of consensus on the cost of modalities, their efficacy, and cost-effectiveness, suggests a gap in knowledge that could be filled by future research. Specifically, there is a need to discover not only the cost to the Medicare program of the different modalities, adjusted for patient characteristics, but also the cost of providing these modalities. The latter is a difficult undertaking since facilities produce multiple modalities and, as previously discussed, it is not straightforward to separate the costs of the different modalities. Cost-effectiveness studies present greater obstacles since researchers need to compare the costs to outcomes. Nevertheless, such research is necessary for a more informed evaluation of modality selection among ESRD patients.

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