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RESEARCH ARTICLE

The Effect of Dialysis Chains on Mortality among Patients Receiving Hemodialysis

Yi Zhang, Dennis J. Cotter, and Mae Thamer

Objective. To examine the association between dialysis facility chain affiliation and patient mortality.
Study Setting. Medicare dialysis population.
Study Design. Data from the United States Renal Data System (USRDS) were used to identify 3,601 free-standing dialysis facilities and 34,914 Medicare patients' incidence to end-stage renal disease (ESRD) in 2004. Mixed-effect regression models were used to estimate patient mortality by dialysis facility chain and profit status during the 2-year follow-up.
Data Collection. USRDS data were matched with facility, cost, and census data.
Principle Findings. Of the five largest dialysis chains, the lowest mortality risk was observed among patients dialyzed at nonprofit (NP) Chain 5 facilities. Compared with Chain 5, hazard ratios were 19 percent higher (95 percent CI 1.06–1.34) and 24 percent higher (95 percent CI 1.10–1.40) for patients dialyzed at for-profit (FP) Chain 1 and Chain 2 facilities, respectively. In addition, patients at FP facilities had a 13 percent higher risk of mortality than those in NP facilities (95 percent CI 1.06–1.22).
Conclusions. Large chain affiliation is an independent risk factor for ESRD mortality in the United States. Given the movement toward further consolidation of large FP chains, reasons behind the increase in mortality require scrutiny.

Key Words. Dialysis facility, mortality, chain, profit

The majority of U.S. patients with end-stage renal disease (ESRD) receive hemodialysis treatment three times a week from Medicare-certified dialysis facilities. During the past decade, the dialysis industry has undergone tremendous market structural changes. The number of outpatient dialysis facilities doubled from 2,000 in 1991 to more than 4,000 facilities in 2005, with free-standing dialysis units having grown more rapidly than hospital-based facilities. The growth of multiunit dialysis chains is even more striking. Chain membership, similar to franchising, is an organizational form where a single firm owns a number of dialysis facilities. According to the United States Renal

Data System (USRDS), the number of chain-owned dialysis units has grown more than 11-fold since 1991. Roughly 85 percent of the for-profit (FP) and almost one-third of the nonprofit (NP) facilities are now operated by large corporations (USRDS 2008).

The growth and consolidation into large dialysis chains has raised concerns about the quality of care being delivered to ESRD patients, especially given most of the large dialysis providers are FP entities (General Accounting Office 2000; Medicare Payment Advisory Commission 2003) and FP facilities appear to use lower resources (Held et al. 1990; Griffiths et al. 1994) and have higher mortality rates (McClellan, Soucie, and Flanders 1998; Irvin 2000; Devereaux et al. 2002). However, few researchers have reported whether a facility's affiliation with multicenter dialysis chains is associated with patient outcomes. Differences in outcomes by chain affiliation might be expected given the observed differences in practice patterns across chain and nonchain facilities. For example, a study by Thamer et al. (2007) indicated that facility ownership and chain status had a strong effect on use of erythropoietin-stimulating agents for anemia management. In addition, other studies have found differences in use of IV iron and IV vitamin D (USRDS 2006), use of arteriovenous fistulas (AVFs) (USRDS 2007), receipt of renal transplants (Garg et al. 1999), and staffing by chain status (Held et al. 1990; Ozgen 2006). Therefore, a question remains whether these differences in chain practice patterns could lead to a difference in patient outcomes. In this analysis, we evaluate the relationship between chain affiliation of dialysis facility and patient mortality.

METHODS

Study Data

Data from several sources were combined to conduct this study. The main data source used for this analysis was the most recent standard analytical files (SAFs) collected and maintained by the USRDS, which contains extensive demographic, clinical, and facility data on ESRD patients covered by the Medicare program. The variables included in the USRDS SAFs, as well as the collection methods, and validation studies, are listed at the USRDS

Address correspondence to Yi Zhang, Ph.D., Medical Technology and Practice Patterns Institute (MTPPI), 4733 Bethesda Ave., Suite #510, Bethesda, MD 20814; e-mail: yz@mtppi.org. Dennis Joseph Cotter, M.S.E., and Mae Thamer, Ph.D., are with the Medical Technology and Practice Patterns Institute (MTPPI), Bethesda, MD.

website, http://www.usrds.org. In addition, Dialysis Compare Data (Centers for Medicare & Medicaid Services [CMS] 2009) and Renal Cost Report Data, collected by CMS, were used to obtain additional facility characteristics that are not available in the USRDS database such as facility-level hematocrit (HCT) value, urea reduction ratio (URR), and facility staffing patterns. The 2000 U.S. Census data were used to obtain information on several ecological characteristics, including race-specific median household income, percent Caucasian population, urbanicity status, and GINI Index for each facility using zip codes. Files were merged based on unique encrypted patient or facility identifiers.

Study Design and Sample Selection

This is a retrospective cohort study of incident hemodialysis patients and their providers with two main observation phases: a 3-month baseline period and a follow-up period ranging from 18 to 30 months, depending on enrollment date, used to track death and all censoring events.

All Medicare-eligible, adult ($\geq$ 18 years old) ESRD patients initiating in-center hemodialysis in 2004 were deemed eligible for inclusion in the study sample. All patients were required to (1) have their first ESRD service date at least 90 days before the beginning of the baseline period due to the 90-day enrollment rule required by Renal Beneficiary Utilization System; (2) receive hemodialysis service from the same provider during the 3-month baseline period; (3) survive the entire baseline period; and (4) use Medicare as the primary payor throughout the entire baseline period to ensure the completeness of clinical and treatment history data.

Patients were excluded if they were previously diagnosed with human immunodeficiency virus (HIV) infection because studies have shown that patients with ESRD and HIV infection are different from the general ESRD population (Weiner, Goodman, and Kimmel 2003). Patients who had missing predialysis information collected on the Medical Evidence form such as glomerular filtration rate, serum creatinine, epoetin (EPO) use, or HCT values were excluded from the study cohort. Furthermore, because patients treated in hospital-based facilities have more comorbidities compared with patients treated in free-standing facilities (USRDS 2007), only free-standing facilities were included in this analysis. Each patient was assigned to the specific facility where he or she was receiving care at the end of the baseline period (12 percent of patients received dialysis from more than one provider during the study baseline). Patients were followed until December 31, 2006 (the end of available data) or censoring due to transplantation, 60 days after a switch to

peritoneal dialysis, 60 days after a facility provider change, gap in outpatient dialysis services (defined as missing institutional claims for 60 consecutive days or longer), or death. By cross-referencing facility data, patient-level data, and ESRD Medicare institutional claims, a patient–provider file was constructed for analysis and modeling.

Among 50,174 patients who had at least one dialysis claim 90 days after initiation of ESRD in 2004, 41,356 patients were treated in free-standing dialysis facilities using Medicare as primary payor. An additional 6,442 patients were excluded due to use of dialysis modality other than hemodialysis, diagnosis of HIV, or death during the baseline period. The final study cohort consists of 34,914 patients treated at 3,601 free-standing dialysis facilities.

Variable Construction

The study end point was death during the study follow-up period. The main exposure of interest was the seven facility types that were compared in the study, including five dialysis chains and two nonchain groups. All chains were FP with the exception of Chain 5, which is the nation's largest nonprofit (NP) chain, and therefore was chosen to be the reference group. Two nonchain groups, including FP nonchain facilities and NP nonchain facilities, were also included to provide a complete spectrum of existing free-standing facilities providing outpatient dialysis to U.S. patients. In addition to chain status, facilities were grouped according to the their profit status. Several other facility-level characteristics, including facility size (Flanigan 1995), geographic region (Rodriguez et al. 2007), staffing, urban status (Stivelman et al. 1995; O'Hare, Johansen, and Rodriguez 2006), and clinical performance measures (HCT and URR) (Szczech et al. 2006) found to be associated with patient outcomes were also adjusted in the model. Furthermore, the GINI coefficient was adjusted for income inequality in the geographic area where the facility is located (Lynch et al. 2000). Use of injectable medications, including EPO, iron, and vitamin D, was estimated using facility average use for 2004. A summary measure of drug use was generated based on the sum of the quartile scores of the three drug dose distributions.

An array of 30 patient-level characteristics, known to be potential confounders, were used to adjust for differences in case mix among facilities, as listed in Table 2. Sociodemographics must be accounted for as potential confounders in any analysis on patient outcomes and survival, particularly given the complexities involved with the chronic renal failure population. For example, there is an excess burden of ESRD in nonwhite populations and

mounting evidence to suggest that significant racial and ethnic disparities exist, including referral and initiation of dialysis, adequacy of dialysis, and anemia management (Gadegbeku, Freeman, and Agodoa 2002). Although poorly understood, research suggests that low-income patients with ESRD experience higher mortality (Garg, Diener-West, and Powe 2001). Age of onset of ESRD influences mortality as well; mortality rates of patients older than 55 years beginning chronic dialysis treatment increased dramatically as age at initiation of dialysis increased (Byrne, Vernon, and Cohen 1994). To control for the impact of comorbidities, the Charlson Comorbidity Index was used to measure the severity and range of patient comorbid conditions based on the presence or absence of nonrenal disease during the baseline period (Charlson et al. 1987; Van Manen et al. 2002). Preexisting comorbidities (before initiation of dialysis) were collapsed into cardiovascular and noncardiovascular causes. Cutoffs for categorical variables were chosen based on the distribution of the variable (usually quartiles).

Statistical Analysis

Unadjusted cumulative mortality rates were estimated and compared by means of the Kaplan–Meier product-limit method. Because the patient months (level 1) observed in the follow-up period are nested within patients (level 2), which are nested within dialysis facilities (level 3), a three-level logistic regression modeling (random-effects regression or hierarchical regression modeling) was performed to control for both within-facility and within-patient variations (Rice and Leyland 1996; Christiansen and Morris 1997). Unlike simple single-level analyses that prevent researchers from disentangling individual patient and facility effects on mortality, multilevel analytic techniques allow one to simultaneously consider the effects of facility-level and individual-level variables on individual-level outcomes (Diez-Roux 2000; Osborne 2000; Bingenheimer and Raudenbush 2004). Specifically, a random intercept model using *SAS GLIMMIX* procedures that treats the dialysis facility effects as random effects was fit with patient months as the unit of analysis (Witte et al. 2000). Hazard ratios (HRs) were estimated comparing the incidence of death in each facility group using pooled logistic regression. This pooled logistic regression is also called discrete-time hazard modeling and has been shown to be asymptotically equivalent to the Cox regression model (D'Agostino et al. 1990). By using *GLIMMIX* to fit an empty model with no predictors included, the random intercept variance was estimated as 0.104 with a standard error of 0.04 (p-value based on z-test $< .03$, data not shown).

This parameter measures the variability between providers. The fact that the estimated value of the random intercept variance was significantly larger than zero indicates that there were facility-to-facility variation in patient mortality. All analyses were performed using *SAS*, version 9.1.3 for Linux. Statistical significance is defined as a p-value $< .05$.

RESULTS

Distribution of Facilities and Patients by Facility Type

During the follow-up period, 44 percent of all patients survived, 34 percent died, and 22 percent were censored due to *nonadministering* censoring events such as gap in outpatient dialysis services (3 percent), change of dialysis provider (11 percent), change of modality (5 percent), and kidney transplantation (3 percent). Mean follow-up time was 16 months.

Table 1 shows that in 2004, more than 75 percent of patients received dialysis from chain facilities and about 30 percent were treated in the largest dialysis chain (Chain 1). Most of these chain facilities are FP except Chain 5, accounting for 5.0 percent of all free-standing facilities. Among the 835 small chain or nonchain free-standing facilities, 672 were FP and 163 were NP facilities.

Table 1: Distribution of Facilities and Patients by Facility Type

*Facility Type Chains**	*Facilities (N = 3,601)*		*Patients (N = 34,914)*	
	No.	*%*	*No.*	*%*
FP Chain 1	1,075	29.9	10,763	30.8
FP Chain 2	544	15.1	5,284	15.1
FP Chain 3	583	16.2	5,673	16.3
FP Chain 4	383	10.6	3,419	9.8
NP Chain 5	181	5.0	1,405	4.0
Nonchains				
FP nonchain†	672	18.7	6,570	18.8
NP nonchain	163	4.5	1,800	5.2

*The USRDS defines a chain-affiliated unit as one of a group of 20 or more freestanding facilities that have been owned or operated by a corporation for 1 year or longer and that are located in more than one state.

†Only 25 facilities from Chain 6 were identified in 2004 and were placed into this category.

FP, for-profit; NP, nonprofit; USRDS, United States Renal Data System.

Patient Characteristics by Type of Facility

Among the study cohort of 34,914 individuals, more than 63 percent were older than 65 years, 51 percent were male, 63 percent were white, and 13 percent were Hispanic (data not shown). Because of exclusion of patients without Medicare as a primary payor and patients who died within the first 3 months of dialysis, our study population is slightly older than the general incident ESRD patients (66.2 versus 62.7 years, respectively), although other demographic characteristics are similar. Almost all the variables examined in the study were found to be significantly associated with facility organizational status using analysis of variance (ANOVA) analyses (Table 2). Compared with other facilities, patients from NP Chain 5 tended to be younger, non-Hispanic, and from lower income areas. Patients treated in FP Chain 1, the largest chain, were most likely to have Hispanic ethnicity and patients treated in FP Chain 2, the second largest chain, were more likely to be blacks.

Patients from NP Chain 5 and other NP facilities had the lowest average EPO doses and the largest proportion of patients (62.3 percent) who had achieved HCT in the recommended target range (33–36 percent) during the baseline period. Patients in Chain 2 were administered the highest EPO doses.

Comorbid conditions were highly prevalent among dialysis patients. Before the start of dialysis, 55 percent already had cardiovascular diseases and 65 percent had noncardiovascular diseases. After 3 months of dialysis, more than 40 percent had a Charlson Index score of 3 or more. Patients from Chain 5 had the highest Charlson Index scores, the highest proportion of patients with cancer (8.9 percent), and the highest rate of preexisting noncardiovascular comorbidities (73.5 percent), while having the lowest rates of congestive heart failure (22.1 percent). Chain 2 had the highest proportion of patients with congestive heart failure (24.8 percent) and hypertension (61.0 percent). Patients from FP Chain 2 and FP nonchain facilities had the longest hospital stays while patients from NP Chain 5 had the shortest length of hospitalization.

Facility Characteristics by Type of Facility

Facility characteristics are significantly different by type of facility using ANOVA analyses ($p < .0001$, Table 3). Specifically, NP nonchain facilities had the largest facility sizes with an average of 89 patients per facility; Chain 5 had the smallest size with 66 patients per facility. The ratio of technicians to registered nurses was highest among Chain 3 and lowest among Chain 5 facilities. Chain 5 facilities were located in areas with the highest percentage of whites

Table 2: Patient Characteristics by Facility Type ($N = 34{,}914$)

	FP Chain 1	*FP Chain 2*	*FP Chain 3*	*FP Chain 4*	*NP Chain 5*	*FP Nonchain*	*NP Nonchain*	*p-Value*
Sociodemographics								
Age (years)	65.7 (14.3)	66 (14.4)	66 (14.7)	65.8 (14.6)	65.2 (14.8)	67.4 (14.1)	66.9 (14.6)	*<.0001*
Male gender (%)	52.4	52.2	52.7	51	52.2	53.1	52.7	.62
% White	64.0	58.4	61.7	64.8	62.1	66.7	66.4	*<.0001*
Hispanic ethnicity (%)	16.5	11.4	14.7	9.5	8.2	15.2	8.3	*<.0001*
Median household income among white householders (U.S.$)	40,747 (15,178)	42,348 (15,122)	43,215 (15,593)	40,073 (13,111)	40,097 (14,646)	41,529 (15,367)	44,019 (15,388)	*<.0001*
Median household income among black householders (U.S.$)	31,259 (20,914)	32,579 (19,270)	33,681 (20,233)	29,727 (20,446)	29,059 (20,370)	33,120 (21,773)	35,977 (23,336)	*<.0001*
ESRD clinical history/severity of disease								
Cause of ESRD (%)								*<.0001*
Diabetes	50.7	48.2	48.9	48.5	50.0	49.7	47.5	
Hypertension	31.2	33.1	30.6	31.6	28.3	31.6	29.3	
Body mass index (kg/m^2)	28.2 (7.5)	27.5 (7.1)	27.7 (7.3)	28.4 (7.7)	28.1 (7.4)	27.7 (7)	27.7 (7.3)	*<.0001*
Number of vascular access procedures*	0.2 (0.6)	0.2 (0.6)	0.2 (0.6)	0.2 (0.5)	0.1 (0.5)	0.2 (0.6)	0.2 (0.5)	.19
Total inpatient days*	3.9 (9)	4.3 (9.3)	4.1 (9.2)	4 (8.7)	3.3 (8)	4.3 (9.8)	3.8 (9)	*.001*
Blood transfusions (pints)*	0.2 (1)	0.2 (0.8)	0.2 (0.9)	0.2 (0.8)	0.2 (0.9)	0.2 (0.9)	0.3 (2.7)	*.004*
Predialysis GFR (ml/min)	9.9 (4.5)	10.1 (4.7)	10.1 (4.7)	10.5 (4.7)	9.7 (4.4)	10.1 (4.6)	9.9 (4.7)	*<.0001*
Predialysis serum creatinine (mg/dl)	6.9 (3.4)	6.9 (3.6)	6.8 (3.4)	6.5 (3.2)	7 (3.2)	6.6 (3.1)	6.8 (3.3)	*<.0001*
Predialysis albumin (g/dl)	3.1 (0.7)	3.1 (0.7)	3.1 (0.7)	3.1 (0.7)	3.1 (0.7)	3.2 (0.7)	3.2 (0.7)	*<.0001*
Anemia management								
Predialysis EPO use	34.5	29.4	32	32.6	37.2	32.8	39.4	*<.0001*
Predialysis hematocrit (%)	30.3 (6.4)	30.3 (5.1)	30.2 (5.1)	30.5 (5.2)	30 (5.1)	30.6 (5.1)	30.7 (9.4)	*<.0001*
Average epoetin dose (units/administration)*	7,457 (6,389)	8,664 (7,945)	7,898 (6,351)	7,555 (6,715)	6,440 (5,492)	7,035 (10,777)	6,208 (5,378)	*<.0001*

Average hematocrit value (%)*								*<.0001*
<33%	12.6	11.0	10.6	14.5	16.2	16.9	15.1	
33–<37%	37.7	49.2	30.4	41.8	62.3	40.3	40.4	
⩾37%	49.7	39.8	59.0	43.7	21.5	42.8	44.5	
Comorbidities (%yes)†								
Charlson Index	3 (3.2)	3 (3.3)	2.9 (3.1)	3 (3.3)	3.2 (3.4)	3 (3.3)	2.8 (3.1)	*.002*
Atherosclerotic heart disease (yes)	25.0	23.9	23.3	25.0	25.5	25.6	24.8	.08
Cancer	6.7	7.2	7.0	7.8	8.9	7.1	7.4	*.05*
Congestive heart failure	23.3	24.8	21.5	23.1	22.1	23.7	23.3	*.004*
Hypertension	60.1	61.0	58.4	60.6	60.4	59.7	54.4	*<.0001*
Peripheral vascular disease	12.4	12.2	11.6	14.9	11.5	12.8	12.3	*.0004*
Chronic obstructive pulmonary disease	9.4	9.7	8.6	9.9	9.6	9.5	8.6	.26
Cerebrovascular accident/transient ischemic attack	6.9	7.5	6.3	6.7	6	6.5	6.3	.14
Gastrointestinal bleeding	0.9	1.2	0.9	1.0	0.9	1.0	0.8	.48
Liver disease	1.4	1.8	1.9	1.5	1.3	2.1	5.2	*<.0001*
Cardiovascular comorbidities‡	55.6	54.5	50.9	53.5	58.4	58.2	62.4	*<.0001*
Noncardiovascular comorbidities§	67.2	64.5	64.2	66.8	73.5	66.3	66.3	*<.0001*

Notes. Italics indicate significance of 0.05. Numbers in parentheses are standard deviations.

*Measured during baseline period (months 4–6).

†All comorbidities are measured during baseline period, except for preexisting cardiovascular and noncardiovascular comorbidities, which are collected from Medical Evidence form.

‡Included cardiac arrest, congestive heart failure, cerebrovascular disease, cardiac dysrhythmia, pericarditis, peripheral vascular disease, ischemic heart disease, and myocardial infarction.

§Included alcohol dependence, cancer, drug dependence, human immunodeficiency virus (HIV infection), acquired immunodeficiency syndrome (AIDS), inability to ambulate, inability to transfer, chronic obstructive pulmonary disease, tobacco use, diabetes, currently on insulin, and diabetes mellitus, primary or contributing.

ESRD, end-stage renal disease; EPO, epoetin; FP, for-profit; GFR, glomerular filtration rate; NP, nonprofit.

Table 3: Facility Characteristics by Type of Facility (N = 3,419 Facilities)

	FP Chain 1	*FP Chain 2*	*FP Chain 3*	*FP Chain 4*	*NP Chain 5*	*FP Nonchain*	*NP Nonchain*	*p-Value*
Facility size (avg # patients/facility)	73 (43)	78 (46)	82 (51)	70 (46)	66 (40)	73 (48)	89 (63)	*<.0001*
Ratio of technicians to registered nurses	2.2 (1.5)	2.4 (8.3)	2.7 (1.3)	2.6 (3.7)	1.4 (0.9)	2 (1.7)	1.8 (2)	*.0001*
% White based on facility zip code	70 (24)	67 (26)	68 (25)	72 (23)	74 (23)	70 (25)	73 (24)	*.0006*
GINI coefficient for income inequality*	0.45 (0.04)	0.45 (0.04)	0.45 (0.04)	0.45 (0.03)	0.46 (0.04)	0.45 (0.04)	0.44 (0.03)	*.0004*
Region (%)								*<.0001*
Northeast (Networks 1–5)	23.0	22.2	18.9	6.3	26.5	25.0	21.5	
Southeast (Networks 6–8, 13, 14)	46.0	40.6	35.0	43.1	42.5	38.2	19.0	
Midwest (Networks 9–12)	19.3	20.2	22.3	34.7	18.8	20.2	27.0	
West (Networks 15–18)	11.7	16.9	23.8	15.9	12.2	16.5	32.5	
Urban/rural status								*.0002*
Rural (% yes)	31.1	25.7	25.7	36.0	39.8	28.6	27.0	
Urban (% yes)	68.9	74.3	74.3	64.0	60.2	71.4	73.0	
Facility clinical characteristics								
Use of EPO (average units/month)†	85,377 (21,323)	99,354 (23,289)	92,309 (22,791)	86,667 (22,390)	76,398 (19,817)	75,177 (25,538)	75,488 (24,370)	*<.0001*
Use of iron (average mg/month)†	227 (68)	283 (74)	290 (84)	221 (66)	228 (55)	225 (83)	192 (68)	*<.0001*
Use of Vitamin D (average mcg/month)†	43 (15)	52 (17)	47 (19)	35 (13)	18 (12)	29 (16)	26 (13)	*<.0001*
Use of all three injectable medications*	7.4 (2.1)	9.3 (2.1)	8.7 (2.3)	6.9 (2.3)	5.5 (1.7)	6 (2.2)	5.4 (1.9)	*<.0001*
% Patients with HCT > 33%	91 (7)	92 (9)	93 (7)	92 (7)	90 (9)	88 (13)	89 (12)	*<.0001*
% Patients with URR > 65%	96 (4)	93 (7)	95 (5)	96 (4)	90 (7)	92 (9)	93 (7)	*<.0001*

Notes. Italics indicate significance of 0.05. Numbers in parentheses are standard deviations.

*Summarized based on the dose quartile distributions with a minimum of 9 and a maximum of 12.

†Summarized for every certified facility based on entire 2004 outpatient dialysis claims.

EPO, epoetin; FP, for-profit; HCT, hematocrit; NP, nonprofit; URR, urea reduction ratio.

(74 percent) and in areas which had the highest GINI coefficient. Chain 5 facilities were more likely to be found in the Northeast region and NP nonchain facilities were more likely to be located in the West region. Compared with other facilities, Chain 5 facilities were more likely to be in rural areas. All FP dialysis chains used significantly higher EPO and vitamin D doses compared with NP Chain 5 and nonchain facilities (both FP and NP). Specifically, Chain 2 and Chain 3 had the highest average doses for all three injectables.

Unadjusted Mortality Rates

Kaplan–Meier analysis by facility type shows the cumulative mortality rate ranged from 42 percent in Chain 5 to 47 percent in nonchain FP facilities (data not shown). Compared with all others, the survival advantage of Chain 5 was present throughout most of the follow-up period, while Chain 2 and FP nonchain facilities had the highest cumulative mortality. Overall, the adjusted mortality differences at end of follow-up were statistically significant by both log-rank test and Wilcoxon test ($p < .0001$). In the first 6 months of follow-up, Chain 2 and FP nonchain facilities had the highest death rate (46.1 and 46.7 percent, respectively; both had standard errors of 1.0 percent) and Chain 5 had the lowest death rate (41.8 percent with standard error of 2.1 percent).

Mortality Risks Based on Hierarchical Multivariate Regression Analyses

Table 4 depicts the estimated HRs during the entire follow-up based on both unadjusted and adjusted *GLIMMIX* Model. In contrast with the unadjusted results indicating that only patients from Chain 2 and nonchain FP facilities had increased mortality risk when compared with Chain 5, adjusted analyses revealed an increased risk for patients from the two largest FP chains and FP nonchain facilities when compared with Chain 5 facilities. Notably, HRs were 19 percent higher (95 percent CI 1.06–1.34) for patients from Chain 1, 21 percent higher for patients from FP nonchain units (95 percent CI 1.10–1.39), and 24 percent higher for patients from Chain 2 (95 percent CI 1.10–1.40), compared with the reference group Chain 5. NP nonchain facilities had risk profiles similar to Chain 5 facilities. We performed sensitivity analyses to address potential endogeneity introduced by adjusting for endogenous variables that might be affected by facility type and also affect patient outcome, such as comorbidity, disease severity, and anemia management variables measured after dialysis was initiated. After removing these potentially endog-

Table 4: Hazard Ratios for Mortality by Dialysis Facility Type Based on Random Effect Models*

	Unadjusted Model			*Adjusted Model*†		
Facility	*HR*	*Lower CI*	*Upper CI*	*HR*	*Lower CI*	*Upper CI*
Chain 1	1.10	1.00	1.22	1.19	1.06	1.34
Chain 2	1.21	1.09	1.34	1.24	1.10	1.40
Chain 3	1.07	0.96	1.18	1.14	1.00	1.29
Chain 4	1.09	0.98	1.22	1.13	1.00	1.29
Chain 5	Reference			Reference		
FP nonchain	1.21	1.09	1.34	1.24	1.10	1.39
NP nonchain	1.04	0.92	1.18	1.06	0.92	1.22

*All models are based on *SAS GLIMMIX* procedure to account for within facility correlations.
†Adjusted for patient and facility characteristics listed in Tables 2 and 3.
CI, 95% confidence interval; FP, for-profit; HR, hazard ratio; NP, nonprofit.

enous variables, the estimated hazard ratios were similar to the adjusted HRs reported in Table 4.

To examine whether profit status of the facility was associated with patient mortality, the analysis was repeated replacing facility type with facility ownership status. A significant association was found (HR for FP versus NP = 1.13, 95 percent CI 1.06–1.22), indicating that patients from FP facilities had 13 percent higher mortality risk compared with patients from NP facilities. The associations between use of injectable drugs and GINI coefficient and patient mortality have not been evaluated in previous studies. Results based on the summary measure of dose levels suggested that, compared with patients in facilities that had used at least two injectable drugs at the highest quartile levels, patients from facilities that used less injectable drugs appeared to have lower mortality risk with marginal statistical significance (HR = 0.93; 95 percent CI 0.87–1.00). The association between GINI coefficient and patient mortality was not found to be significant ($p = .21$).

We performed an analysis to test the proportional hazards (PHs) assumption by examining the interaction effect between facility type and follow-up time (cubic splines). Results were not found to be significant, so the PH model assumption is justified. We also considered the possibility that survival advantage of Chain 5 might have been due to informative censoring. Analyses were repeated without censoring, assuming all patients survived until the end of the study. Results based on this sensitivity analysis were similar (data not shown). In addition, we selected a study cohort from the 2003 USRDS data and repeated the analyses. Results were also similar (data not shown).

DISCUSSION

There has been an accelerated movement in the U.S. dialysis market toward facility affiliation with large chain organizations, but little is known about the impact of such consolidation on patient outcomes. The findings of our analysis suggest that large chain status of a dialysis facility is independently related to patient mortality, after accounting for an extensive array of sociodemographic risk factors, patient disease severity, comorbid conditions, and facility characteristics, other than chain status. Specifically, study results indicated either significant or marginally significant associations between the nation's three FP largest dialysis chains (Chain 1, Chain 2, and Chain 3) and FP nonchain units and higher patient mortality, compared with NP facilities, organized independently or in chains. Patients from Chain 2 had the highest risk of mortality and the difference in the mortality risks between Chain 2 and Chain 5 (which had the lowest mortality) was found to be 24 percent.

The observation that patients from Chain 5 had the lowest mortality risk is consistent with USRDS findings. Since 1999, USRDS reported standardized mortality rates (SMRs) of the large dialysis organizations, adjusted for age, gender, race, primary diagnosis, and ESRD vintage. According to the 2007 USRDS annual data report, SMRs remain lowest in Chain 5 facilities each year from 1999 to 2006. We expanded upon the USRDS analysis by including an extensive list of patient and facility characteristics and yet the improved survival in Chain 5 facilities remained. An examination of facility case mix did not reveal that patients from Chain 5 tended to have more potentially favorable characteristics. Specifically, although patients in Chain 5 were slightly younger than patients from other facilities, they also had clinical factors that have been shown to be associated with decreased survival, such as lower serum albumin, higher serum creatinine, lower predialysis HCT, and the highest Charlson Index scores. Compared with patients in Chain 2 who had the highest risk of mortality, patients in Chain 5 also had similar preexisting comorbid conditions.

In this study, we also found that patients from FP facilities had 13 percent higher risk of mortality than NP facilities. This finding is consistent with several previous studies that found FP facilities have significantly higher rates of mortality than nonprofit facilities (McClellan, Soucie, and Flanders 1998; Irvin 2000; Devereaux et al. 2002). However, our study results contrast with two other recently published reports by Foley et al. (2008) and Brooks et al. (2006) regarding the association between ownership and patient mortality, where they found no significant relationships. The major factor that contributes to the

discordant results with our findings is likely to be attributable to the inclusion of patients treated in hospital-based facilities (all NP) by Foley and Brooks. As noted by USRDS, hospital-based units have both hospitalization and mortality rates that are higher than those of all other free-standing providers (USRDS 2006). For example, SMRs for hospital-based facilities between 2003 and 2006 were 1.74, 2.15, and 2.21, which were consistently the highest among all facility types. In contrast, all other facilities had SMRs below 1.0 (national average). It has been suggested that higher mortality and hospitalization ratios relate to treatment of more complex patients (Plough et al. 1984). Given the studies by Foley and Brooks included patients from hospital-based facilities, the effect of facility profit versus NP status might have been diluted by the inclusion of more complex patients from hospital-based facilities.

Whether patients dialyzed in NP dialysis centers or chains have superior health outcomes to patients treated in FP dialysis centers is still controversial. Basic microeconomic theories usually model FP as profit maximizers, which raises the question of whether profit is obtained at the expense of quality. As such, researchers and policy makers have expressed concerns about the fast growth rate of FP dialysis facilities versus decreasing number of NP facilities (Himmelfarb et al. 2007). Higher observed death rates in FP facilities were interpreted as evidence suggesting FP facilities might be more likely than NP facilities to respond to financial pressures by taking steps that compromise the quality of care in order to maintain shareholder returns. However, proponents of investor-owned facilities countered by arguing that financial incentives are found in any medical practice and that the profit motive simply induces physicians to deliver health care more cost efficiently and that the ethical norms conveyed through medical training ameliorate any undesirable economic incentives (Lowrie and Hampers 1981).

Some contend that lower resource use in the delivery of dialysis by FP facilities compromises the health outcomes of dialysis patients. FP facilities use less labor and equipment per treatment, for instance, suggesting a lower average cost per dialysis session (Griffiths et al. 1994). Poor outcomes might also be attributable to lower levels of staffing in FP facilities (Held et al. 1990), which notably affects ESRD patients who rely on their dialysis center as their primary health care provider (Holley and Nespor 1993; Bender and Holley 1996). Effects of these possible differences are unclear because the higher level of resources used by NP centers might be inefficient in providing patient care (Ozgen and Ozcan 2002). Market competition is another factor that is cited as potentially contributing to differences in facility outcomes. Differing effects of FP ownership in mixed counties (with both FP and NP facilities) and in coun-

ties with only FP facilities support the hypothesis that FP facilities might deliver better care when competing for patients with nearby NP facilities (Hirth 1997; Garg et al. 1999). Future studies that include these factors should be used to reevaluate the relationship found herein. Because there was only one NP chain included in our study, conclusions regarding the role of profit status in chains must be made with caution due to the lack of variation of this characteristic.

A number of published studies suggest that factors related to practice patterns, such as dialysis dose, vascular access, and injectable drugs can influence patient outcomes. All facilities in 2004 appear to have high dialysis doses. Although greater mortality risks have been seen for hemodialysis patients dialyzing with a catheter or graft versus a native AVF (Ethier et al. 2008), data on vascular use by dialysis facilities are not available and were not included in our model. This study evaluated and compared the use of all three major injectable drugs among dialysis facilities. Consistent with prior findings based on EPO use by the authors, significant variations in the use of both vitamin D and iron were also found across facilities. Compared with other facility types, this study found that large FP chains that administered higher EPO and iron doses had higher achieved HCT levels, as well as a larger proportion of patients above the FDA-approved upper level of HCT.

Given the organizational status of a facility was found to be strongly associated with the use of injectables and use of higher drug doses did not improve patient survival, the current study might have important implications regarding the wisdom of bundling separately billable items (primarily injectable medications) with other composite rate services into the new dialysis prospective payment system to be implemented in January 2011. The findings of this study suggest that patients from Chain 5 who use the least amount of injectable drugs had the best survival. If all other chains were to follow the resource use profile of Chain 5, costs of injectable drugs might be reduced without compromising patient outcomes, with the caveat that providers will not excessively lower doses. Our findings—that lower doses of injectable drugs do not appear to compromise quality of care—supports Medicare's implementation of a bundled payment system for injectable drugs.

The findings reported herein should be considered in the context of an observational study and its inherent limitations. Specifically, the observed relationship between type of facility and patient mortality should not be interpreted as causal. Selection bias likely still exists, despite our considerable efforts to control for numerous patient- and facility-level characteristics. It is well documented that FP facilities tend to locate in certain economically

advantageous areas, instead of locating randomly (Norton and Staiger 1994; Hirth 1997). Adjusting for income differences as we did might not fully address differences in available medical resources found outside the dialysis unit. If such differences exist, they might influence our results. Misclassification bias could also have arisen from several sources. First, the time when a dialysis facility was surveyed by CMS might be different from the time when patients entered study (baseline period). However, change of facility type is expected to be rare during the 12-month survey period. Second, comorbidity data used in the study originate from Medicare's dialysis initiation form (CMS Medical Evidence Form 2728), in which comorbid conditions are found to be underreported (Longenecker et al. 2000). Third, the geographic analyses of socioeconomic data in each zip code were ascertained from the 2000 U.S. Census, although cohort patients received initial dialysis during 2004. However, a serious misclassification is unlikely, and, if it occurred, it is likely to be random in nature (Geronimus, Bound, and Neidert 1996). Several factors that might affect quality differences across the various dialysis facilities, such as length of dialysis treatment time (Fan et al. 2005), adherence to prescribed dialysis time (Leggat 2005), affiliation of dialysis units with academic medical centers (NP dialysis centers are more likely to develop affiliations with academically related facilities) (Kalantar-Zadeh, Mehrotra, and Kopple 2003), physicians' bed-side time (Ronco and Marcelli 1999), and patient counseling or education are not observed. Finally, the results might be subject to survivor bias (i.e., patients who died before the follow-up began were not evaluated in relation to facility type).

The characteristics of the dialysis marketplace continues to transform dramatically into fewer large profit chains that treat more patients. Since our study in 2004, a major consolidation of dialysis units and chains has occurred, resulting in only two large, FP chains, which currently treat nearly 60 percent of the dialysis population and Chain 5, although still small in relationship to their FP competitors, also continued to grow, from 186 U in 2002 to 205 U in 2007. Changes in facility ownership are anticipated to have a major impact on influencing the policies and practices of individual units, as new owners imprint their own systems of care. The current study should encourage further exploration of factors that could improve high-quality care.

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