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Original Investigation

Patient Care Staffing Levels and Facility Characteristics in US Hemodialysis Facilities

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Background: Higher numbers of registered nurses (RNs) per patient have been associated with improved patient outcomes in acute-care facilities. Variation in and associations of patient care staffing levels and hemodialysis facility characteristics have not been examined previously.

Study Design: Cross-sectional study using Poisson regression to examine associations between patient care staffing levels and hemodialysis facility characteristics.

Setting & Participants: 4,800 US hemodialysis facilities in the 2009 Centers for Medicare & Medicaid (CMS) End-Stage Renal Disease Annual Facility Survey (CMS-2744 form).

Predictors: Facility characteristics, including profit status, freestanding status, chain affiliation, and geographic region, adjusted for facility size, capacity, functional type, and urbanicity.

Outcomes: Patient care staffing levels, including ratios of RNs, licensed practical nurses (LPNs), patient care technicians (PCTs), composite staff (RN + LPN + PCT), social workers, and dietitians to in-center hemodialysis patients.

Results: After adjusting for background facility characteristics, ratios of RNs and LPNs to patients were 35% ($P < 0.001$) and 42% ($P < 0.001$) lower, respectively, but the PCT to patient ratio was 16% ($P < 0.001$) higher in for-profit than nonprofit facilities (rate ratios of 0.65 [95% CI, 0.63-0.68], 0.58 [95% CI, 0.51-0.65], and 1.16 [95% CI, 1.12-1.19], respectively). Regionally, compared to the Northeast, the adjusted RN to patient ratio was 14% ($P < 0.001$) lower in the Midwest, 25% ($P < 0.001$) lower in the South, and 18% ($P < 0.001$) lower in the West. Even after additional adjustments, the large for-profit chains had significantly lower RN and LPN to patient ratios than the largest nonprofit chain, but a significantly higher PCT to patient ratio. Overall composite staffing levels also were lower in for-profit and chain-affiliated facilities. The patterns hold when hospital-based units were excluded.

Limitations: Nursing hours were not available. Two part-time staff were counted as one full-time equivalent, which may not always be accurate.

Conclusions: The significant variation in patient care staffing levels and its associations with facility characteristics warrants inclusion in future large-scale hemodialysis outcomes studies. End-stage renal disease networks and hemodialysis facilities should attend to quality assurance and performance improvement initiatives that maximize licensed nurse staffing levels in hemodialysis facilities.
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INDEX WORDS: US Renal Data System (USRDS); in-center hemodialysis; Centers for Medicare & Medicaid (CMS) End-Stage Renal Disease (ESRD) Facility Survey; staffing ratios; profit; region.

Across the United States, approximately 400,000 patients with end-stage renal disease (ESRD) undergo maintenance hemodialysis each year.[1] Medicare provides payment for services, while a health care team organizes and delivers the hemodialysis treatment. The universal payment from Medicare does not vary by dialysis facility size, capacity, region, chain affiliation, or profit status.[2] Within each facility, registered nurses (RNs), licensed practical nurses (LPNs), and unlicensed patient care technicians (PCTs) provide the direct care during hemodialysis. Nurses' and technicians' responsibilities include monitoring the arteriovenous fistula or access device, physical assessment, safe medication administration, psychosocial and physical problem management, patient education, and care planning and coordination.

Despite equal payment, equal outcomes have not yet been realized. Prior studies have reported differences in quality of care and outcomes such as mortality,[3] infection rate,[4] epoetin dosing,[5] adequacy of dialysis dose,[6] and hospitalization.[7] Studies examining variation in outcomes have included patient-level risk factors and facility characteristics, including chain affiliation and profit status.[3,7,8] Very few have considered nurse staffing mix indicators or social worker or dietitian measures, although these are key professionals providing direct care.

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In 2011, an article by Wolfe[9] gave a detailed review of issues in dialysis facility staffing and quality of care. He pointed to the need for further investigation of dialysis facility staffing practices. Because the direct care provided to patients in any setting is linked to the degree of expertise and scope of practice of those providing care, and hospitals with higher proportions of RNs experience better patient outcomes,[10] the regional and organizational variation of nurse staffing mix in hemodialysis facilities warrants further investigation. If there is significant variation in nurse staffing mix in relation to facility characteristics, this heterogeneity must be considered in the identification of relevant solutions for outcome disparities. Therefore, the first objective of this study was to examine the variation in nurse staffing levels across US hemodialysis facilities and its associations with facility characteristics and geographic region. Our secondary objective was to examine whether similar variation and associations exist in dietitian and social worker staffing levels.

METHODS

Data Sources and Study Sample

We used data from the 2009 Centers for Medicare & Medicaid (CMS) ESRD Facility Survey (CMS-2744 form; required annually for all Medicare-certified dialysis facilities) in the US Renal Data System.[11] The survey collects facility-level data, including profit status, chain affiliation, services provided, number of patients receiving care, and patient care staffing. We identified all outpatient dialysis facilities and centers that completed the 2009 survey form, were located in any of 50 states or the District of Columbia, provided in-center hemodialysis, and did not offer transplantation services (n = 5,068). Units were excluded if they provided only a home dialysis program or reported zero patients at year end (n = 78). Additionally, units were excluded if they reported zero for both RNs and LPNs (n = 27), profit status was not concordant with chain profit status (n = 55), or no profit status was indicated (n = 108). The final study sample consisted of the remaining 4,800 hemodialysis facilities. The Institutional Review Board at the University of Virginia approved the study.

Staffing Level Measures

We examined 6 different staff to patient ratios. The first 3 were the ratios of full-time RNs, full-time LPNs, and full-time PCTs to total in-center hemodialysis patients (ie, excluding home dialysis patients). The next 2 were ratios of full-time social workers and full-time dietitians to in-center hemodialysis patients. For any part-time staff, we converted 2 part-time staff to 1 full-time equivalent (FTE). Finally, we calculated a composite staffing ratio (FTE RNs + LPNs + PCTs to patients) to assess overall staff to patient ratios. To depict variation in staffing mix, we calculated 3 proportions of total full-time nursing staff (defined as all RNs, LPNs, and PCTs) that were RNs, LPNs, and PCTs. All patient and staffing numbers were based on end-of-year data.

Table 1. Distribution of Dialysis Facilities, Overall and by Size and RN to Patient Ratio

Characteristics	Overall	Size, Expressed as No. of HD Stations			RN to Patient Ratio[a]	
		≤10	11-25	≥26	≤6	>6
No. of facilities	4,800	623 (13.0)	3,552 (74.0)	625 (13.0)	2,336 (48.7)	2,464 (51.3)
Functional type						
In-center HD only	62.3	82.3	62.5	41.1	67.5	57.4
In-center HD & home dialysis	37.7	17.7	37.5	58.9	32.5	42.6
Capacity						
≤4 patients/station	63.5	72.1	63.4	55.5	55.4	71.1
>4 patients/station	36.5	27.9	36.6	44.5	44.6	28.9
Geographic location						
Urban	73.7	44.0	76.0	90.1	81.0	66.8
Rural	26.3	56.0	24.0	9.9	19.0	33.2
Profit status						
For profit	84.2	64.8	87.9	82.7	93.7	75.3
Nonprofit	15.8	35.2	12.1	17.3	6.3	24.7
Facility type						
Freestanding	91.7	73.7	94.5	93.9	98.1	85.6
Hospital based	8.3	26.3	5.5	6.1	1.9	14.4
Census region						
Northeast	14.2	14.0	14.2	14.4	9.5	18.7
Midwest	23.6	41.4	21.7	17.0	19.1	27.9
South	44.7	29.2	46.3	51.0	51.6	38.2
West	17.5	15.4	17.8	17.6	19.8	15.2

Note: Number of facilities given as number (percentage); all other values given as percentages.
Abbreviations: HD, hemodialysis; RN, registered nurse.
[a]Median number per 100 patients.

Facility Organizational Measures and Geographic Region

We examined the following facility organizational characteristics: profit status (for profit/nonprofit); hospital based or freestanding; chain ownership; facility capacity, defined as number of in-center hemodialysis patients per station (≤4 or >4); facility size, determined by number of hemodialysis stations: small (1-10 stations), medium (11-25 stations), and large (≥26 stations); and functional type, defined by whether the facility offered home dialysis services in addition to in-center hemodialysis. For chain ownership, according to the 2009 survey, most chain-affiliated facilities were associated with Dialysis Clinic Inc (DCI), DaVita, Fresenius, and Renal Advantage Inc. We combined the other 8 chains into an "other chains" group. DCI was the only nonprofit chain and was chosen as the referent category in all regression analyses. Facilities not affiliated with a chain were categorized further into freestanding and hospital based because all hospital-based facilities reported no chain affiliation.

Facility urban/rural location was defined according to facility location zip code using Rural-Urban Commuting Area Codes developed by the US Department of Agriculture Economic Research Service and University of Washington.[12,13] Finally, we used facility location zip code to assign each facility to 1 of the 4 standard US census regions (Northeast, Midwest, South, and West).

Statistical Analyses

Poisson regression was used to examine the relationship between facility characteristics and geographic region with each staff to patient ratio measure. Facility and geographic characteristics of interest include profit status, freestanding/hospital-based status, chain ownership, and geographic region. For each staff to patient ratio, 3 sets of multivariate models were constructed. The first set of multivariate models (model 1) examined the effect of each predictor (profit status, freestanding status, geographic region, and chain ownership) adjusted for the background variables (facility size, urban/rural location, functional type, and capacity). Because profit and freestanding variables were correlated highly with chain ownership, the second model (model 2) included all predictors except chain ownership, together with background variables. Thus, this additionally adjusted model examined the effect of each predictor (profit, freestanding, and region) while adjusting for all others in the model, but not chain ownership. In model 3, profit and freestanding variables were replaced with chain ownership. That is, the effect of chain ownership was adjusted for all others, but not profit and freestanding variables. We used overdispersed Poisson regression models with confidence intervals (CIs) and *P* values adjusted for overdispersion. All Poisson models used number of facility staff members under investigation as the response and the natural logarithm of number of facility in-center hemodialysis

Table 2. Distribution of Dialysis Facilities by Profit Status and Chain Ownership

			Chain Ownership Status						
	Profit Status		Nonprofit Chain:	For-Profit Chain			Other	Nonchain	
Characteristics	Nonprofit	For Profit	DCI	DaVita	Fresenius	RAI	Chains	Freestanding	Hospital Based
No. of facilities	756 (15.8)	4,044 (84.2)	179 (3.7)	1,392 (29.0)	1,595 (33.2)	118 (2.5)	406 (8.5)[a]	712 (14.8)[b]	398 (8.3)[c]
Size[d]									
≤10 stations	29.0	10.0	12.8	10.7	7.6	1.7	9.9	17.3	41.2
11-25 stations	56.7	77.2	69.8	77.7	77.6	79.7	79.3	69.6	49.2
≥26 stations	14.3	12.8	17.3	11.6	14.8	18.6	10.8	13.1	9.6
Functional type									
In-center HD	65.5	61.7	65.4	59.0	65.8	50.8	59.4	61.2	66.6
In-center HD & home dialysis	34.5	38.3	34.6	41.0	34.2	49.2	40.6	38.8	33.4
Capacity									
≤4 pts/station	62.4	63.7	82.7	58.4	69.6	61.9	59.1	61.7	56.3
>4 pts/station	37.6	36.3	17.3	41.6	30.4	38.1	40.9	38.3	43.7
Urban	62.3	75.8	67.6	78.6	70.8	83.9	81.8	76.7	54.3
Facility type									
Freestanding	49.3	99.6	100.0	100.0	100.0	100.0	100.0	100.0	
Hospital based	50.7	0.4							100.0
Census region									
Northeast	24.3	12.3	24.0	9.9	11.1	—	19.7	16.9	31.2
Midwest	33.1	21.9	16.2	22.3	22.8	18.6	17.0	23.9	42.7
South	23.1	48.7	45.3	47.2	53.3	49.2	38.2	40.4	14.3
West	19.4	17.1	14.5	20.6	12.8	32.2	25.1	18.8	11.8

Note: Values are given as number (percentage) or percentage.
Abbreviations: DCI, Dialysis Clinic Inc; HD, hemodialysis; pts, patients; RAI, Renal Advantage Inc.
[a]Nonprofit, 7.4%; for profit, 92.6%.
[b]Nonprofit, 23.0%; for profit, 77.0%.
[c]Nonprofit, 96.2%; for profit, 3.8%.
[d]Number of HD stations.

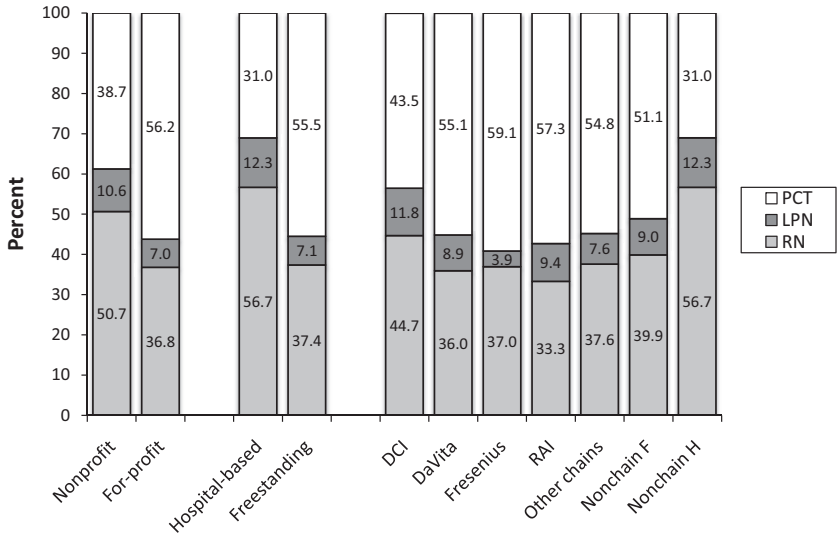

Figure 1. Mean proportions of total full-time nursing staff that are registered nurses (RNs), licensed practical nurses (LPNs), and unlicensed patient care technicians (PCTs) across facilities according to profit status, freestanding (F) status, and chain ownership. Abbreviations: H, hospital-based; DCI, Dialysis Clinic Inc; RAI, Renal Advantage Inc.

patients as an offset.[14] Results are presented as rate ratios (RRs) in comparison to the reference group. All models were performed using SAS GENMOD procedures (SAS Institute Inc).

We conducted several sensitivity analyses to examine the robustness of our main results. The first was to limit the study sample to facilities that provided only in-center hemodialysis (62%; ie, excluded facilities with a home program), followed by separate analyses for facilities with small, medium, and large sizes (13%, 74%, and 13%, respectively). Then, we conducted the analysis using the study sample that included facilities with profit status corrected according to its chain affiliation (n = 4,855) and using the study sample that included facilities that had not reported profit status (n = 4,908). Finally, we analyzed only freestanding facilities (n = 4,402) because hospital-based facilities were heavily skewed to nonprofit.

RESULTS

Facility Characteristics

Of 4,800 facilities, most offered only in-center hemodialysis (62.3%) and were midsized (74.0%), urban (73.7%), for profit (84.2%), and freestanding (91.7%; Table 1). Large facilities were more likely to have a home dialysis program, have 4 or more patients per station, and be in an urban setting. Most midsized and large facilities were located in the South, whereas most small facilities were in the Midwest. Characteristics of the facilities stratified by median RN to patient ratio (≤6 or >6 RNs per 100 patients) also are listed in Table 1. Most facilities were chain affiliated (76.9%; Table 2). Fresenius was the largest for-profit chain (33.2%), followed by DaVita (29.0%). Compared with other regions, the largest percentage of for-profit facilities was located in the South (48.7%) and the largest percentage of nonprofit facilities was in the Midwest (33.1%). All hospital-based facilities reported no chain affiliation and were skewed to nonprofit status. Distributions of hospital-based and freestanding facilities that were not affiliated with any chain also differed somewhat in size, urbanicity, and region (Table 2).

Staffing Level Characteristics

Across the 4,800 facilities, there were a total of 20,709 FTE RNs at the end of survey year 2009, with an average of 4.31 (range, 0-40.5) per facility; 4,220 FTE LPNs, with an average of 0.88 (range, 0-31.0) per facility; 30,290 FTE PCTs, with an average of 6.31 (range, 0-44.5) per facility; 3,893 FTE dietitians, with an average of 0.81 (range, 0-10.5) per facility; and 4,026 FTE social workers, with an average of 0.84 (range, 0-11.0) per facility. Figure 1 represents mean proportions of different types of nursing staff across facilities according to profit and freestanding status and chain ownership.

Figure 2 presents distributions of RN, LPN, PCT, and the composite staff to patient ratios across 4,800 facilities, showing that facilities differed greatly in various staffing ratios. Mean and median values for these staffing ratios and those of dietitians and social workers are listed in Table 3. Staff to patient ratios generally were higher in small than large facilities. Nonprofit and hospital-based facilities had higher licensed staff to patient ratios and lower PCT to patient ratios than for-profit and freestanding facilities. DCI facilities had higher numbers of RNs and LPNs, but lower numbers of PCTs compared with other chain-affiliated facilities.

Across the 4 geographic regions, the average RN to patient ratio was highest in the Northeast and Midwest, intermediate in the West, and lowest in the South (10.35, 10.11, 8.06, and 7.29 average RNs per 100 patients, respectively). In contrast, the average PCT to patient ratio was lowest in the Northeast and highest in the West (8.76 and 10.37 PCTs per 100

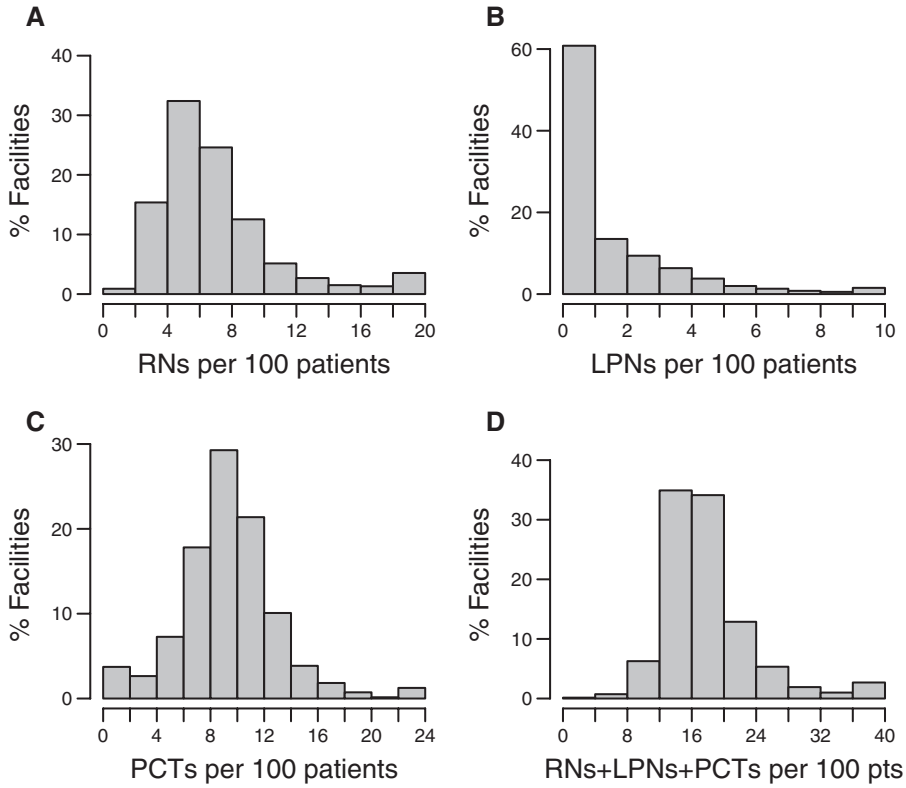

Figure 2. Histograms of nurse staffing ratios across hemodialysis facilities. Facilities with staffing ratios above the largest depicted category were included in the largest category. Abbreviations: LPN, licensed practical nurse; PCT, patient care technician; RN, registered nurse.

patients, respectively). The average LPN to patient ratio in the South was notably more than 3 times higher than that in the West (1.9 and 0.62 LPNs per 100 patients, respectively). Interestingly, the composite staff to patient ratio showed less variation by region. Facilities in the Midwest had the highest ratio for both dietitians and social workers compared with other regions.

Adjusted Associations Between Facility Characteristics and Staffing Levels

Table 4 presents adjusted associations for RNs, LPNs, PCTs, and composite staff, and Table 5 presents adjusted associations for dietitians and social workers. After controlling for facility size, urban/rural location, functional type (in-center only or in-center plus home dialysis), and capacity, the number of RNs and number of LPNs (per 100 patients) were substantially lower in for-profit facilities compared with nonprofit facilities (RRs of 0.65 [95% CI, 0.63-0.68; $P < 0.001$] and 0.58 [95% CI, 0.51-0.65; $P < 0.001$], respectively). In contrast, the number of PCTs was significantly higher in for-profit than nonprofit facilities (RR, 1.16; 95% CI, 1.12-1.19; $P < 0.001$). Numbers of dietitians and social workers in for-profit facilities were 8% and 7% lower, respectively, than in nonprofit facilities ($P = 0.001$; Table 5). After additional adjustments for facilities' freestanding status and region (model 2), the profit-status associations were attenuated but remained significant for each individual staffing indicator (Table 4) except dietitians and social workers (Table 5). Although variation in the composite staffing ratio was less dramatic, profit status remained a significant predictor of overall lower nurse staffing ratios ($P < 0.001$). When hospital-based facilities were removed from the analysis (Table S1, available as online supplementary material), effects of profit status were virtually identical to the original model 2 results (Tables 4 and 5).

After controlling for background facility characteristics, numbers of RNs and LPNs in freestanding facilities were 45% and 53% lower (both $P < 0.001$) and the number of PCTs was 26% higher ($P < 0.001$) than those in hospital-based facilities (Table 4). Dietitian numbers were 10% lower ($P = 0.001$) and social worker numbers were 12% lower ($P < 0.001$). All patterns except for dietitians remained statistically significant after additional adjustment for profit status and geographic region. The composite staff to patient ratio was 16% lower ($P < 0.001$) in freestanding facilities after controlling for background variables, as well as profit-status and region.

Table 3. Staffing Levels by Facility Characteristics

Characteristics	RN to Patient		LPN to Patient		PCT to Patient		Composite Staff to Patient		Dietitian to Patient		Social Worker to Patient	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Overall	8.52	6.12	1.45	0.00	9.66	9.38	19.63	16.67	1.78	1.20	1.81	1.22
Size[a]												
≤10 stations	20.57	9.09	2.11	0.00	10.51	8.70	33.20	20.00	4.26	2.27	4.25	2.27
11-25 stations	6.89	5.95	1.35	0.00	9.54	9.38	17.79	16.67	1.47	1.18	1.51	1.20
≥26 stations	5.80	5.38	1.37	0.84	9.44	9.62	16.61	16.23	1.01	0.97	1.08	1.01
Functional type												
In-center HD	8.02	5.88	1.31	0.00	9.60	9.38	18.93	16.38	1.80	1.24	1.85	1.27
In-center HD & home dialysis	9.36	6.56	1.68	0.55	9.75	9.40	20.79	17.34	1.73	1.15	1.75	1.18
Capacity												
≤4 pts/station	9.89	6.59	1.61	0.00	9.95	9.43	21.45	17.39	2.18	1.41	2.23	1.47
>4 pts/station	6.15	5.48	1.17	0.56	9.15	9.23	16.47	15.91	1.07	0.98	1.10	1.01
Geographic location												
Urban	8.55	5.80	1.32	0.00	9.91	9.48	19.78	16.46	1.69	1.12	1.73	1.16
Rural	8.45	7.14	1.83	0.00	8.94	8.90	19.23	17.86	2.02	1.56	2.05	1.56
Profit status												
Nonprofit	15.67	9.09	2.28	0.68	8.43	8.15	26.39	19.76	2.32	1.33	2.44	1.42
For profit	7.19	5.79	1.30	0.00	9.89	9.52	18.37	16.38	1.67	1.19	1.70	1.20
Facility type												
Freestanding	7.42	5.88	1.32	0.00	9.81	9.47	18.54	16.50	1.68	1.19	1.70	1.22
Hospital based	20.77	11.11	2.91	0.94	8.00	7.00	31.68	21.74	2.87	1.56	3.05	1.61
Chain ownership status												
DCI	10.11	7.55	2.17	1.60	8.23	8.53	20.51	18.50	1.58	1.22	1.70	1.33
DaVita	6.56	5.41	1.47	0.75	9.40	9.02	17.44	15.86	1.77	1.22	1.78	1.22
Fresenius	6.80	5.77	0.66	0.00	10.09	10.00	17.56	16.36	1.49	1.14	1.56	1.18
RAI	5.61	5.20	1.53	1.11	9.40	9.23	16.55	16.27	1.38	1.16	1.39	1.12
Other chains	8.03	6.19	1.29	0.61	9.46	9.38	18.78	16.67	1.60	1.15	1.59	1.18
Nonchain freestanding	9.75	6.63	2.26	0.58	10.61	9.52	22.62	17.95	2.03	1.26	1.98	1.30
Nonchain hospital based	20.77	11.11	2.91	0.94	8.00	7.00	31.68	21.74	2.87	1.56	3.05	1.61
Census regions												
Northeast	10.35	6.98	1.39	0.00	8.76	8.57	20.51	16.93	1.52	1.09	1.62	1.13
Midwest	10.11	6.94	1.26	0.00	9.90	9.09	21.27	17.17	2.23	1.37	2.24	1.41
South	7.29	5.71	1.90	1.11	9.53	9.38	18.72	16.67	1.72	1.22	1.77	1.27
West	8.06	5.66	0.62	0.00	10.37	10.00	19.05	16.67	1.50	1.09	1.50	1.09

Note: Values are expressed as number of specified staff per 100 patients.

Abbreviations: DCI, Dialysis Clinic Inc; HD, hemodialysis; LPN, licensed practical nurse; PCT, patient care technician; pts, patients; RAI, Renal Advantage Inc.; RN, registered nurse.

[a]Number of HD stations.

Compared to the Northeast, after adjusting for background characteristics, numbers of RNs were 14% lower in the Midwest, 25% lower in the South, and 18% lower in the West (all $P < 0.001$; Table 4). Numbers of LPNs were 23% lower ($P = 0.002$) in the Midwest and 47% lower ($P = 0.001$) in the West, but 17% higher ($P = 0.02$) in the South. In contrast, PCT to patient ratios in these 3 regions were all significantly higher than in the Northeast ($P < 0.001$). The composite staffing ratio differed significantly in only the South (5% lower; $P < 0.001$) and was no longer significant after additional adjustment for profit and freestanding status. Compared to the Northeast, after adjusting for background characteristics, only those in the Midwest had higher ratios of dietitians (6%; $P = 0.06$) and social workers (8%; $P = 0.007$; Table 5). In the sensitivity analysis in which all facilities offering home programs were excluded (Table S2), the Northeast had even higher RN to patient ratios.

All of the 3 large for-profit chains (DaVita, Fresenius, and Renal Advantage Inc) and the small chains had a significantly lower number of RNs and LPNs than DCI, the largest nonprofit national chain, but significantly higher number of PCTs after adjustment for background variables (Table 4). Numbers of dieticians and social workers in all other chain categories,

Table 4. Adjusted Associations Between Facility Characteristics and Geographic Region With Nurse Staffing Levels

Characteristics	RN to Patient Ratio		LPN to Patient Ratio		PCT to Patient Ratio		Composite Staff to Patient Ratio	
	Model 1[a]	Model 2 or 3[b]	Model 1[a]	Model 2 or 3[b]	Model 1[a]	Model 2 or 3[b]	Model 1[a]	Model 2 or 3[b]
For profit vs nonprofit	0.65 (0.63-0.68)	0.82 (0.78-0.87)	0.58 (0.51-0.65)	0.68 (0.58-0.79)	1.16 (1.12-1.19)	1.08 (1.03-1.12)	0.86 (0.84-0.88)	0.94 (0.90-0.97)
Freestanding vs hospital based	0.55 (0.52-0.58)	0.68 (0.64-0.73)	0.47 (0.41-0.54)	0.61 (0.50-0.74)	1.26 (1.20-1.32)	1.15 (1.09-1.22)	0.79 (0.76-0.82)	0.84 (0.80-0.88)
Census region[c]								
Midwest	0.86 (0.81-0.91)	0.91 (0.86-0.96)	0.77 (0.65-0.91)	0.84 (0.71-0.99)	1.09 (1.05-1.13)	1.08 (1.04-1.12)	0.97 (0.94-1.00)	0.99 (0.96-1.02)
South	0.75 (0.71-0.79)	0.84 (0.80-0.88)	1.17 (1.02-1.34)	1.43 (1.24-1.65)	1.10 (1.06-1.13)	1.06 (1.03-1.10)	0.95 (0.92-0.98)	0.99 (0.96-1.02)
West	0.82 (0.78-0.87)	0.90 (0.85-0.95)	0.53 (0.44-0.63)	0.62 (0.52-0.74)	1.19 (1.15-1.23)	1.16 (1.12-1.20)	0.98 (0.95-1.01)	1.01 (0.98-1.05)
Chain ownership[d]								
DaVita	0.72 (0.67-0.79)	0.74 (0.68-0.81)	0.67 (0.55-0.83)	0.66 (0.54-0.81)	1.11 (1.04-1.18)	1.09 (1.02-1.16)	0.89 (0.84-0.94)	0.89 (0.84-0.94)
Fresenius	0.78 (0.71-0.85)	0.79 (0.73-0.86)	0.30 (0.24-0.37)	0.28 (0.23-0.35)	1.22 (1.15-1.31)	1.22 (1.14-1.30)	0.92 (0.87-0.97)	0.92 (0.87-0.97)
RAI	0.71 (0.62-0.80)	0.72 (0.63-0.83)	0.69 (0.49-0.96)	0.73 (0.54-1.00)	1.12 (1.02-1.23)	1.07 (0.98-1.17)	0.89 (0.82-0.96)	0.88 (0.81-0.96)
Other chains	0.79 (0.72-0.87)	0.80 (0.72-0.88)	0.64 (0.50-0.82)	0.65 (0.51-0.82)	1.14 (1.06-1.23)	1.13 (1.05-1.21)	0.93 (0.87-0.99)	0.93 (0.87-0.99)
Nonchain freestanding	0.90 (0.82-0.98)	0.90 (0.82-0.98)	0.81 (0.65-1.01)	0.82 (0.67-1.02)	1.16 (1.08-1.24)	1.15 (1.08-1.24)	1.00 (0.94-1.06)	1.00 (0.94-1.06)
Nonchain hospital based	1.43 (1.31-1.57)	1.40 (1.27-1.53)	1.23 (0.97-1.55)	1.31 (1.05-1.63)	0.92 (0.85-0.99)	0.93 (0.86-1.01)	1.17 (1.10-1.25)	1.17 (1.10-1.25)

Note: Values are given as rate ratio (95% confidence interval).

Abbreviations: LPN, licensed practical nurse; PCT, patient care technician; RAI, Renal Advantage Inc; RN, registered nurse.

[a]Each individual predictor is adjusted for the background variables (facility size, urban/rural location, functional type, and capacity).

[b]Results for profit, freestanding, and region are from model 2 that included these 3 predictors and the background variables, and results for chain ownership are from model 3 that included chain ownership, region, and the background variables.

[c]Northeast is reference.

[d]Dialysis Clinic Inc is reference.

Table 5. Adjusted Associations Between Facility Characteristics and Geographic Region With Dietitian and Social Worker Staffing Levels

Characteristics	Dietitian to Patient Ratio		Social Worker to Patient Ratio	
	Model 1[a]	Model 2 or 3[b]	Model 1[a]	Model 2 or 3[b]
For profit vs nonprofit	0.92 (0.88-0.97)	0.94 (0.89-1.00)	0.93 (0.89-0.97)	0.97 (0.91-1.03)
Freestanding vs hospital based	0.90 (0.84-0.95)	0.94 (0.87-1.02)	0.88 (0.83-0.93)	0.89 (0.83-0.97)
Census region[c]				
Midwest	1.06 (1.00-1.12)	1.07 (1.01-1.13)	1.08 (1.02-1.14)	1.09 (1.03-1.15)
South	1.03 (0.97-1.08)	1.05 (0.99-1.10)	1.04 (0.98-1.09)	1.06 (1.01-1.12)
West	0.98 (0.93-1.04)	1.00 (0.94-1.06)	0.98 (0.93-1.04)	1.00 (0.95-1.06)
Chain ownership[d]				
DaVita	1.04 (0.94-1.15)	1.03 (0.94-1.14)	0.99 (0.90-1.08)	0.98 (0.89-1.07)
Fresenius	0.94 (0.85-1.04)	0.93 (0.84-1.02)	0.92 (0.84-1.01)	0.91 (0.83-1.00)
RAI	0.99 (0.86-1.14)	0.99 (0.86-1.14)	0.94 (0.82-1.07)	0.93 (0.81-1.07)
Other chains	1.03 (0.93-1.15)	1.03 (0.93-1.15)	0.95 (0.85-1.05)	0.95 (0.86-1.05)
Nonchain freestanding	1.08 (0.98-1.20)	1.07 (0.97-1.19)	1.03 (0.93-1.13)	1.02 (0.93-1.12)
Nonchain hospital based	1.13 (1.01-1.26)	1.12 (1.01-1.26)	1.11 (1.00-1.23)	1.10 (0.99-1.22)

Note: Values are given as rate ratio (95% confidence interval).

Abbreviation: RAI, Renal Advantage Inc.

[a]Each individual predictor is adjusted for the background variables (facility size, urban/rural location, functional type, and capacity).

[b]Results for profit, freestanding, and region are from model 2 that included these 3 predictors and the background variables, and results for chain ownership are from model 3 that included chain ownership, region, and the background variables.

[c]Northeast is reference.

[d]Dialysis Clinic Inc is reference.

compared to DCI, were not significantly different. Finally, we found that even after additional adjustment for region (model 3), the composite staff to patient ratio was 7%-11% lower ($P < 0.02$) in chain-affiliated facilities and 17% higher ($P < 0.001$) in nonchain hospital-based facilities compared to DCI.

Results of sensitivity analyses were similar to these main results. Notably, even after removing hospital-based facilities entirely from the regression analyses, results remained virtually identical to the main results in the additionally adjusted models (models 2 and 3; compare Tables 4 and 5 with Table S1).

DISCUSSION

Our findings show that dialysis facilities for in-center hemodialysis differed substantially in RN, LPN, and PCT staffing levels. The differences were associated strongly with facility characteristics (profit status, freestanding status, and chain affiliation) and geographic region after controlling for background variables such as facility size, functional type, number of patients per station, and urbanicity. There was less variation in dietitians and social workers across the US facilities. More specifically, there were higher levels of RNs and LPNs in nonprofit facilities, including DCI, whereas numbers of PCTs were lower in these facilities. Total numbers of nurses also were higher in nonprofit/DCI facilities. The lower numbers of RNs and LPNs and higher number of PCTs in for-profit facilities are not a completely unexpected finding because the cost of employing a licensed nurse is higher than employing an unlicensed PCT. However, the large magnitude of the differences was surprising. It should be noted that the higher number of PCTs in for-profit facilities did not offset the lower number of RNs and LPNs, as indicated by the overall lower composite nurse to patient ratios in these facilities.

With fixed reimbursement, all dialysis facilities face the challenge of balancing outcomes and costs. The practice of replacing licensed nurses with unlicensed assistive personnel does not necessarily improve cost efficiency in the organization.[15] Furthermore, replacing licensed nurses with PCTs may jeopardize long-term patient outcomes.[9] Even when the unlicensed technicians are functioning under the direct supervision of a licensed nurse, having fewer licensed nurses per patient increases the demands on the licensed nurse.[16]

After controlling for all background facility characteristics plus geographic region, some chains differed by up to 26% for number of RNs, with higher levels in DCI facilities (Table 4). Differences between the chains' staffing levels could be attributable to pressure to sign noncompete clauses and difficulty recruiting licensed nurses.[17] Moreover, it is likely that professional nurses will not want to work in settings with limited support for continuing education and professional advancement or the time to practice the full scope of their skills.[18] As expected, higher numbers of

RNs and LPNs were observed in hospital-based facilities. This could be attributed to the portion of these facilities that might regularly enhance their licensed staff levels to provide care for acutely ill (ie, hospitalized) patients under a dialysis center certification.

Regionally, the number of RNs was substantially lower in the 3 regions other than the Northeast, whereas the South had substantially higher numbers of LPNs (Table 4). There were fewer regional differences in overall composite staffing levels. Regional differences in staffing mix could be due to the hiring availability of licensed personnel with adequate previous experience[19] or the availability of training programs to become a licensed nurse within a given region. Although area population contributes to the number of available nurse training programs, it is notable that a Southern state such as Mississippi has approximately 21 available RN training programs, whereas Ohio has approximately 90 programs.[20] In essence, the regional differences could be driven by the supply of RNs or variations in state nurse practice regulations; however, most states do not specify regulations for nurse staffing mix in hemodialysis facilities, and of the 5 that do (Massachusetts, Connecticut, New Jersey, Texas, and Georgia), none of the designated ratios differentiate between RNs and LPNs.[9]

Some policy implications may be drawn from these findings. The 2008 CMS hemodialysis facility regulations list requirements for nurse staffing and qualifications of the nurses and PCTs.[21] They do not discuss nurse to patient ratios and overall staffing mix. Zhang et al[3] recently reported significantly higher mortality rates in for-profit facilities after controlling for numerous patient and facility characteristics. Our study identified strong associations between for-profit status and lower numbers of RNs and LPNs per patient. Although we cannot conclude that increased mortality is a direct effect of RN and LPN staffing mix, it is possible that patient care staffing mix in for-profit facilities influences mortality rates. Lee et al[7] found significant differences in numbers of days that patients were hospitalized depending on facility profit status, but did not include staffing measures. Mandated nurse to patient ratios is a controversial issue across the nation.[22] However, hospitals are beginning to act on the findings of the 2007 Agency for Healthcare Research and Quality report that describes the positive effects on patient outcomes related to increased numbers of RNs at the bedside.[10] Regional ESRD networks might assess the barriers to employing more RNs. Supporting specific recommendations for facilities' quality assurance and performance improvement initiatives concerning nurse-friendly work environments could be another approach to attracting licensed nurses to hemodialysis nursing. Finally, for-profit chains and freestanding facilities should examine the ways in which employing more RNs could improve their facilities' attractiveness to patients and nurses, the efficiency with which care is planned and delivered, and their patients' outcomes.

Several limitations of our study need to be considered. First, we were unable to account for actual nursing hours per patient, a common measure used to evaluate nursing effects. This information cannot be ascertained from the facility survey. Second, our study cohort did not exclude hospital-based units because our purpose was to provide a more complete assessment of US dialysis facilities. Although the adjusted findings in models 2 and 3 should remove the confounding from inclusion of hospital-based units, there may still be some residual confounding not accounted for by the models. To further assess this, we performed sensitivity analysis that excluded hospital-based units. We found that results were similar to the main results. Third, the data are subject to reporting error because of the survey techniques. To overcome this limitation, we did sensitivity analyses and determined that any identifiable reporting error had no significant effects on results. Finally, we are aware that our use of 2 part-time staff as 1 FTE person has limitations. However, this was the most accurate way we could identify the number of nurses per patient using the available data.

Hemodialysis outcomes of interest include mortality,[23-26] transplantation,[27] quality of life,[28] hospitalization rates,[29,30] and adequate dialysis.[31] Arteriovenous fistula use,[32] pre-ESRD nephrologist care,[33] regional intensity of care,[8] ESRD network,[34] chain status,[3] and for-profit status[7] of dialysis facilities have explained some of the variation in these outcomes, even after accounting for patient case-mix. Fortunately, physician prescribing practices, quality improvement efforts, advances in technology, and updated quality measures[35] are helping to enhance hemodialysis services. Unfortunately, the contribution of licensed and unlicensed nursing staff in these processes remains underinvestigated. To our knowledge, the present study is the first to systematically examine the variation in patient care staffing levels across US hemodialysis facilities by facility characteristics and geographic region. We found that RN, LPN, and PCT staffing levels differed substantially across US dialysis facilities. There are intangible elements of care that occur in the nurse-patient relationship that have been shown to improve outcomes.[10] Future studies that examine dialysis patient outcomes should include processes of dialysis care, quality of life, medical conditions, socioeconomic influences, and facility staffing ratios to better understand the unique interactions of these elements. This will provide the requisite foundation

for better understanding of optimal staffing ratios and the impact of different health care providers in various dialysis facility settings. The CMS, ESRD networks, and hemodialysis facilities should attend to the policies, regulations, and performance improvement initiatives that support advancing the role of and exploring the relationship between dietitians, social workers, and licensed nurses in structurally different hemodialysis facilities.

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SUPPLEMENTARY MATERIAL

Table S1: Adjusted associations in analyses including freestanding facilities only.

Table S2: Adjusted associations in analyses that excluded all facilities with home dialysis program.

Note: The supplementary material accompanying this article (http://dx.doi.org/10.1053/j.ajkd.2013.05.007) is available at www.ajkd.org.

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