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Dialysis Facility and Network Factors Associated With Low Kidney Transplantation Rates Among United States Dialysis Facilities

R. E. Patzer[1,2,*], L. Plantinga[2,3], J. Krisher[4] and S. O. Pastan[5,6]

[1]Division of Transplantation, Department of Surgery, Emory University School of Medicine, Atlanta, GA
[2]Department of Epidemiology, Rollins School of Public Health, Atlanta, GA
[3]Laney Graduate School, Emory University, Atlanta, GA
[4]Southeastern Kidney Council of ESRD Network 6, Raleigh, NC
[5]Renal Division, Department of Medicine, Emory University School of Medicine, Atlanta, GA
[6]Emory Healthcare, Emory Transplant Center, Atlanta, GA
**Corresponding author: Rachel E. Patzer, rpatzer@emory.edu*

Variability in transplant rates between different dialysis units has been noted, yet little is known about facility-level factors associated with low standardized transplant ratios (STRs) across the United States End-stage Renal Disease (ESRD) Network regions. We analyzed Centers for Medicare & Medicaid Services Dialysis Facility Report data from 2007 to 2010 to examine facility-level factors associated with low STRs using multivariable mixed models. Among 4098 dialysis facilities treating 305 698 patients, there was wide variability in facility-level STRs across the 18 ESRD Networks. Four-year average STRs ranged from 0.69 (95% confidence interval [CI]: 0.64–0.73) in Network 6 (Southeastern Kidney Council) to 1.61 (95% CI: 1.47–1.76) in Network 1 (New England). Factors significantly associated with a lower STR ($p < 0.0001$) included for-profit status, facilities with higher percentage black patients, patients with no health insurance and patients with diabetes. A greater number of facility staff, more transplant centers per 10 000 ESRD patients and a higher percentage of patients who were employed or utilized peritoneal dialysis were associated with higher STRs. The lowest performing dialysis facilities were in the Southeastern United States. Understanding the modifiable facility-level factors associated with low transplant rates may inform interventions to improve access to transplantation.

Keywords: Dialysis facilities, ESRD Networks, kidney transplantation

Abbreviations: AVF, arteriovenous fistula; CI, confidence interval; CMS, Centers for Medicare & Medicaid Services; DD, deceased donor; DFR, Dialysis Facility Report; ESA, erythropoiesis-stimulating agents; ESRD, end-stage renal disease; ICC, the intraclass correlation coefficient; LD, living donor; OPTN, Organ Procurement and Transplant Network; PD, peritoneal dialysis; SES, socioeconomic status; STR, standardized transplant ratio

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Introduction

For the >600 000 patients in the United States with end-stage renal disease (ESRD) (1), kidney transplantation represents the optimal treatment for most patients, providing longer survival, better quality of life, lower hospitalization rates and substantial cost savings compared with dialysis (2,3). However, variability in kidney transplant rates and access to the deceased donor (DD) waiting list exists across racial and ethnic groups (4), socioeconomic status (SES) levels (5), geographic regions (6–8) and patient age (9). Additionally, little is known regarding variations in the early steps of the kidney transplant evaluation process. For example, no national data exist on the quality and timing of kidney transplantation education that ESRD patients receive at dialysis facilities; data regarding patient referrals to transplant centers for evaluation are also lacking.

To our knowledge, there have been no studies that have examined whether transplant rates at the dialysis facility level—where ESRD patients receive the majority of their pretransplant care—vary across ESRD Network regions. As a condition of the ESRD Medicare program, the 18 ESRD Networks in the United States are required by statute to ensure access to high-quality care for patients with or at risk for kidney disease (10). Because ESRD Networks are responsible for overseeing this care, including addressing barriers to timely referral for ESRD treatment, ESRD Networks play an important role in facilitating access to transplantation for patients. In addition, while prior studies have shown that dialysis facility characteristics—such as for-profit status (11)—influence access to kidney transplantation,

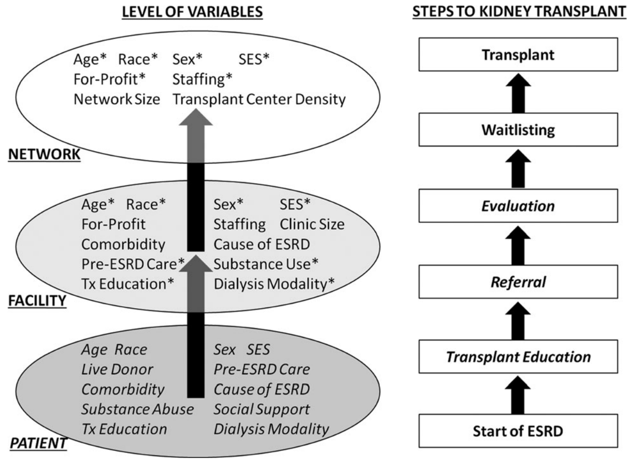

Figure 1: Conceptual model indicating hierarchical or nesting levels of explanatory variables of interest (left) in this study, the typical timeline to (nonpreemptive) transplant (right) and possible associations between them. Patient- (dark gray circle), facility– (light gray circle) and End-Stage Renal Disease (ESRD) Network–level (white circle) explanatory variables are hypothesized to influence multiple steps in access to transplantation (left). *Italics*, no data to address these variables were available for this analysis. SES, socioeconomic status; Tx, transplant. *At the aggregate level.

no studies have comprehensively examined which dialysis facility– and ESRD Network–level characteristics are associated with reduced transplant access. An overview of the conceptual model for these multi-level influences in access to transplant examined in this study is depicted in Figure 1. The overall purpose of this study was to examine the dialysis facility– and ESRD Network–level factors associated with reduced transplant rates. We further sought to determine whether variations in dialysis-level transplant rates were explained by differences in ESRD Network regions. We hypothesized that there may be modifiable and nonmodifiable ESRD Network factors, in addition to dialysis facility factors, that may influence regional differences in transplant access.

Methods

Data sources

Dialysis Facility Report (DFR) data are publicly available and reported annually by the University of Michigan Kidney Epidemiology and Cost Center under a contract with the Centers for Medicare & Medicaid Services (CMS). The DFR data set is derived from the CMS Program Medical Management and Information System, the SIMS database maintained by the 18 ESRD Networks, the CMS Annual Facility Survey (Form CMS-2744), Medicare dialysis and hospital payment records, CMS Medical Evidence Report Form (Form CMS-2728), transplant data from the Organ Procurement and Transplant Network (OPTN), the Nursing Home Minimum Dataset, and the Social Security Death Master File. Patients treated at transplant-only facilities or Veterans Affairs dialysis facilities and patients who received renal replacement therapy for <90 days are excluded from the DFR data set (12). Data on the 18 ESRD Network regions (Figure 2) were obtained from aggregating DFR data by Network and by publicly available data from OPTN and the United States Renal Data System annual data report (1).

Study population

A total of 5388 dialysis facilities within the 18 ESRD Networks were included in the DFR 2007–2010 data. In this study, we restricted analyses to US dialysis facilities that reported a 4-year average standardized transplant ratio (STR) from 2007 to 2010 (n = 4098). STRs are not reported for facilities that have <3 expected transplants over the 4-year period due to the instability of the estimates.

Outcome variable

The primary outcome variable was the 4-year average STR, which is calculated separately for each dialysis facility by DFR (www.dialysisreports.org/methodology). Each year the STR is calculated as the total number of observed first transplants (including living donor [LD] or DD) divided by the total number of expected first transplants within a facility. The expected number of transplants within a facility is defined by a Cox model that adjusts for age and calendar year. STR calculations are based on patients <70 years of age only; preemptive transplants and transplants within the first 3 months of initiating dialysis are excluded.

Potential factors associated with STR

Dialysis facility characteristics are collected annually within the DFR data set; for this analysis of DFR data from 2007 to 2010, we used the baseline (2007) values of all covariates. The facility characteristics we examined included profit status (profit vs. nonprofit), total number of staff (including full-time and part-time employees), total number of treated patients, ESRD Network region of the facility location, and the average standardized mortality ratio, standardized hospitalization ratio and standardized hospitalization ratio in the emergency room. We also examined summary patient characteristics within a dialysis facility, including mean age; percentages of patients by sex, race, ethnicity (Hispanic vs. non-Hispanic), dialysis modality (hemodialysis or peritoneal dialysis [PD]), employment status, insurance status and smoking status; average years on dialysis; percentages of patients with diabetes, cerebrovascular accident, cardiovascular disease or transient ischemic attack; reported use of erythropoiesis-stimulating agents (ESA) prior to ESRD; mean number of comorbid conditions; percentage of patients reportedly informed of transplant as a treatment option; and percentage of patients who had no access to pre-ESRD nephrology care (defined by CMS-2728). Baseline (2007) covariate data were missing for <2.9% of facilities. For facilities with missing covariate data in 2007, covariate values for the nearest year available (2008, 2009 or 2010) were used because most

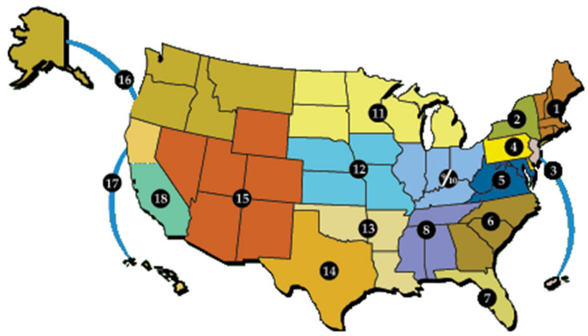

Figure 2: Map of the 18 End-Stage Renal Disease Networks in the United States. (Reprinted with Permission from the ESRD Network Forum.)

covariates did not significantly change over the 4-year time period; covariate data were missing for all 4 years in <0.26% of facilities. ESRD Network–level factors included Network-level mean demographics and clinical characteristics (including age, race, profit status and staffing) as well as ESRD patient volume (total prevalent ESRD patient population) and the number of transplant centers per 10 000 prevalent ESRD patients.

Data analysis

Facility characteristics as well as clinical and demographic characteristics of patients within dialysis facilities were compared across ESRD Networks using chi-square tests for categorical variables and analysis of variance for continuous variables. Spearman correlation coefficients were used to examine the associations between the facility characteristics and STR.

To account for the potential nesting or correlation of dialysis facilities within ESRD Network regions and allow examination of between- and within-Network variation, we assumed two levels for these data: dialysis facility (level 1) and ESRD Network (level 2). We compared variance components from conditional and unconditional linear mixed models using STR as the outcome to examine the proportion of between- and within-ESRD Network variation in STR explained by the level 1 dialysis facility covariates and the level 2 ESRD Network covariates. To meet normality assumptions, the STR was logarithmically transformed. We included a random intercept in the mixed models to account for variation among dialysis facilities both between and within ESRD Networks. To examine the degree of correlation of facilities within ESRD Networks, we calculated the intraclass correlation coefficient (ICC) from an intercept-only model.

To examine factors associated with STR, we calculated rate ratios and 95% confidence intervals (CIs) using generalized linear models (negative binomial distribution) with the observed number of transplants (numerator of STR) modeled as the outcome and the expected valued of transplants (denominator of the STR) used as an offset. Generalized estimating equations assumed an exchangeable (compound symmetric) covariance structure to account for the correlation of dialysis facilities within ESRD Networks. The empirical sandwich estimator of the variance-covariance of the parameter estimate was used in all multivariable models (13). Our multivariable modeling strategy was as follows: all variables potentially associated with transplantation were considered as candidate predictor variables; variables were screened based on univariate associations with STR and correlation analyses; if two variables were correlated with one another, only one was considered in the full model; a fully adjusted multivariable model was considered and nonautomated backward elimination was performed based on statistical significance ($p < 0.1$) of covariates and model goodness-of-fit. Markov Chain Monte Carlo multiple imputation was used in multivariable analyses to account for missing covariate data (0.26%). SAS v. 9.3 (SAS Institute, Cary, NC) was used for all analyses.

Sensitivity analyses

While the STR counts LD and DD transplants the same, we repeated analyses using observed transplants and at-risk person years separately by donor type using negative binomial regression models.

A total of 1279 dialysis facilities were excluded because the facility either closed during the 4-year time period or was too small to have a reported STR. To examine whether facilities excluded from analyses were systematically different, we compared facility- and patient-level characteristics within a facility by exclusion status.

Results

Dialysis facility characteristics across ESRD Networks

A total of 4098 dialysis facilities were examined in this study population, representing 305 698 unique ESRD patients across the United States. The facility-level demographic and clinical characteristics of patients in the study population and across the 18 ESRD Networks are presented in Tables 1A and 1B. There were significant differences in baseline dialysis facility characteristics across ESRD Networks (all $p < 0.0001$). On average, there were 16.3 total staff members treating a median of 47 (interquartile range: 31, 70) patients within facilities. ESRD Network 13 (AR, LA, OK) had the fewest number of staff (12.4 ± 5.5) and ESRD Network 2 (NY) had the highest number of staff (24.6 ± 11.9). The majority (84.5%) of facilities were for-profit, but for-profit facilities ranged from 58.1% (Network 2) to 99.4% in ESRD Network 10 (IL). The average number of transplant centers per 10 000 ESRD patients across the nation was 4.6, and ranged across ESRD Networks from 2.2 transplant centers/10 000 ESRD patients in ESRD Network 6 (GA, NC, SC) and ESRD Network 17 (HI, N. CA, American Somoa) to 7.7 transplant centers/10 000 ESRD patients in ESRD Network 4 (DE, PA). The mean age of patients within dialysis facilities was 62.4 ± 7.6. The majority of patients (63.6%) were white, 13.3% were African-American, and 12.8% were Hispanic. Patients had on average 3.0 ± 0.8 comorbid conditions. Nearly one-third (30.8%) of patients within facilities reported no access to pre-ESRD nephrology care and the majority (66.0%) were unemployed (Tables 1A and 1B).

Standardized transplant ratios

Dialysis facility–level demographic and clinical factors that were significantly correlated with STR are presented in Table 2. The percentage of African-Americans within a facility was moderately negatively correlated with STR. PD modality and ESA use were weakly positively correlated with STR, and unemployment and no health insurance were weakly negatively correlated with STR (Table 2).

Among 4098 dialysis facilities treating 305 698 patients, the mean observed transplant count over the 4-year study

Table 1A: Baseline characteristics of dialysis facilities within ESRD Network regions (ESRD Networks 1–9), 2007

		ESRD Network number (states within ESRD Network)								
	All US facilities in study	1 (CT, ME, MA, NH, RI, VT)	2 (NY)	3 (NJ, PR, VI)	4 (DE, PA)	5 (DC, MD, VA, WV)	6 (GA, NC, SC)	7 (FL)	8 (AL, MS, TN)	9 (IN, KY, OH)
Number of facilities	4098	128	179	139	183	243	456	262	280	285
Number of ESRD patients	305 698	10 020	19 654	13 035	12 724	17 793	30 665	17 088	18 119	21 019
# Patients per facility, median, IQR	47 (31, 70)	44 (31, 59)	70 (42, 105)	55 (36, 87)	39 (29, 60)	46 (32, 70)	48 (32, 67)	42 (29, 61)	41 (28, 66)	45 (31, 63)
Number of staff, mean, SD	16.3 ± 7.6	17.6 ± 7.8	24.6 ± 11.9	22.5 ± 12.3	15.2 ± 7.5	15.8 ± 7.6	13.6 ± 6.2	13.6 ± 6.3	13.5 ± 6.6	15.7 ± 8.9
Transplant centers per 10 000 ESRD patients	4.6	7.6	3.8	4.1	7.7	4.4	2.2	3.4	3.9	3.9
For-profit, %	84.5%	81.3%	58.1%	74.8%	89.1%	87.2%	86.8%	92.4%	83.9%	87.0%
Age mean, SD	62.4 ± 7.6	65.2 ± 7.6	64.4 ± 6.1	63.8 ± 7.2	65.2 ± 5.1	62.0 ± 7.4	60.5 ± 5.9	63.6 ± 8.8	61.1 ± 7.0	63.8 ± 6.7
% White	63.6%	84.8%	59.1%	66.3%	70.3%	45.1%	39.8%	66.9%	49.5%	76.8%
% African-American	13.3%	13.8%	31.3%	26.3%	24.5%	47.3%	55.6%	30.1%	49.9%	20.4%
% Asian	3.7%	2.4%	4.9%	2.8%	1.5%	3.2%	1.1%	1.2%	0.5%	0.6%
% Native American	1.5%	0.2%	0.4%	0.01%	0.1%	0.5%	0.8%	0.1%	0.3%	0.1%
% Hispanic	12.8%	7.7%	13.3%	37.9%	3.3%	2.1%	1.7%	15.3%	0.5%	1.5%
% Peritoneal dialysis modality	6.7%	9.3%	5.2%	5.2%	4.2%	5.5%	5.9%	6.2%	5.8%	8.5%
% Uninsured	7.7%	1.6%	2.6%	4.7%	3.1%	6.6%	11.3%	7.4%	10.8%	6.8%
% Medicaid	11.7%	12.0%	15.4%	8.4%	11.7%	10.7%	10.2%	10.2%	10.1%	9.9%
% Unemployed	66.0%	65.0%	63.8%	66.8%	68.2%	61.7%	69.2%	66.8%	68.0%	69.8%
Time on dialysis (years), mean, SD	14.5 ± 4.7	14.3 ± 4.5	14.5 ± 4.8	13.9 ± 4.6	15.8 ± 4.3	14.9 ± 4.1	13.4 ± 4.5	9.6 ± 2.5	11.5 ± 4.1	14.4 ± 5.5
% Receiving no access to pre-ESRD nephrology care	30.8%	22.5%	29.0%	40.9%	28.5%	31.6%	29.8%	30.8%	32.9%	25.6%
% Not informed of transplant options	6.6%	8.0%	8.3%	8.6%	7.1%	6.4%	6.1%	6.1%	6.2%	7.5%
% Diabetes	59.1%	54.8%	55.5%	62.3%	56.5%	57.0%	58.8%	56.2%	58.5%	59.0%
% With CVA, CVD or TIA	12.7%	7.2%	12.7%	30.6%	3.6%	2.6%	1.9%	14.3%	0.5%	1.8%
% AV fistula present at ESRD start	30.5%	40.6%	39.9%	37.3%	28.1%	28.4%	29.9%	28.9%	30.7%	29.4%
% Smoker	6.7%	5.9%	4.6%	4.4%	6.1%	5.8%	9.5%	5.4%	9.7%	7.3%
Comorbidities, mean, SD	3.0 ± 0.8	3.4 ± 0.9	3.0 ± 0.7	3.4 ± 0.8	3.1 ± 0.7	2.8 ± 0.8	3.1 ± 0.8	3.0 ± 0.8	3.1 ± 0.9	3.3 ± 0.8
% ESA prior to dialysis	20.2%	45.1 ± 18.7	35.5 ± 18.9	29.4 ± 21.9	30.3 ± 18.7	30.2 ± 21.5	27.5 ± 20.6	26.7 ± 21.3	27.9 ± 20.6	26.6 ± 18.5
Standardized mortality ratio	1.00	0.99	1.07	1.02	1.19	1.05	0.91	1.15	0.95	1.07
Days hospitalized rate (pt year), SD	14.5 ± 4.7	14.9 ± 5.1	17.8 ± 4.8	16.3 ± 4.2	17.6 ± 4.9	14.1 ± 4.9	12.9 ± 3.3	16.8 ± 4.6	13.0 ± 3.9	15.1 ± 4.0
Standardized hospitalization ratio in ER	1.00	1.04	0.85	1.01	1.08	1.13	1.04	1.01	1.08	1.10
% Waitlisted (age < 70 years only)	23.0%	27.8%	29.1%	26.4%	27.1%	23.9%	15.6%	17.5%	23.0%	17.3%

AV, arteriovenous; CVA, cerebrovascular accident; CVD, cardiovascular disease; ER, emergency room; ESA, erythropoietin-stimulating agents; ESRD, end-stage renal disease; IQR, interquartile range; PR, Puerto Rico; SD, standard deviation; TIA, transient ischemic attack; VI, Virgin Islands.

Facility characteristic differences across ESRD Networks, all $p < 0.0001$.

Prevalence of ESRD in 2007 as reported by the United States Renal Data System 2012 annual data report.

Table 1B: Baseline characteristics of dialysis facilities within ESRD Network regions (ESRD Networks 10–18), 2007

		ESRD Network number (states within ESRD Network)								
	All US facilities	10 (IL)	11 (MI, MN, ND, SD, WI)	12 (IA, KS, MO, NE)	13 (AR, LA, OK)	14 (TX)	15 (AZ, CO, NV, NM, UT, WY)	16 (AK, ID, MT, OR, WA)	17 (AS, HI, N. CA)	18 (S. CA)
Number of facilities	4098	157	232	162	218	384	209	113	187	281
Number of ESRD patients	305 698	13 004	17 113	9813	11 875	28 772	13 965	8281	17 028	25 730
# Patients per facility, median, IQR	47 (31,70)	50 (35, 77)	43 (29, 64)	35 (23, 52)	37 (27, 55)	53 (36, 76)	43 (29, 65)	44 (29, 68)	57 (37, 85)	63 (40, 90)
Number of staff, mean, SD	16.2 ± 9.0	15.0 ± 9.4	16.4 ± 7.6	13.6 ± 7.9	12.4 ± 5.5	16.1 ± 8.1	15.4 ± 7.1	17.9 ± 11.3	19.9 ± 12.0	20.1 ± 10.8
Transplant centers per 10 000 ESRD patients	4.6	4.0	5.5	6.7	6.7	5.4	6.0	5.0	2.2	3.9
For-profit, %	84.5%	99.4%	71.6%	77.2%	92.2%	94.8%	80.4%	67.3%	74.3%	92.9%
Age mean, SD	62.4 ± 7.6	62.7 ± 8.3	62.6 ± 8.3	63.6 ± 8.7	60.7 ± 7.9	60.3 ± 8.2	61.2 ± 8.6	63.4 ± 7.3	62.2 ± 8.5	62.3 ± 7.5
% White	63.6%	62.6%	67.1%	74.9%	52.4%	72.9%	75.4%	83.0%	57.8%	74.1%
% African-American	13.3%	32.0%	23.2%	21.3%	39.6%	24.5%	8.6%	6.4%	12.5%	13.3%
% Asian	3.7%	3.0%	2.1%	0.9%	0.8%	2.0%	2.8%	6.4%	26.4%	11.9%
% Native American	0.1%	0.1%	3.7%	1.2%	4.0%	0.4%	11.9%	4.1%	0.8%	0.2%
% Hispanic	12.8%	10.0%	3.1%	3.1%	2.3%	41.3%	25.1%	6.1%	20.0%	38.3%
% Peritoneal dialysis modality	6.7%	6.5%	7.3%	8.8%	4.7%	5.6%	6.3%	9.2%	11.3%	8.3%
% Uninsured	7.7%	7.8%	4.6%	5.6%	9.8%	16.0%	6.2%	6.2%	3.6%	6.2%
% Medicaid	11.7%	11.6%	10.8%	10.4%	12.9%	10.3%	13.5%	10.7%	16.6%	17.6%
% Unemployed	66.0%	65.5%	67.5%	62.8%	65.8%	64.5%	63.1%	62.0%	64.7%	66.4%
Time on dialysis (years), mean, SD	4.2 ± 1.0	4.1 ± 0.9	4.1 ± 0.8	4.2 ± 1.0	4.1 ± 1.0	4.2 ± 1.1	4.1 ± 0.8	4.2 ± 0.8	4.2 ± 0.9	4.1 ± 1.0
% Receiving no access to pre-ESRD nephrology care	30.8%	32.4%	32.5%	31.3%	37.2%	34.9%	31.2%	29.7%	28.0%	25.1%
% Not informed of transplant options	6.6%	8.9%	7.0%	6.6%	5.0%	5.4%	6.1%	8.7%	4.6%	7.0%
% Diabetes	59.1%	56.5%	57.4%	55.5%	60.0%	66.0%	60.4%	55.6%	61.9%	62.7%
% With CVA, CVD or TIA	12.7%	11.1%	2.9%	3.0%	2.4%	39.8%	23.7%	7.3%	18.9%	35.5%
% AV fistula present at ESRD start	30.5%	23.9%	29.3%	32.4%	27.2%	29.4%	32.3%	39.7%	35.9%	21.6%
% Smoker	6.7%	5.1%	8.9%	7.1%	10.3%	5.5%	6.0%	7.5%	3.8%	3.2%
Comorbidities, mean, SD	3.0 ± 0.8	2.8 ± 0.8	3.3 ± 0.9	3.1 ± 0.8	3.2 ± 0.9	3.1 ± 0.8	2.8 ± 0.6	3.1 ± 0.6	2.6 ± 0.7	2.6 ± 0.8
% ESA prior to dialysis	20.2%	23.9 ± 17.7	32.6 ± 18.9	31.5 ± 20.8	22.1 ± 17.6	26.1 ± 20.3	26.8 ± 18.3	37.6 ± 18.0	35.8 ± 21.1	20.2 ± 22.1
Standardized mortality ratio	1.00	1.11	1.07	1.00	0.99	0.91	0.99	0.86	0.86	1.06
Days hospitalized rate (pt year), SD	14.5 ± 4.7	14.3 ± 4.5	14.5 ± 4.8	13.9 ± 4.6	15.8 ± 4.3	14.9 ± 4.1	13.4 ± 4.5	9.6 ± 2.5	11.5 ± 4.1	14.4 ± 5.4
Standardized hospitalization ratio in ER	1.00	1.04	1.07	0.97	1.06	0.93	0.93	0.98	0.85	0.84
%Waitlisted (age < 70 years only)	23.0%	27.1%	25.3%	17.9%	14.7%	20.9%	21.6%	19.1%	48.1%	29.1%

AS, American Samoa; AV, arteriovenous; CVA, cerebrovascular accident; CVD, cardiovascular disease; ER, emergency room; ESA, erythropoietin-stimulating agents; ESRD, end-stage renal disease; IQR, interquartile range; N. CA, Northern California; PR, Puerto Rico; SD, standard deviation; S. CA, Southern California; TIA, transient ischemic attack; VI, Virgin Islands.
Facility characteristic differences across ESRD Networks, all $p < 0.0001$.
Prevalence of ESRD in 2007 as reported by the United States Renal Data System 2012 annual data report.

Table 2: Correlation between dialysis facility–level demographic and clinical factors with facility-level standardized transplant ratios (STRs)

Demographic and clinical covariates	Spearman correlation coefficient	p-Value
Dialysis facility–level variables		
Factors negatively correlated with STR		
% African-American	−0.32156	<0.0001
% Unemployed	−0.27224	<0.0001
% Uninsured	−0.20395	<0.0001
% Medicaid	−0.19181	<0.0001
% Diabetes	−0.18304	<0.0001
Standardized hospitalization ratio in emergency room	−0.13326	<0.0001
For-profit	−0.11617	<0.0001
% With no access to pre-ESRD nephrology care	−0.11614	<0.0001
Average time on dialysis, years	−0.08865	<0.0001
% Smoker	−0.06783	<0.0001
Days hospitalized rate (pt year)	−0.06003	0.0001
Mean number of comorbidities	−0.03591	0.0215
Standardized mortality ratio	−0.01072	0.4926
Factors positively correlated with STR		
% White	0.34238	<0.0001
% ESA prior to dialysis	0.27108	<0.0001
% Peritoneal dialysis modality	0.26143	<0.0001
Age, years	0.20288	<0.0001
% Asian	0.15929	<0.0001
% AV fistula present at ESRD start	0.15221	<0.0001
Number of staff	0.09627	<0.0001
Number of patients per facility	0.08073	<0.0001
% Not informed of transplant options	0.05843	0.0002
% Native American	0.03857	0.0135
% With CVA, CVD or TIA	0.03485	0.0257

AV, arteriovenous; CVA, cerebrovascular accident; CVD, cardiovascular disease; ESA, erythropoietin-stimulating agents; ESRD, end-stage renal disease; TIA, transient ischemic attack.

period was 10.1 (±8.7) transplants per dialysis facility. There was wide variability in 4-year average facility-level STRs across the 18 ESRD Networks (range 0.0–5.1). A total of 99 (2.4%) dialysis facilities reported no transplants

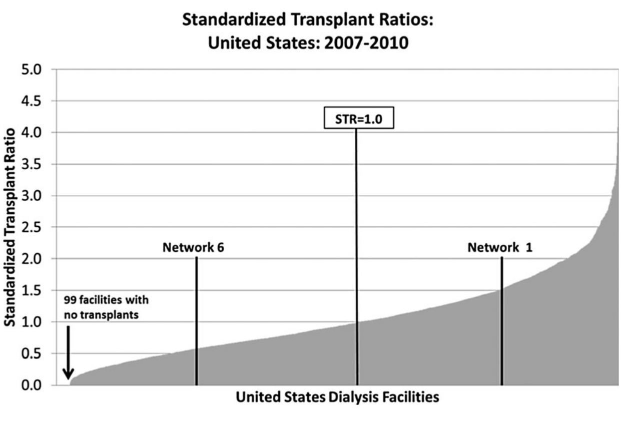

Figure 3: Age- and calendar year–adjusted standardized transplant ratios (STRs) among United States dialysis facilities, 2007–2010. This figure shows STRs, or the ratio of the observed to expected transplants for each dialysis facility in the Unite States. Mean STRs for End-Stage Renal Disease (ESRD) Network 6 (lowest STR) and ESRD Network 1 (highest STR) are plotted. The middle line depicts an STR of 1.0, where the observed number of transplants equals the expected number of transplants.

(STR = 0) for all 4 years (Figure 3). The majority of these facilities were in the South, including ESRD Network 6 (n = 34 facilities) and ESRD Network 13 (n = 11 facilities). The 4-year ESRD Network-level STRs ranged from 0.69 (95% CI: 0.64–0.73) in Network 6 (Southeastern Kidney Council) to 1.61 (95% CI: 1.47–1.76) in Network 1 (New England). Nationally, Georgia had the lowest STR of all states, followed by Mississippi, Alabama, Louisiana and South Carolina. Table 3 reports the rank and STR and 95% CI by ESRD Network.

Variation in dialysis facility–level STR within and between ESRD Networks

In a crude, unconditional means generalized linear regression model accounting for the variability of dialysis facilities between and across ESRD Networks, the random intercept for ESRD Network was statistically significant ($p < 0.0001$), indicating that STRs at the dialysis facility–level vary across ESRD Networks. Model estimates of the intercept and residual variance suggest that the variation among dialysis facility–level STR within ESRD Networks was almost six times greater (residual estimate = 0.083, $p < 0.0001$) than the variation between (intercept variance estimate = 0.014, $p = 0.002$) ESRD Networks. The ICC was 0.15, indicating that 15% of the variability in STR was attributable to clustering of facilities within Networks. In multivariable

Table 3: Rank of age- and calendar year–adjusted standardized transplant ratio by ESRD Network, US dialysis facilities, 2007–2010

Rank	ESRD Network	Standardized transplant ratio, 95% CI
18 (*lowest STR*)	Network 6 (GA, NC, SC)	0.69 (0.64–0.73)
16	Network 13 (AR, LA, OK)	0.72 (0.66–0.78)
17	Network 8 (AL, MS, TN)	0.75 (0.70–0.81)
15	Network 14 (TX)	0.83 (0.78–0.88)
14	Network 18 (S. CA)	0.94 (0.88–1.01)
13	Network 17 (AS, HI, N. CA)	1.02 (0.93–1.11)
11	Network 7 (FL)	1.08 (1.00–1.16)
12	Network 9 (IN, KY, OH)	1.09 (1.02–1.15)
10	Network 5 (DC, MD, VA, WV)	1.14 (1.06–1.22)
8	Network 15 (AZ, CO, NV, NM, UT, WY)	1.24 (1.13–1.35)
9	Network 3 (NJ, PR, VI)	1.25 (1.12–1.37)
7	Network 10 (IL)	1.26 (1.15–1.36)
6	Network 2 (NY)	1.30 (1.21–1.39)
5	Network 12 (IA, KS, MO, NE)	1.22 (1.11–1.34)
4	Network 4 (DE, PA)	1.32 (1.22–1.43)
3	Network 16 (AK, ID, MT, OR, WA)	1.33 (1.21–1.45)
2	Network 11 (MI, MN, ND, SD, WI)	1.48 (1.39–1.57)
1 (*highest STR*)	Network 1 (CT, ME, MA, NH, RI, VT)	1.61 (1.47–1.76)

AS, American Samoa; CI, confidence interval; ESRD, end-stage renal disease; N. CA, Northern California; PR, Puerto Rico; S. CA, Southern California; STR, standardized transplant ratio; VI, Virgin Islands.

analyses, variation among dialysis facility STR within ESRD Networks was 5.7 times greater (residual estimate = 0.058; $p < 0.0001$) than the variation (intercept variance estimate = 0.010, $p < 0.0001$) between ESRD Networks.

Dialysis facility– and ESRD Network–level factors associated with STR

Dialysis facility– and ESRD Network–level factors significantly associated with 4-year facility–level transplant rates are presented in Tables 4 and 5. In multivariable analyses, dialysis facility–level factors associated with a lower transplant rate ($p < 0.05$) included longer time on dialysis, a higher percentage of patients classified within a facility as African-American or Native American, the percentage of patients with diabetes and the percentage of patients with no health insurance at the time of ESRD. In addition, for-profit status of the dialysis facility was associated with a 6.5% lower STR (RR = 0.933, 95% CI: 0.882–0.986). Dialysis facility–level factors associated with a higher STR included a higher percentage of patients classified as employed, PD as the dialysis modality, a higher percentage of patients with arteriovenous fistula (AVF), a higher percentage of patients with a history of ESA use, and more staff per facility. Of note, for-profit dialysis facilities had fewer average numbers of staff versus nonprofit facilities (15.3 vs. 20.1, $p < 0.0001$) (data not shown). A higher number of transplant centers per 10 000 ESRD patients was the only ESRD Network–level factor that was statistically significantly associated with higher transplant rates, where the addition of one transplant center

Table 4: Crude and multivariable generalized linear regression model for dialysis facility–level and ESRD Network–level factors associated with a higher standardized transplant ratio

	Crude model	Multivariable-adjusted model[1]	
Dialysis facility or network–level factors	Rate ratio of STRs in a dialysis facility over 4 years (95% CI)		Multivariable p-value
Dialysis facility–level factors associated with a higher STR			
% Patients who are employed, per 10% increase	1.067 (1.060–1.076)	1.042 (1.034–1.051)	<0.0001
% ESA use prior to ESRD, per 10% increase	1.081 (1.071–1.090)	1.039 (1.021–1.057)	<0.0001
% Patients on peritoneal dialysis, per 10% increase	1.068 (1.057–1.079)	1.039 (1.022–1.057)	<0.0001
Number of staff, per 10 staff change	1.037 (1.015–1.059)	1.031 (1.003–1.060)	0.033
% Patients with AVF, per 10% increase	1.043 (1.033–1.054)	1.025 (1.012–1.037)	<0.0001
ESRD Network–level factors associated with a higher STR			
Transplant centers per 10 000 ESRD patients	1.074 (1.061–1.087)	1.053 (1.019–1.091)	0.0023

AVF, arteriovenous fistula; CI, confidence interval; ESA, erythropoiesis-stimulating agents; ESRD, end-stage renal disease; STR, standardized transplant ratio.

[1]Multivariable model was adjusted for all covariates shown in Table 4 as well as organ procurement organization region from which the dialysis facility resided. Markov Chain Monte Carlo multiple imputation used for missing covariate data (<2% of data).

Table 5: Crude and multivariable generalized linear regression model for dialysis facility–level and ESRD Network–level factors associated with a lower standardized transplant ratio

Dialysis facility factors	Crude model	Multivariable-adjusted model[1]	Multivariable p-value
	Rate ratio of STRs in a dialysis facility over 4 years (95% CI)		
Dialysis facility–level factors associated with a lower STR			
% Of patients with no health insurance, per 10% increase	0.865 (0.848–0.882)	0.925 (0.896–0.955)	<0.0001
For-profit facility	0.824 (0.784–0.867)	0.933 (0.882–0.986)	0.0143
% Patients who are African-American, per 10% increase	0.922 (0.916–0.928)	0.940 (0.926–0.953)	<0.0001
% Patients with diabetes, per 10% increase	0.937 (0.926–0.947)	0.951 (0.934–0.968)	<0.0001
% Of patients who are Native American, per 10% increase	0.971 (0.947–0.996)	0.956 (0.932–0.980)	0.0005
Average time on dialysis (years), per 1 year increase	0.942 (0.924–0.961)	0.981 (0.967–0.995)	0.008

CI, confidence interval; ESRD, end-stage renal disease; STR, standardized transplant ratio.
[1]Multivariable model was adjusted for all covariates shown in Table 4 as well as organ procurement organization region from which the dialysis facility resided. Markov Chain Monte Carlo multiple imputation was used for missing covariate data ($<2\%$ of data).

per 10 000 ESRD patients in a Network was associated with a 5.3% higher number of transplants per dialysis facility (RR = 1.053; 95% CI: 1.019–1.091) (Tables 4 and 5).

Sensitivity analyses

While not directly comparable to STRs used in main analyses, results modeling observed transplants and person years at-risk were fairly consistent across donor type. The effects of profit status and the proportion of African-Americans within a facility on reduced transplant access were greater among LD versus DD transplant recipients (Table S1).

For the 2007–2010 DFR data, STR estimates were not reported for a total of n = 1280 facilities. Compared to facilities included in the study population, excluded facilities were on average smaller (mean = 20 vs. 47 patients), had fewer staff (n = 7 vs. 16), and treated older patients (median age = 67 vs. 62 years). Otherwise, the excluded facilities did not differ from the 4098 dialysis facilities included in the final study population.

Discussion

In this study of 4098 dialysis facilities treating more than 300 000 ESRD patients across the nation, we observed significant heterogeneity in dialysis facility–level STRs across the 18 US ESRD Networks, even after accounting for dialysis facility and network factors. The Southeast (ESRD Network 6) and Northeast (ESRD Network 1) had the lowest and highest, respectively, STRs in the nation. Potentially modifiable dialysis facility– and ESRD Network–level factors associated with transplant rates included the number of staff within a facility and the number of transplant centers per 10 000 ESRD patients. Additionally, we found the percentages of patients with AVF and with ESA use prior to dialysis were associated with higher STRs. While modifiable, these factors most likely are associated with improved access to care prior to the onset of ESRD. For-profit facilities were associated with a 6.5% lower STR in a facility. We also found that the variability in STR *within* an ESRD Network was almost six times greater than the variability *between* ESRD Networks, which suggests that geographic region explains some, but not all, of the heterogeneity in transplant rates across US dialysis facilities. These results imply that identifying dialysis facilities with very low STRs within ESRD Networks for targeted interventions may represent the best opportunity for improving transplant access and decreasing variability in dialysis facility–level STRs.

We observed significant variation in the STRs within ESRD Networks, ranging from 0.69 in ESRD Network 6 (Southeast) to 1.61 in ESRD Network 1 (Northeast). We found that the most important Network-level factor associated with lower STR was the number of transplant centers in a region, where an additional one transplant center for every 10 000 ESRD patients increased the facility-level STR by 5.3%. ESRD Network 6 has the largest number of dialysis facilities (n = 456) treating the most ESRD patients (n = 30 665) and yet has only 2.2 transplant centers for every 10 000 ESRD patients. In contrast, ESRD Network 1 has 128 dialysis facilities treating 10 020 ESRD patients and has 7.6 transplant centers for every 10 000 ESRD patients. These results may suggest that transplant centers are not optimally distributed geographically based on ESRD burden, although prior studies have found no association between the distance a patient has to travel to a transplant center and access to transplantation, both nationally (14) and in the Southeast (15). These regional differences may also be due to unmeasured factors in these analyses, such as the higher concentration of poverty in the South (16).

Wide variations in an individual's use of healthcare services and health system performance have been documented across geographical regions, and this variability significantly impacts the quality of care in a community (17). For example, geographic differences in transplant access have previously been reported across donation service area (18) and state (8). These geographic variations may drive racial disparities in healthcare, since minorities live disproportionately in regions of the country with low-quality hospitals and providers (17). For example, Jha et al (19) showed that racial differences in the quality of care received at a hospital are primarily a result of the concentration of remarkably poor quality at only a small percentage of hospitals. In our study, African-American race was a significant predictor of lower transplant rates at the dialysis facility level. Racial disparities in access to kidney transplantation have been previously documented in which, compared with white patients, African-American ESRD patients are less likely to access multiple steps in the kidney transplant process, including referral for transplant evaluation (11), completion of the transplant evaluation (20), placement on the national waiting list (15), and receipt of an LD (8,21–23) or DD transplant (24). While race is not a modifiable barrier, targeting facilities with a higher proportion of African-Americans with evidence-based quality improvement interventions has the potential to both improve access to transplant and reduce disparities in transplant access (25). Evidence suggests that targeting the ESRD Networks with the most racial disparity in transplant access would reduce the overall racial disparity in access to the transplant waiting list by 25% (26). These racial disparities are more pronounced in the Southeast (15,27), where we documented the lowest dialysis facility–level STRs in the United States.

While it is unknown whether altering the factors associated with lower STR will improve access to transplant, identification of other facility-level factors associated with kidney STRs across dialysis facilities could help identify modifiable factors to guide quality improvement interventions to improve the equitability of kidney transplant access. In addition to African-American race and fewer transplant centers in a region, we found a number of both modifiable and nonmodifiable barriers to facility-level transplantation rates. Several important SES and access-to-care factors, including a higher percentage of patients who were unemployed or were without health insurance and patients with no prior ESA use, were all associated with lower rates of transplantation. These results are not surprising, as many studies have previously reported that poverty and reduced access to care influence the incidence of kidney disease, progression to ESRD, inadequate dialysis treatment, delays in transplantation and poor health outcomes (28). In addition, we report that for-profit facilities were associated with an 18% lower STR in crude analyses and a 6.5% lower STR in multivariable-adjusted analyses compared with nonprofit facilities. Because the majority (84.5%) of US facilities are for-profit, a 6.5% lower STR in a facility has a meaningful impact on transplant rates. In 1999, Garg et al similarly reported that ESRD patients receiving care at for-profit dialysis facilities in the early 1990s had a 26% lower rate of waitlisting compared with patients treated at not-for-profit facilities (11). While dialysis facility ownership may not necessarily be modifiable, the policies and practices related to transplantation within these facilities are certainly modifiable with commitment by large dialysis organizations as well as CMS, which provides funding for the ESRD Networks.

We also found that fewer staff in a facility is associated with a lower STR at the dialysis facility level. This may suggest that time constraints on both full- and part-time staff within a facility may be reducing the opportunity for patient education and potentially interfering with and delaying referral for kidney transplantation. Despite mandates through the Medicare Improvements for Patients and Providers Act for education about transplantation among late-stage CKD patients, evidence suggests that there are wide variations in access to pre-ESRD nephrology care (29). Patients who live in rural versus urban areas and black versus white patients are less likely to have access to pre-ESRD nephrology care. In our study, we found that reported lack of pre-ESRD nephrology care was associated with lower transplantation rates at the dialysis facility level in bivariate but not multivariable results. However, the proportion of patients with documented use of ESAs was associated with an increased transplant rate, suggesting that earlier access to care prior to ESRD may increase access to transplantation. Promoting transplant education may be one potential intervention for dialysis facilities with low transplant rates. Furthermore, once patients have ESRD and start dialysis, there are disparities in access to transplant education: nearly one-third of ESRD patients are not informed of kidney transplantation as a treatment option within the first 45 days of ESRD (30). Patients who are younger, African-American and uninsured are less likely to be assessed for transplant within the first 60 days of ESRD diagnosis (5). Among those who are reported as being informed of kidney transplantation as a treatment option, there is likely variability in the information patients receive since the content of the transplant discussion is neither defined nor standardized (31). Improving or standardizing recommendations for transplant education at dialysis facilities may represent one potential intervention to improve transplant access at the dialysis facility-level.

However, lower STRs at dialysis facilities in the United States does not necessarily mean that dialysis facilities are not educating, referring, or waitlisting ESRD patients in their facilities. Ashby et al documented significant state-to-state disparities in access to waitlisting and to DD and LD kidney transplantation and found that, in general, states with lower waitlisting rates had higher transplantation rates (8). In our study, waitlisting was strongly correlated with transplantation, and ESRD Network regions with the lowest STR also had the lowest rates of waitlisting (14.7% in Network 13; 15.6% in Network 6). No national data exist on transplant referral at the dialysis facility level, and thus it is difficult to assess the extent to which lower rates of transplantation are due to lower referral by providers at facilities, or to referred patients not showing up at the transplant center for evaluation, not completing the evaluation, or ineligibility for transplantation. We previously documented that nearly half of patients referred for kidney transplant evaluation do not start the transplant evaluation process (27). Thus, while there may be a number of patients who are referred for transplant at their dialysis facility, there may be other barriers to transplantation that are not currently measured or understood.

There are several limitations to the current study. First, this is an ecologic study at the dialysis facility level, and reported effects are associations and should not be interpreted as causal effects. Many prior studies have established patient-level risk factors for lower transplant rates that are either measured in average in this study or unmeasured, such as distance to transplant center or individual- and neighborhood-level poverty (28,32). However, these results suggest that future research on the patient level should consider controlling for these important facility-level factors identified in this study. While our study design precludes causality, the associations we reported between facility characteristics on transplant rates could potentially help target resources to facilities that are low performers. Second, the only dialysis facilities considered in this study were those with a nonmissing STR: STR values are not reported for facilities with an expected number of transplants of <3, and STRs are calculated only for patients <70 years of age. Thus, these results may only be generalizable to larger dialysis facilities and/or those with younger, rather than older, dialysis patients. There are also other inherent limitations to examining STR as an outcome: STR does not separate LD and DD transplants, the STR does not exclude patients who may be ineligible for transplantation, it does not take into consideration the behavior and policies of local transplant centers, and the STR does not adjust for variables outside of age and year of transplant. However, CMS reports STR as a quality measure to help dialysis facilities in planning quality improvement projects.

We observed significant heterogeneity in dialysis facility–level transplant rates across the 18 ESRD Network regions, with the lowest rates of transplantation among the South and Southeast regions. A regionally coordinated policy change is needed to eliminate health disparities that exist on a structural level (33,34). A targeted intervention among poorly performing dialysis facilities within ESRD Network regions with low transplant rates has the potential to increase rates of LD and DD kidney transplantation and reduce disparities in access to kidney transplantation.

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Disclosure

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Supporting Information

Additional Supporting Information may be found in the online version of this article.

Table S1: Factors associated with kidney transplantation rates among US dialysis facilities, stratified by donor type.