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Disentangling Dialysis Facility and Transplant Center Factors on Evaluation Start Following Referral for Kidney Transplantation: A Regional Study in the United States

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Rationale & Objective: Little is known about the relative importance of dialysis facilities and transplant centers on variability in starting an evaluation among patients referred for kidney transplant. The primary objective of this study was to leverage cross-classified multilevel modeling to simultaneously examine the contextual effects of dialysis facilities and transplant centers on variation in the start of the transplant evaluation process.

Study Design: Retrospective cohort study.

Setting & Participants: Dialysis patients referred for kidney transplant to transplant centers across the Southeast, Northeast, New York, or Ohio River Valley US regions from January 1, 2012, to December 31, 2020, were identified from the United States Renal Data System and the Early Steps to Transplant Access Registry and followed through June 30, 2021. A total of N=25,488 referred patients were nested with 1,720 dialysis facilities and 26 transplant centers.

Outcomes: Starting an evaluation for kidney transplant at a transplant center within 6 months of referral.

Analytical Approach: A series of multilevel models were performed to estimate the variability in starting an evaluation for kidney transplant within 6 months of referral. The between-dialysis facility and/or transplant center variation in starting an evaluation was quantified using the median OR.

Results: Among 25,488 dialysis patients referred for kidney transplantation, 51% of patients started an evaluation at a transplant center within 6 months of referral. In multilevel models, the median OR between transplant centers was higher (indicating higher unexplained variability) than the dialysis facility median OR, regardless of measured patient, dialysis facility, and transplant center characteristics.

Limitations: Early transplant access data was limited to 20 of 48 transplant centers across these 4 regions.

Conclusions: When taking dialysis facilities and transplant centers into account, variation in starting an evaluation for kidney transplant appeared at both the dialysis facility and transplant center-level but was more apparent among transplant centers.

Complete author and article information provided before references.

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A majority of patients with kidney failure begin treatment at a dialysis facility, with 84% starting in-center hemodialysis in 2020.[1] The first step in the kidney transplant process involves referral, typically by a dialysis facility nephrologist, to a transplant center for medical evaluation. Few studies have examined access to these early steps because of the lack of national surveillance data on prewaitlisting outcomes. A study in the Southeastern United States observed substantial variation in early transplant steps, with a median of 34% of patients referred from dialysis facilities within 1 year of kidney failure start and evaluation start rates ranging from 18% to 71% among referred patients across dialysis facilities.[2]

Previous studies have identified barriers to starting and completing an evaluation at a transplant center. Patient-level barriers consistently reported include race, sex, health insurance, socioeconomic status (eg, low education, unemployment, low income), and inadequate transplant knowledge.[2-12] However, the majority of this prior work is from single centers and few studies have examined barriers at the provider and health systems levels. Among studies examining provider-level barriers, miscommunication between patients and providers, the perceptions and attitudes of health care providers, and the availability and expertise of staff were commonly cited barriers to early access to kidney transplant.[10,11,13,14]

Research on multilevel variability in starting an evaluation at a transplant center among patients referred for kidney transplantation is limited. Although dialysis facilities and transplant centers are known to jointly influence access to transplantation, their relative contributions to starting the evaluation process has not been examined simultaneously. It remains unclear whether these health care entities are equally important or if one plays a more significant role than the other. Our study aimed to address this gap by using cross-classified multilevel modeling techniques to disentangle and quantify the relative contributions of dialysis facilities and transplant centers in starting an evaluation at a transplant center for kidney transplantation.

METHODS

Data Sources and Study Population

Patient data were obtained from the United States Renal Data System (USRDS) standard analytic files, which collect

PLAIN-LANGUAGE SUMMARY

Kidney transplantation is a life-saving treatment, but not all dialysis patients referred for transplant take the next step of starting their evaluation at a transplant center. Our study sought to understand the relative influence of dialysis facilities and transplant centers in starting an evaluation for kidney transplantation. When taking both dialysis facilities and transplant centers into account, we observed variation in starting an evaluation for kidney transplantation appeared at both the dialysis facility and transplant center-level but characteristics specific to transplant centers appeared to play a larger role in explaining these differences. These findings underscore the need for health system-level improvements to promote more equitable early access to kidney transplantation.

demographic, clinical, and socioeconomic information at kidney failure start (defined as the date of first kidney failure service) using the Centers for Medicare & Medicaid Services (CMS) 2728 form.[1] Patient-level referral and evaluation start data from the novel Early Steps to Transplant Access Registry (E-STAR) were collected from 28 of 48 transplant centers across 4 regions in the United States [Southeast (GA, NC, SC), Northeast (CT, ME, MA, NH, RI, VT), New York, and Ohio River Valley (IN, KY, OH)] and linked with USRDS data, as previously described.[2] Rurality was determined using 2013 Rural-Urban Commuting Area codes linked to patient residential ZIP code at time of kidney failure start.[15] Dialysis facility variables were obtained from Dialysis Facility Reports (DFR), and transplant center variables were obtained from the Scientific Registry of Transplant Recipients (SRTR).

Given that we do not have referral and evaluation data from all 48 transplant centers in ESRD Networks 1, 2, 6, and 9, we used catchment areas informed by transplant center waitlisting patterns (called transplant referral regions [TRRs]) to better define the underlying population served by each of the 28 transplant centers currently included in E-STAR. Our analytic cohort was limited to patients residing in ZIP codes affiliated with one of the 18 TRRs assigned to the 28 transplant centers in E-STAR.[16]

Figure 1 provides a detailed description of the data merge between USRDS and E-STAR and the cohort selection process. Of the 127,423 adult patients with incident kidney failure eligible for merging with E-STAR, exclusions were applied based on dialysis facility characteristics and referral timing. Additionally, patients who were referred to transplant centers that did not submit complete evaluation start data to E-STAR were excluded from the analysis. Our final analytic cohort consisted of N=24,588 patients referred for kidney transplant within one year of kidney failure start nested within 1,720 dialysis facilities and 26 transplant centers.

Outcomes and Study Variables

The primary outcome was starting an evaluation at a transplant center within 6 months of referral (yes/no) to one of the 26 transplant centers in E-STAR. Evaluation start was defined as the date when a patient initiated a required component of the transplant evaluation process within 6 months of referral.[2]

Patient-level characteristics at the time of kidney failure start were obtained from USRDS as reported by clinicians on the CMS-2728 form, including demographics (age, sex as assigned at birth, race, and Hispanic ethnicity), clinical characteristics (transplant education, primary cause of kidney failure, comorbid conditions, and lifestyle behaviors), and socioeconomic characteristics (primary source of health insurance and patient residential rural/urban classification). In this context, we conceptualize race as a social construct rather than a biological categorization.[17] US region of treatment was categorized as Southeast, Northeast, New York, and Ohio River Valley.

Selected dialysis facility-level characteristics (at time of dialysis start) were obtained through the annual USRDS facility survey, including dialysis facility profit status (profit vs nonprofit) and patient to social worker ratio (the number of patients for every 1 social worker and categorized into quartiles). Additional characteristics were obtained through the DFR, including dialysis facility patient volume (total number of dialysis patients in a facility at the end of the year), proportion of Black patients, proportion of Hispanic patients, average number of comorbid conditions per patient, and the proportion of waitlisted patients <75 years.

Transplant center characteristics from SRTR included the total number of waitlisted candidates, and candidate demographics at time of waitlisting (sex, minority race, ethnicity, and age). Each patient was assigned to the Organ Procurement and Transplantation Network (OPTN) region associated with the transplant center to which they were referred.

Statistical Analysis

We described demographic, clinical, socioeconomic, dialysis facility, and transplant center characteristics of our study population, both overall and by evaluation start status. We conducted 7 multilevel (MLM) and cross-classified multilevel (CCMM) logistic mixed regression models to estimate unmeasured variability in starting an evaluation for kidney transplant within 6 months of referral (yes/no) and examined the influence of patient, dialysis facility, and transplant center characteristics on this variability. CCMMs permit simultaneous estimation of the shared variance because of individuals nested within the same dialysis center and transplant center simultaneously.

We first ran random intercept-only models: a dialysis facility-only MLM including the dialysis facility unique identifier CCN (CMS Certification Number) as a random effect (Model 1A), a transplant center-only MLM including

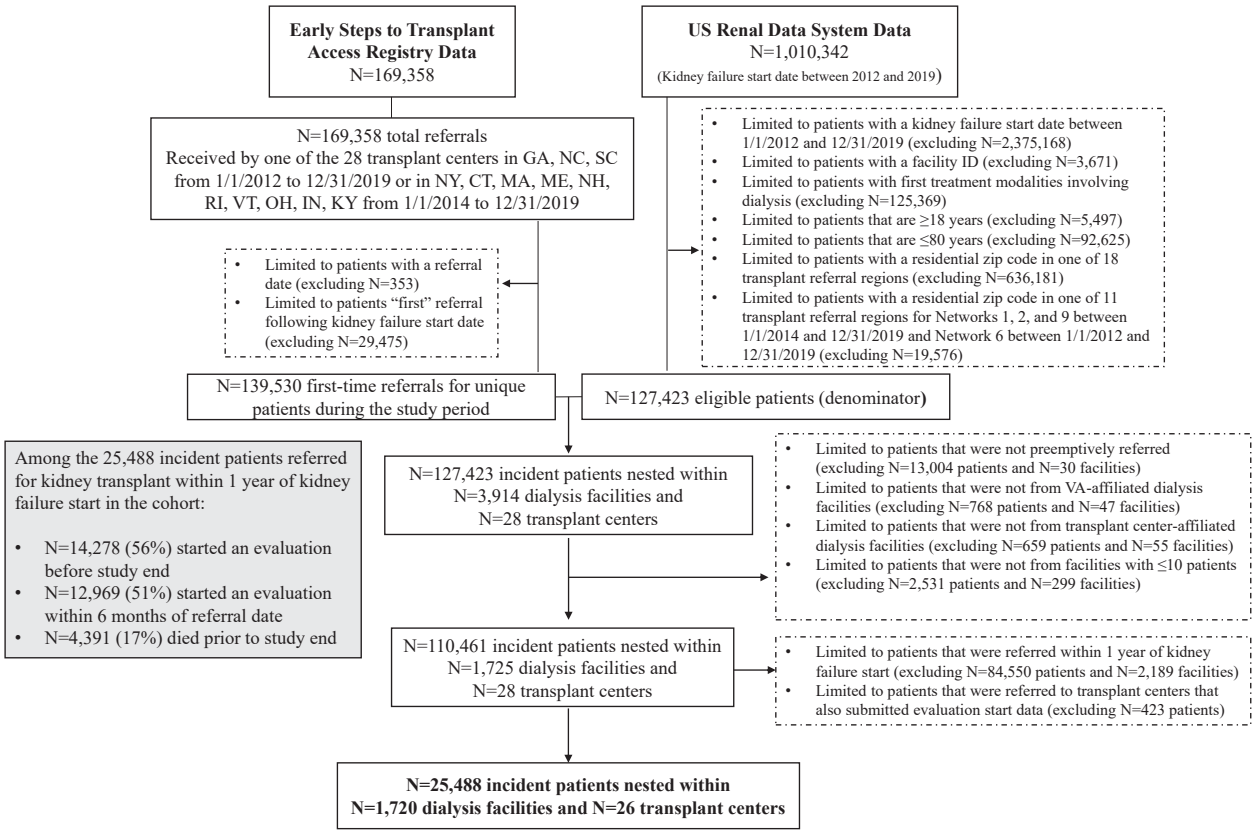

Figure 1. Data merge and cohort selection to examine the relative variability in starting an evaluation at a transplant center among patients with kidney failure referred for kidney transplant across dialysis facilities and transplant centers in the Northeast, New York, Southeastern, and Ohio River Valley regions of the United States.

the transplant center unique identifier as a random effect (Model 1B), and a CCMM with both dialysis facility and transplant center random effects (Model 1C). We then estimated a CCMM by adding patient characteristics to Model 1C (age, sex, race, ethnicity, primary source of health insurance, primary cause of kidney failure, and body mass index $\leq 35\ kg/m^2$) (Model 2). Subsequent CCMMs built on Model 2 by including measured dialysis facility characteristics (aggregate dialysis facility size, proportion of Black patients, mean number of comorbid conditions per patient, patient to social worker ratio, profit status, and proportion of patients waitlisted <75 years old) (Model 3), measured transplant center characteristics (aggregate transplant center waitlisting volume, mean age of waitlisted candidates, proportion of waitlisted candidates that were female and minority race, and transplant center assigned OPTN region) (Model 4), and both dialysis facility and transplant center characteristics (Model 5).

For each model, we quantified and interpreted the residual or unexplained between-dialysis facility and/or transplant center variation in starting an evaluation for kidney transplant using the median odds ratio (MOR), which transforms the random effect variance (ie, area level variance above and beyond that "explained" by covariates in the model) onto an odds ratio (versus logit) scale. The MOR for dialysis facilities can be interpreted, for example, as the odds of starting an evaluation at a transplant center for a patient referred from a given dialysis facility relative to the same patient referred from another randomly selected dialysis facility.[18] If the MOR=1, there is no variability among dialysis facilities. If the MOR > 1, variability exists among dialysis facilities, and this variability is greater as the MOR increases. Given the potential for biased inference because of falsely small standard errors in the setting of CCMMs, confidence intervals around the MOR were not obtained.[19,20]

Missing data were analyzed and there was less than <2% missing data per variable and less than 2.4% across all variables. We conducted a complete case analysis and did not impute for missing data in the CCMMs. The Emory University Institutional Review Board (IRB) and research ethics committee approved this study (IRB00113572) and waived the requirement for written informed consent because of deidentified information.

RESULTS

The mean age for the cohort (N=25,488 patients) was 55.0 years (standard deviation [SD]: 13.1). Most patients were male (60.5%) and Black (51.9%), and a small

proportion were Hispanic (5.3%). A plurality of patients had Medicare as their primary source of health insurance (28.6%). Most patients had diabetes as their provider perceived attributable primary cause of kidney failure (46.2%). Majority of patients resided in a metropolitan area (81.5%) and were treated at a dialysis facility in the Southeastern United States (70.8%). Approximately half of the patients started an evaluation at a transplant center within 6 months of being referred (50.9%). Compared with patients who did not start an evaluation within 6 months of being referred, patients who started an evaluation were younger (53.5 vs 56.5 years), more likely to be male (62.3% vs 58.6%), and less likely to have any of the 8 assessed comorbid conditions. Patients who started the evaluation were more likely to have private insurance as their payer (30.1% vs 20.4%), but less likely to be treated at a facility in the Southeastern United States (68.5% vs 73.3%) (Table 1).

A plurality of patients received treatment from large (43.5%, facilities treating >79 patients) and majority from for-profit (87.8%) dialysis facilities. On average, the percentages of Black and Hispanic patients in each dialysis facility were 48.3% and 5.3%, respectively. Dialysis facilities treated patients with an average of 3 comorbid conditions. The mean proportion of waitlisted patients <75 years at a dialysis facility was 17.6% (SD: 10.0). Patients who started an evaluation were more likely to receive dialysis at larger facilities (87.0 vs 81.4 patients) compared with patients who did not start the evaluation (Table 1). Patients were referred to transplant centers with a mean of 157.2 (SD: 72.2) waitlisted candidates. On average, the proportion of waitlisted candidates within a transplant center who were female and of minority race was 40.7% (SD: 5.5) and 48.0% (SD: 14.8), respectively, and the mean age at time of waitlisting was 50.4 years (SD: 2.2). Among patients who started an evaluation, 40.6% were referred to a transplant center in OPTN 3 (AL, AR, FL, GA, LA, MS); in contrast, among patients who did not start an evaluation, 40.7% were referred to a transplant center in OPTN 11 (KY, NC, SC, TN, VA) (Table 1).

Table 2 presents the results of the dialysis facility- and transplant center-only MLMs; the CCMM containing random effects for both dialysis facilities and transplant centers; and the CCMMs that include patient-, dialysis facility- and transplant center-level characteristics. In the empty models, the MOR for dialysis facilities was 1.95 (Model 1A) and the MOR for transplant centers was 2.11 (Model 1B). The results of the CCMM (Model 1C), which examines the random effects of dialysis facilities and transplant centers simultaneously, suggest that the variance in starting an evaluation was greater for transplant centers (MOR=2.13) as compared with dialysis facilities (MOR=1.37). To clarify, the MOR indicates that on average (on 'median') there is an approximately 2-fold difference in baseline odds of starting an evaluation for a patient referred for kidney transplant between any 2 randomly selected transplant centers. Adding patient-level covariates to the CCMM (Model 2) did not markedly change the residual heterogeneity between dialysis facilities (MOR=1.33) or between transplant centers (MOR=2.11), suggesting the observed variation is not driven by the prevalence of patient-level demographic and clinical factors across dialysis facilities or transplant centers. In Model 3, which added the dialysis facility-level characteristics only, the MOR for dialysis facilities (MOR=1.29) and transplant centers (MOR=1.92) were modestly attenuated, but largely unchanged from Model 2. The results for Model 4, which added the transplant center-level characteristics only, differed from Model 3 in that the MOR for transplant centers was lower (1.49), whereas the MOR for dialysis facilities remained similar (1.32). The results for Model 5, which included both dialysis facility- and transplant center-level characteristics, yielded very similar results to Model 4 with a MOR of 1.28 for dialysis facilities and 1.45 for transplant centers.

DISCUSSION

In this study, we leveraged CCMM to disentangle the impact of measured and unmeasured dialysis facility and transplant center characteristics on starting an evaluation at a transplant center, a critical early step in access to kidney transplantation. Among referred dialysis patients to selected transplant centers in the Northeast, New York, Southeast, and Ohio River Valley regions of the United States, evaluation start varied substantially between dialysis facilities and between transplant centers. These findings expand on a previous study reporting variation in evaluation start across US Southeastern dialysis facilities by examining variability among dialysis facilities and transplant centers concurrently.[2] In our study, the magnitude of the unexplained variation was greater for transplant centers (MOR=1.45) than dialysis facilities (MOR=1.28), even after measured patient-, dialysis facility-, and transplant center-level characteristics had been considered. Notably, there was a marked decrease in the MOR for transplant centers after adjusting for transplant center characteristics (eg, reduction in residual heterogeneity across transplant centers), but the MOR for dialysis facilities was similar regardless of adjustment for dialysis facility and transplant center characteristics. These results suggest that variation in the likelihood of starting an evaluation is affected by factors that were measured at the transplant center level, but unobserved and/or unmeasured transplant center factors remain important. Early access to kidney transplantation is affected by practice patterns from both dialysis facilities and transplant centers, transplant center-level variation appears more relevant, which is perhaps not surprising given competing incentives.

In our study, the magnitude of variation in evaluation start was smaller for dialysis facilities than transplant centers and remained relatively unchanged regardless of including select patient, dialysis facility, and transplant center characteristics. Although we were able to include

Table 1. Patient, Dialysis Facility, and Transplant Center Characteristics of Patients With Kidney Failure Referred for Kidney Transplant, Stratified by Starting an Evaluation at a Transplant Center Within 6 Months of Referral Date, 2012-2020

		Evaluation start status within 6 months of referral date	
	Overall Population N=25,488	Started evaluation N=12,969 (50.9%)	Did not start evaluation N=12,519 (49.1%)
Patient-Level Characteristics[a]			
Age (y), mean ± SD	55.0 ± 13.1	53.5 ± 13.1	56.5 ± 12.9
Age (y), n (%)			
18-34	2,181 (8.6)	1,323 (10.2)	858 (6.9)
35-49	5,850 (23.0)	3,233 (24.9)	2,617 (20.9)
50-64	10,715 (42.0)	5,446 (42.0)	5,269 (42.1)
65-80	6,742 (26.5)	2,967 (22.9)	3,775 (30.2)
Sex, n (%)			
Male	15,418 (60.5)	8,079 (62.3)	7,339 (58.6)
Female	10,070 (39.5)	4,890 (37.7)	5,180 (41.4)
Race, n (%)			
White	11,375 (44.6)	5,828 (44.9)	5,547 (44.3)
Black	13,234 (51.9)	6,562 (50.6)	6,672 (53.3)
Other[b]	877 (3.4)	577 (4.5)	300 (2.4)
Hispanic ethnicity, n (%)	1,338 (5.3)	891 (6.9)	448 (3.6)
Patient informed of kidney transplant options, n (%)	23,290 (91.4)	11,992 (92.5)	11,298 (90.3)
Attributed primary cause of kidney failure, n (%)			
Diabetes	11,768 (46.2)	5,755 (44.4)	6,013 (48.0)
Hypertension	8,638 (33.9)	4,335 (33.4)	4,303 (34.4)
Lupus nephritis	159 (0.6)	65 (0.5)	94 (0.7)
Other glomerulonephritis	2,151 (8.4)	1,288 (9.9)	863 (6.9)
Other cause	2,355 (9.2)	1,077 (8.6)	1,278 (9.9)
Unknown cause	417 (1.6)	198 (1.6)	219 (1.7)
Comorbid conditions, n (%)			
BMI > 35 kg/m^2	6,464 (25.4)	2,928 (22.6)	3,536 (28.3)
Congestive heart failure	6,072 (23.8)	2,664 (20.5)	3,408 (27.2)
Atherosclerotic heart disease	2,252 (8.8)	1,060 (8.2)	1,192 (9.5)
Cardiovascular disease	8,125 (31.9)	3,680 (28.4)	4,445 (35.5)
Cerebrovascular disease	1,802 (7.1)	803 (6.2)	999 (8.0)
Peripheral vascular disease	1,833 (7.2)	786 (6.1)	1,047 (8.4)
Chronic obstructive pulmonary disease	1,579 (6.2)	580 (4.5)	999 (8.0)
Cancer	939 (3.7)	436 (3.4)	503 (4.0)
Tobacco use (current smoker)	2,106 (8.3)	832 (6.4)	1,274 (10.2)
Alcohol dependence	406 (1.6)	176 (1.4)	230 (1.8)
Primary source of health insurance			
Medicaid	6,627 (26.0)	3,125 (24.1)	3,502 (28.0)
Medicare	7,296 (28.6)	3,307 (25.5)	3,989 (31.9)
Employer group	6,464 (25.4)	3,909 (30.1)	2,555 (20.4)
Other	1,902 (7.5)	983 (7.6)	919 (7.3)
No insurance	2,802 (11.0)	1,458 (11.2)	1,344 (10.7)
Urban/rural classification, n (%)			
Metropolitan	20,771 (81.5)	10,865 (83.8)	9,906 (79.1)
Micropolitan	2,996 (11.8)	1,329 (10.3)	1,667 (13.3)
Rural	1,720 (6.8)	774 (6.0)	946 (7.6)
US treatment region, n (%)[c]			
Southeast	18,048 (70.8)	8,878 (68.5)	9,170 (73.3)
New York	1,556 (6.1)	1,166 (9.0)	390 (3.1)
Northeast	2,465 (9.7)	1,598 (12.3)	867 (6.9)
Ohio River Valley	3,419 (13.4)	1,327 (10.2)	2,092 (16.7)

(Continued)

Table 1 (Cont'd). Patient, Dialysis Facility, and Transplant Center Characteristics of Patients With Kidney Failure Referred for Kidney Transplant, Stratified by Starting an Evaluation at a Transplant Center Within 6 Months of Referral Date, 2012-2020

		Evaluation start status within 6 months of referral date	
	Overall Population N=25,488	Started evaluation N=12,969 (50.9%)	Did not start evaluation N=12,519 (49.1%)
Dialysis Facility-Level Characteristics[d]			
Dialysis facility patient volume[e]			
Mean ± SD	84.2 ± 46.6	87.0 ± 49.2	81.4 ± 43.7
N (%)			
Very small, 11-25 patients	742 (2.9)	356 (2.8)	386 (3.1)
Small, 26-54 patients	5,793 (22.8)	2,806 (21.6)	2,987 (23.9)
Medium 55-78 patients	7,844 (30.8)	3,918 (30.2)	3,926 (31.4)
Large, >79 patients	11,080 (43.5)	5,876 (45.3)	5,204 (41.6)
Percentage Black patients, mean ± SD	48.3 ± 28.7	47.5 ± 28.8	49.2 ± 28.7
Percentage Hispanic patients, mean ± SD	5.3 ± 9.5	6.3 ± 10.5	4.3 ± 8.1
Average number of comorbid conditions per patient, mean ± SD	3.2 ± 0.8	3.1 ± 0.75	3.2 ± 0.75
Patient to social worker ratio[f]			
Mean ± SD	76.7 ± 29.5	77.6 ± 29.5	75.8 ± 29.4
Quartile, n (%)			
57:1 (Quartile 1)	6,580 (25.8)	3,177 (24.5)	3,403 (27.2)
57:1-74:1 (Quartile 2)	6,134 (24.1)	3,132 (24.2)	3,002 (24.0)
74:1-95:1 (Quartile 3)	6,551 (25.7)	3,361 (25.9)	3,190 (25.5)
95:1-222:1 (Quartile 4)	6,223 (24.4)	3,299 (25.4)	2,924 (23.4)
Facility profit status, n (%)			
For-profit	22,380 (87.8)	11,309 (87.2)	11,071 (88.4)
Nonprofit	3,108 (12.2)	1,660 (12.8)	1,448 (11.6)
Proportion of waitlisted patients <75 y, mean ± SD	17.6 ± 10.0	19.5 ± 10.8	15.7 ± 8.7
Transplant Center-Level Characteristics,[g] mean±SD			
Number of waitlisted candidates[e]	157.2 ± 72.2	159.6 ± 72.5	154.7 ± 71.7
Patient age at time of waitlisting (y)	50.4 ± 2.2	50.6 ± 2.1	50.2 ± 2.3
Percentage female waitlisted candidates	40.7 ± 5.5	40.9 ± 5.3	40.5 ± 5.8
Percentage minority race[h] waitlisted candidates	48.0 ± 14.8	47.7 ± 15.2	48.2 ± 14.4
Percentage Hispanic waitlisted candidates	6.3 ± 6.2	7.1 ± 7.1	5.4 ± 5.1
Transplant center OPTN region, n (%)			
1 (CT, Eastern VT, MA, ME, NH, RI)	2,521 (9.9)	1,630 (12.6)	891 (7.1)
3 (AL, AR, FL, GA, LA, MS)	9,368 (36.8)	5,267 (40.6)	4,101 (32.8)
9 (NY, Western VT)	1,443 (5.7)	1,117 (8.6)	326 (2.6)
10 (IN, MI, OH)	3,432 (13.5)	1,331 (10.3)	2,101 (16.8)
11 (KY, NC, SC, TN, VA)	8,724 (34.2)	3,624 (27.9)	5,100 (40.7)

Abbreviations: BMI, body mass index; OPTN, organ procurement transplant network; SD, standard deviation.
Missing Data: <1% missing race, <1% missing ethnicity, n=397 (1.6%) missing primary source of health insurance, n=36 (0.1%) missing information on informed status of treatment options, <1% missing rural/urban residential classification status, n=29 (0.1%) missing facility size, n=217 (0.9%) missing facility characteristics including percentage Black patients, percentage Hispanic patients, and average number of comorbid conditions, <1% missing patient to social worker ratio, and n=36 (0.1%) missing percentage waitlisted patients.
[a]Characteristics abstracted from the United States Renal Data System at time of kidney failure start.
[b]Includes American Indian/Alaskan Native, Asian, Native Hawaiian, Pacific Islander, Middle Eastern, Indian, Multiracial, and other.
[c]Southeast (GA, NC, SC), New York (NY), Northeast (CT, MA, ME, NH, RI, VT), Ohio River Valley (IN, KY, OH).
[d]Dialysis facility characteristics were obtained from the most recent nonmissing year of data between 2012 and 2019 from the dialysis facility report.
[e]Captured at the end of year.
[f]Defined as the number of patients for every 1 social worker per dialysis facility and obtained from the facility file within the United States Renal Data System.
[g]Transplant center characteristics obtained from Scientific Registry of Transplant Recipients and linked to the patient-level cohort by the year that the patient was referred for kidney transplant.
[h]Includes Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islands, Arab or Middle Eastern, and Indian Subcontinent.

dialysis facility characteristics related to the demographic and clinical composition of their patient populations, these covariates did not appear to fully account for the small, but persistent between-dialysis facility variation in evaluation start. Dialysis patient engagement in comprehensive transplant education has contributed to improved access to

Table 2. Random Effects at the Dialysis Facility and Transplant Center Level for a Series of Random Intercept Only Multilevel and Cross-Classified Multilevel Models Measuring the Relative Variation in Starting an Evaluation for Kidney Transplant Within 6 Months of Being Referred Among 25,488 Patients with Kidney Failure, 2012-2019 (Followed Through June 30, 2021)

		Random-Effect Estimates	
		Median Odds Ratios[a]	
Models		Dialysis Facility	Transplant Center
Model 1A[b]	Dialysis Facility-Only MLM	1.95	-
Model 1B[c]	Transplant Center-Only MLM	-	2.11
Model 1C[d]	CCMM	1.37	2.13
Model 2[e]	CCMM + Patient[f] Characteristics	1.33	2.11
Model 3[e]	CCMM + Patient[f] and Dialysis Facility[g] Characteristics	1.29	1.92
Model 4[e]	CCMM + Patient[f] and Transplant Center[h] Characteristics	1.32	1.49
Model 5[e]	CCMM + Patient,[f] Dialysis Facility,[g] and Transplant Center[h] Characteristics	1.28	1.45

Abbreviations: CCMM, cross-classified multilevel model; MLM, multilevel model.
Missing Data: <1% missing race, <1% missing ethnicity, n=397 (1.6%) missing primary source of health insurance, n=36 (0.1%) missing information on informed status of treatment options, <1% missing rural/urban residential classification status.
[a]Measures between dialysis facility and transplant center practice variation with respect to starting an evaluation. When the median odds ratio=1, there is no variation in dialysis facility and/or transplant center patients' starting an evaluation. The higher the median odds ratio, the more variation in starting an evaluation between dialysis facilities and/or transplant centers.
[b]Model 1A: Random intercept only multilevel model that includes a random effect for dialysis facilities.
[c]Model 1B: Random intercept only multilevel model that includes a random effect for transplant centers.
[d]Model 1C: Random intercept only cross-classified multilevel model that includes a random effect for dialysis facilities and a random effect for transplant centers.
[e]Cross-classified multilevel model that includes a random effect for dialysis facilities and a random effect for transplant centers; N=25,488 patients nested within 1,720 dialysis facilities and 26 transplant centers.
[f]Patient-level covariates (age, sex, race, ethnicity, primary source of health insurance, primary cause of kidney failure, and body mass index ≤35 kg/m^2).
[g]Dialysis facility-level covariates (dialysis facility size, proportion of Black patients, mean number of comorbid conditions per patient, mean patient to social worker ratio, profit status, and proportion of patients waitlisted <75 years old).
[h]Transplant center-level covariates (transplant center volume, mean age of waitlisted candidate, proportion of female waitlisted candidates, proportion of minority waitlisted candidates, and Organ Procurement & Transplantation Network region).

referral and evaluation for kidney transplant and eventual receipt of a kidney transplant as demonstrated in previous studies.[21-23] CMS requires that dialysis facilities provide information to patients about kidney transplantation within 45 days of starting dialysis and this metric is documented within the USRDS.[24] A nationwide study showed that 70% of providers reported informing patients about kidney transplantation.[21] However, additional research suggests that dissemination of transplant education may be differential across dialysis facilities with respect to quality and time.[22,25] In a recent survey conducted across almost 1,700 US dialysis facilities, 84% of facilities reported verbally recommending patients learn more about transplant and be evaluated for transplant. Yet, very few dialysis facilities (3%) engaged in intensive transplant education, meaning they employed multiple education strategies, including oral transplant recommendations, in-center patient discussions, and distribution of print education.[26]

We found considerable variation in evaluation start by transplant program, even after accounting for multiple sources of variability concurrently at the patient, dialysis facility, and transplant center level. These differences could be reflective of variation in center-defined eligibility criteria and additional medical testing requirements before waitlisting that could affect a patient's decision to start an evaluation at a transplant center following referral.[27] Providing resources such as referral guides that outline transplant center eligibility criteria could improve transparency and help referring nephrologists and social workers refer the most appropriate candidates for evaluation. Given that patients spend upwards of 10 hours per week receiving in-center dialysis treatment, dialysis facilities have historically been targeted for implementation of interventions aimed at improving access to kidney transplantation. However, after examining variation in evaluation start among dialysis facilities and transplant centers concurrently, patients' access to the transplant waitlist may be more heavily influenced by evaluation practice variation at the transplant center level that are beyond the control of dialysis facilities. Our study findings reinforce the need for interventions focused on improving communication and coordination efforts between dialysis facilities and transplant centers at the health systems level. For instance, with the goal of improving patient transplant knowledge, a dialysis facility's referring nephrologists and social workers can collaborate with a transplant center's pretransplant coordinator to ensure they communicate accurate information about the transplant process and disseminate appropriate multimedia transplant educational materials. However, even with improved transplant education, the kidney transplant process is complex for dialysis patients to navigate. Improving communication and transparency about the kidney transplant process between dialysis facility nephrologists and social workers responsible for patient referrals and transplant centers could reduce

fragmented care among dialysis patients and lead to better long-term outcomes. In early 2023, the Health Resources and Services Administration launched the OPTN Modernization Initiative to "strengthen accountability, equity, and performance in the transplantation system," with technology as a key focus.[28] The implementation of electronic portals and applications exemplifies how technology can be leveraged to enhance communication across the health care continuum, enabling staff at both dialysis facilities and transplant centers to better track their patients' progress through the transplant process. For example, granting dialysis facilities access to patients' transplant evaluation appointment schedules could help staff emphasize underscore the importance of these appointments and reduce the risk of incomplete evaluations.[9,29]

The results of this study could also have implications for federal policymakers, like the CMS and ESRD Networks. Federal mandates under the CMS' Conditions for Coverage, the Advancing American Kidney Health Initiative, and the End-Stage Renal Disease Quality Incentive Program, have not only promoted kidney transplant, but also recommended that transplant centers and dialysis facilities work together to increase access to kidney transplant.[24,30,31] However, concerns about misaligned incentives for quality metrics across dialysis facilities and transplant centers have been an ongoing topic of conversation within the kidney transplant community.[32–34] For example, as of the 2022 update of the ESRD Prospective Payment System Final Rule, the proportion of patients waitlisted at a dialysis facility is monitored by CMS as a performance quality metric.[35] As evidenced in our current study, the more salient influence on variation in evaluation start, a step that must be completed before waitlisting, is from transplant centers and renders this metric largely out of the control of dialysis facilities. This metric could also incentivize dialysis facilities to change their referral practices by referring majority of their patients for transplant regardless of eligibility. Additionally, the OPTN Membership and Professional Standards Committee recently implemented a new monitoring system that includes a pretransplant mortality rate ratio as a transplant program performance measure.[36] This measure may encourage more conservative waitlisting behaviors by transplant centers, potentially disadvantaging dialysis facilities accountable for waitlisting metrics. Until recently, post-transplantation metrics (such as 1-year post-transplantation survival) were emphasized to measure quality performance for transplant centers However, there is no current accountable metric for transplant rates. With transplant centers contributing more than dialysis facilities to the variance in starting an evaluation, quality metrics using referral and evaluation start data to assess dialysis facility and transplant center performance should continue to be explored as data collection for E-STAR continues to expand nationally.[37,38] Given this, our study findings support the prior calls and recently announced HRSA directive to expand OPTN data collection to include national data on referral and start of the transplant evaluation among patients with kidney failure.[33,39,40] This effort will enhance our understanding of how transplant centers influence these critical first steps in the kidney transplant process.

Limitations

Our study has limitations. First, we lack early transplant access data for all 48 transplant centers across the 4 regions in this study. Researchers associated with E-STAR were unable to collect complete referral and evaluation start data from 20 centers as of 2022; however, more centers are expected to be included in future data collection. To define our study cohort denominator, we used TRRs informed by transplant center waitlisting patterns to account for incomplete data. However, our results may have limited national generalizability as evaluation trends in these regions may not reflect national patterns. Additionally, our analysis of dialysis facility and transplant center characteristics was constrained by available public data. A more extensive examination of factors related to care patterns (eg, referral closure policies, patient follow-up practices, and eligibility criteria) would better elucidate their impact on evaluation start. Moreover, SRTR data on waitlisted patients may not fully represent all referred patients with kidney failure seeking transplant.

CONCLUSION

This study expands on the existing literature documenting variation in early access to kidney transplant among Southeastern US dialysis facilities. The results provide a new perspective by assessing dialysis facilities and transplant centers concurrently, while also considering measured patient, dialysis facility, and transplant center characteristics previously associated with early transplant access. In this analysis, we found that both dialysis facilities and transplant centers contribute to variation in starting an evaluation for transplant, but measured and unmeasured transplant center characteristics appear more relevant in explaining variation at this step in the kidney transplant process.

ARTICLE INFORMATION

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REFERENCES

1. 2023 USRDS Annual Data Report. Epidemiology of kidney disease in the United States. United States Renal Data System. Accessed August 30, 2023. https://usrds-adr.niddk.nih.gov/2023
2. Patzer RE, McPherson L, Wang Z, et al. Dialysis facility referral and start of evaluation for kidney transplantation among patients treated with dialysis in the Southeastern United States. *Am J Transplant*. 2020;20(8):2113-2125. doi:10.1111/ajt.15791
3. McPherson LJ, Barry V, Yackley J, et al. Distance to kidney transplant center and access to early steps in the kidney transplantation process in the southeastern United States. *Clin J Am Soc Nephrol*. 2020;15(4):539-549. doi:10.2215/cjn.08530719
4. Nonterah CW, Gardiner HM. Pre-transplant evaluation completion for Black/African American renal patients: Two theoretical frameworks. *Patient Educ Couns*. 2020;103(5):988-998. doi:10.1016/j.pec.2019.11.005
5. Monson RS, Kemerley P, Walczak D, Benedetti E, Oberholzer J, Danielson KK. Disparities in completion rates of the medical prerenal transplant evaluation by race or ethnicity and gender. *Transplantation*. 2015;99(1):236-242. doi:10.1097/tp.0000000000000271
6. Waterman AD, Peipert JD, Hyland SS, McCabe MS, Schenk EA, Liu J. Modifiable patient characteristics and racial disparities in evaluation completion and living donor transplant. *Clin J Am Soc Nephrol*. 2013;8(6):995-1002. doi:10.2215/cjn.08880812
7. Weng FL, Joffe MM, Feldman HI, Mange KC. Rates of completion of the medical evaluation for renal transplantation. *Am J Kidney Dis*. 2005;46(4):734-745. doi:10.1053/j.ajkd.2005.06.011
8. Schold JD, Gregg JA, Harman JS, Hall AG, Patton PR, Meier-Kriesche HU. Barriers to evaluation and wait listing for kidney transplantation. *Clin J Am Soc Nephrol*. 2011;6(7):1760-1767. doi:10.2215/cjn.08620910
9. Lockwood MB, Saunders MR, Nass R, et al. Patient-reported barriers to the prekidney transplant evaluation in an at-risk population in the United States. *Prog Transplant*. Jun 2017;27(2):131-138. doi:10.1177/1526924817699957
10. Browne T. The relationship between social networks and pathways to kidney transplant parity: evidence from black Americans in Chicago. *Soc Sci Med*. 2011;73(5):663-667. doi:10.1016/j.socscimed.2011.06.031
11. Butler CR, Taylor JS, Reese PP, O'Hare AM. Thematic analysis of the medical records of patients evaluated for kidney transplant who did not receive a kidney. *BMC Nephrol*. 2020;21(1):300. doi:10.1186/s12882-020-01951-1
12. Jones D, You Z, Kendrick JB. Racial/ethnic differences in barriers to kidney transplant evaluation among hemodialysis patients. *Am J Nephrol*. 2018;47(1):1-7. doi:10.1159/000484484
13. Browne T, Patzer RE, Gander J, Amamoo MA, Krisher J, Sauls L, Pastan S. Kidney transplant referral practices in southeastern dialysis units. *Clin Transplant*. 2016;30(4):365-371. doi:10.1111/ctr.12693
14. Crenesse-Cozien N, Dolph B, Said M, Feeley TH, Kayler LK. Kidney transplant evaluation: inferences from qualitative interviews with African American patients and their providers. *J Racial Ethn Health Disparities*. 2019;6(5):917-925. doi:10.1007/s40615-019-00592-x
15. US Department of Agriculture. Economic research service: Rural-Urban Commuting Area (RUCA) codes. Accessed August 30, 2023. https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/
16. Ross-Driscoll K, Axelrod D, Lynch R, Patzer RE. Using geographic catchment areas to measure population-based access to kidney transplant in the United States. *Transplantation*. 2020;104(12):e342-e350. doi:10.1097/tp.0000000000003369
17. Krieger N. Refiguring "race": epidemiology, racialized biology, and biological expressions of race relations. *Int J Health Serv*. 2000;30(1):211-216. doi:10.2190/672j-1ppf-k6qt-9n7u
18. Merlo J, Chaix B, Ohlsson H, et al. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. *J Epidemiol Community Health*. 2006;60(4):290-297. doi:10.1136/jech.2004.029454
19. Austin PC, Merlo J. Intermediate and advanced topics in multilevel logistic regression analysis. *Stat Med*. 2017;36(20):3257-3277. doi:10.1002/sim.7336
20. Doedens P, Ter Riet G, Boyette LL, Latour C, de Haan L, Twisk J. Cross-classified multilevel models improved standard error estimates of covariates in clinical outcomes - a simulation study. *J Clin Epidemiol*. 2022;145:39-46. doi:10.1016/j.jclinepi.2022.01.005
21. Kucirka LM, Grams ME, Balhara KS, Jaar BG, Segev DL. Disparities in provision of transplant information affect access to kidney transplantation. *Am J Transplant*. 2012;12(2):351-357. doi:10.1111/j.1600-6143.2011.03865.x
22. Waterman AD, Peipert JD, Goalby CJ, Dinkel KM, Xiao H, Lentine KL. Assessing transplant education practices in dialysis centers: comparing educator reported and medicare data. *Clin J Am Soc Nephrol*. 2015;10(9):1617-1625. doi:10.2215/cjn.09851014
23. Plantinga LC, Pastan SO, Wilk AS, et al. Referral for kidney transplantation and indicators of quality of dialysis care: a cross-sectional study. *Am J Kidney Dis*. 2017;69(2):257-265. doi:10.1053/j.ajkd.2016.08.038
24. Medicare and Medicaid programs; conditions for coverage for end-stage renal disease facilities. Final rule. *Fed Regist*. Apr 15 2008;73(73):20369-20484.
25. Balhara KS, Kucirka LM, Jaar BG, Segev DL. Disparities in provision of transplant education by profit status of the dialysis center. *Am J Transplant*. 2012;12(11):3104-3110. doi:10.1111/j.1600-6143.2012.04207.x

26. Waterman AD, Peipert JD, Xiao H, et al. Education strategies in dialysis centers associated with increased transplant waitlisting rates. *Transplantation*. 2020;104(2):335-342. doi:10.1097/tp.0000000000002781
27. Browne T, McPherson L, Retzloff S, et al. Improving access to kidney transplantation: perspectives from dialysis and transplant staff in the southeastern United States. *Kidney Med*. 2021;3(5):799-807.e1. doi:10.1016/j.xkme.2021.04.017
28. HRSA Announces Organ Procurement and Transplantation Network Modernization Initiative. Health Resources & Services Administration. Accessed November 19, 2024. https://www.hrsa.gov/optn-modernization/march-2023
29. Sullivan C, Leon JB, Sayre SS, et al. Impact of navigators on completion of steps in the kidney transplant process: a randomized, controlled trial. *Clin J Am Soc Nephrol*. 2012;7(10):1639-1645. doi:10.2215/cjn.11731111
30. Advancing American Kidney Health Initiative Federal Registrar. Accessed November 19, 2024. https://www.federalregister.gov/documents/2019/07/15/2019-15159/advancing-american-kidney-health
31. ESRD Quality Incentive Program. Centers for Medicaid and Medicare Services. Accessed November 19, 2024. https://www.cms.gov/medicare/quality/end-stage-renal-disease-esrd-quality-incentive-program
32. Schold JD, Patzer RE, Pruett TL, Mohan S. Quality metrics in kidney transplantation: current landscape, trials and tribulations, lessons learned, and a call for reform. *Am J Kidney Dis*. 2019;74(3):382-389.
33. Patzer RE, Pastan SO. Policies to promote timely referral for kidney transplantation. *Semin Dial*. 2020;33(1):58-67.
34. Schold JD, Buccini LD, Phelan MP, et al. Building an ideal quality metric for ESRD health care delivery. *Clin J Am Soc Nephrol*. 2017;12(8):1351-1356. doi:10.2215/cjn.01020117
35. Centers for Medicare and Medicaid Services. End Stage Renal Disease Prospective Payment System. Accessed November 19, 2024. https://www.federalregister.gov/documents/2023/11/06/2023-23915/medicare-program-end-stage-renal-disease-prospective-payment-system-payment-for-renal-dialysis
36. Enhance Transplant Program Performance Monitoring. OPTN. 2021. Accessed November 20, 2024. https://optn.transplant.hrsa.gov/policies-bylaws/enhance-transplant-program-performance-monitoring/
37. Paul S, Plantinga LC, Pastan SO, Gander JC, Mohan S, Patzer RE. Standardized transplantation referral ratio to assess performance of transplant referral among dialysis facilities. *Clin J Am Soc Nephrol*. 2018;13(2):282-289. doi:10.2215/cjn.04690417
38. Paul S, Melanson T, Mohan S, et al. Kidney transplant program waitlisting rate as a metric to assess transplant access. *Am J Transplant*. 2021;21(1):314-321. doi:10.1111/ajt.16277
39. Fowler KJ. Accountability of dialysis facilities in transplant referral: CMS needs to collect national data on dialysis facility kidney transplant referrals. *Clin J Am Soc Nephrol*. 2018;13(2):193-194. doi:10.2215/cjn.13741217
40. HRSA directive to expand OPTN data collection. OPTN. Accessed November 20, 2024. https://optn.transplant.hrsa.gov/news/hrsa-directive-to-expand-optn-data-collection/