Regional Variation in Early Kidney Transplant Access Across Dialysis Facilities in 4 US Regions

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Introduction: Pretransplant access varies, but whether pretransplant steps vary regionally across dialysis facilities remains unclear.

Methods: We identified 62,467 adults (aged 18–80 years) referred from 2471 dialysis facilities and 27,171 initiating transplant evaluation from 2188 facilities in New England, New York, Southeast, and Ohio River Valley within the Early Steps to Transplant Access Registry (E-STAR) (January 1, 2015–December 31, 2023), linked with US Renal Data System (USRDS) and the Scientific Registry of Transplant Recipients data, followed-up through March 2, 2024. We examined dialysis facility–level proportions of evaluation start within 6 months of referral and waitlisting within 1 year of evaluation start. Descriptive statistics using analysis of variance and chi-square tests summarized outcome distributions and baseline characteristics within tertiles of outcome proportions, overall and by region.

Results: Evaluation start within 6 months across 2471 facilities varied from 0% to 100%; median within-facility proportion was 50% (interquartile range: 33.3%–64.3%), ranging from 33.3% (18.2%–50%) in the Ohio River Valley to 66.7% (50%–76.7%) in New York. Waitlisting within 1 year of evaluation start varied from 0% to 100% across 2188 facilities; median within-facility proportion was 41.2% (26.0%–60%), lowest in the Southeast (31.9% [20%–43.8%]) and similar across other regions (50%). Facilities in the lowest tertile of evaluation start proportions ($< 39.13\%$) more often treated patients from high-poverty neighborhoods (36.8% vs. 29.2%) and were for-profit (82.4% vs. 73.5%) than the highest tertile ($> 58.33\%$). These characteristics varied by region. Facility-level clustering explained 12.2% (95% confidence interval [CI]: 10.5%–13.5%) of variation in evaluation and 8.2% (6.7%–9.2%) in waitlisting.

Conclusion: Substantial regional variation in pretransplant access across dialysis facilities reinforces the need for region-specific strategies to improve access.

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Kidney transplantation is the preferred treatment option for most individuals with end-stage kidney disease (ESKD), offering improved life expectancy, quality of life, and cost-effectiveness compared with dialysis.[1-3] However, access to transplantation remains limited and variable, with well-documented differences by patient, provider, and dialysis facility

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characteristics at all steps of the transplant process.[4-13] These differences reflect complex, multifaceted barriers that influence progression through each step of the transplant process; from education and referral to evaluation, waitlisting, and receipt of a transplant.[13-16]

Although access to later steps of transplant care postwaitlisting has been studied extensively, far less is known about earlier steps, including the prewaitlisting care steps of referral and evaluation start. This is primarily because of the lack of national surveillance data on these early steps. Much of the existing evidence on early transplant access comes from E-STAR,[17,18] the only US population-based registry of prewaitlisting data, which has collected referral and evaluation start data across all transplant centers in the Southeastern US for over a decade.[5,19,20] In this region, previous work has shown substantial variation in the within-facility proportion of evaluation start after referral, ranging from 0% to 100% across Southeastern dialysis facilities, with fewer than 1 in 5 referred patients initiating evaluation within 6 months of referral during 2012 to 2018.[5] More recently, McPherson *et al*.[19,20] demonstrated that both dialysis facilities and transplant centers independently contribute to this variation, highlighting the importance of examining access disparities across different health system levels.

Nationally, studies have identified significant geographic variations in later transplant steps, including time to waitlisting and deceased donor transplant rates among active candidates on the kidney waitlist.[21,22] These findings have contributed to a growing policy focus on better aligning dialysis and transplant care delivery and reducing health care costs through performance-based incentive models[23] such as the Kidney Care Choices model,[24] the End-Stage Renal Disease Treatment Choices model,[25] and the newly launched Increasing Organ Transplant Access model.[26] These efforts, along with quality metrics under the End-Stage Renal Disease Quality Incentive Program,[27] emphasize the need to monitor and strengthen early access to transplant care pathways. However, limited availability of data on evaluation and waitlisting outside of the Southeast presents challenges to tracking progress and identifying areas for improvement.

In 2019, E-STAR expanded to include 10 additional states in the Northeast and Midwest, enabling a novel examination of regional variation in early transplant access. Using this expanded dataset, we describe for the first time, regional variation in dialysis facility–level proportions of evaluation start and waitlisting across 4 US regions. We hypothesized that regional variation exists in evaluation start and waitlisting of patients at the dialysis facility level, that this variation would persist after adjusting for patient mix, and that characteristics of facilities with high versus low performance would differ by region. Our findings offer novel insight into regional variation in patterns of access across the early steps of transplant care and may help guide emerging federal efforts to improve transparency and performance, such as the bipartisan-supported 2023 Securing the U.S. Organ Procurement and Transplantation Network Act,[28] the Health Resources and Services Administration's upcoming national data collection on prewaitlisting data nationally, and the Increasing Organ Transplant Access[26] to improve transplant access.

METHODS

Data Sources

Given this study's focus on the quality of care of early transplant access among dialysis facilities and the absence of national surveillance data available for referral and evaluation start, we used transplant center data from E-STAR to identify individuals who had started on dialysis and had been referred for transplant to one of the participating transplant centers in these 4 US regions (13 states). Because there is not 100% participation of transplant centers in these 4 US regions, we could not capture all eligible dialysis patients referred, because some may be referred to centers not captured within E-STAR, impacting our ability to estimate regional dialysis facility–level proportions of individuals referred following dialysis start accurately. Thus, we limited analyses to those patients whose referral records were captured within E-STAR (i.e., referral date available). Detailed information on characteristics of dialysis facilities referring to E-STAR versus those without a corresponding referral record in E-STAR, based on the Dialysis Facility Report data (2020–2023), is presented in Supplementary Table S1.

Patient-level referral and evaluation data (n = 321,871 referral records representing ∼ 217,000 patients) were collected from transplant referral forms and electronic medical records at 36 of the 47 transplant centers in New England (Network 1: CT, MA, ME, NH, RI, VT – 10/13 centers, 77%), New York (Network 2: NY – 10/13 centers, 77%), the Southeast (End-Stage Renal Disease Network 6: GA, NC, SC – 11/11 centers, 100%), and the Ohio River Valley (Network 9: IN, KY, OH – 5/10 centers, 50%) from January 1, 2012 through December 31, 2023. Transplant center data availability varied because of openings, closures, and other administrative reasons (Supplementary Tables S2 and S3). Detailed methods of the data collection process are available elsewhere.[5]

Patient-level characteristics reported by clinicians on the Centers for Medicare and Medicaid Services Medical Evidence Form (2728 form) within 45 days of dialysis initiation were obtained via linkage to the USRDS, a registry of all individuals initiating kidney replacement therapy (dialysis or transplant) in the US. Data on all adults waitlisted for kidney transplantation were obtained via the Scientific Registry of Transplant Recipients and linked to USRDS data via a unique patient identifier. Facility-level characteristics were obtained from the annual USRDS facility survey. Characteristics of patients' residential neighborhood via 5-digit ZIP code tabulation area linkage were obtained from the 2014–2018 American Community Survey data.

The Institutional Review Boards at Emory (IRB00113572) and Indiana (IRB #18998) Universities approved this study.

Study Population

The 2 study cohorts included all adults (aged 18–80 years at dialysis) who were referred (cohort 1) and/or started the evaluation (cohort 2) at one of 36 E-STAR–participating transplant centers from January 1, 2015 to December 31, 2023 (March 2, 2024 for evaluation) and who initiated treatment on dialysis. Patients were assigned to the first facility where they received dialysis services.[5] Preemptively (i.e., before dialysis initiation) referred ($n = 10{,}060$), evaluated ($n = 141$), or waitlisted ($n = 154{,}456$) individuals were excluded because these referrals did not originate from a dialysis facility for which their care could be attributable, and our primary goal was to examine dialysis care quality and processes related to early transplant access, in alignment with our previous studies.[5,19,20] For the same reason, additional inclusions included individuals whose first treatment modality did not involve dialysis (i.e., died, had unknown dialysis status, recovered kidney function, received a preemptive transplant, were lost to follow-up, or nursing home hemodialysis; $n = 260{,}447$) and those with < 6 months of follow-up ($n = 631$). The final analytic samples comprised 62,467 adults referred (cohort 1) and 27,171 who started the evaluation (cohort 2; Figure 1).

Study Outcomes

The primary outcome was evaluation start within 6 months of first referral, at the dialysis facility level. Here, we broadly define evaluation start as the date when a patient initiated a required component of the transplant evaluation process (a more complete definition is in the Supplementary Table S4). Individuals were followed-up with from date of first referral until evaluation start date or December 31, 2023 (end of follow-up in E-STAR).

The secondary outcome was waitlisting within 1 year of evaluation start, defined using the date of first placement on the United Network for Organ Sharing deceased donor waitlist (active or inactive listing), at the dialysis facility level. We examined dialysis facility–level variation by grouping patients by dialysis facility and calculating the percentages of each of our outcomes. Individuals were followed from evaluation start date until waitlisting or 3/02/2024 (end of follow-up in Scientific Registry of Transplant Recipients). Detailed information on data availability for follow-up for our outcomes by center can be found in the Supplementary Material.

Covariates

Patient characteristics included race and ethnicity (Black; Hispanic White; non-Hispanic White; other race or ethnicity: American Indian/Alaska Native, Native Hawaiian/Pacific Islander, Multiracial, and Pacific Islander, Middle Eastern Subcategory, and Indian Subcategory), age, sex, cause of ESKD, and comorbidities (Table 1). Patient-level proxies for socioeconomic status included receipt of pre-ESKD nephrology care (yes, no) and primary source of health insurance at dialysis start (Medicare, Medicaid, employer group coverage, other coverage, no coverage). A hierarchy of employer group coverage, Medicare, Medicaid, other, and no coverage was used to assign a single primary source of coverage for individuals with multiple sources of health insurance listed. Measures of neighborhood socioeconomic status using the patients' residential 5-digit ZIP code included the proportion of Black residents, residents aged ≥ 25 years without a high school degree or equivalent, and neighborhood poverty, defined as ≥ 20% or < 20% of households living below the poverty level. Dialysis facility characteristics included the annual number of patients per facility, the patient–to–social worker ratio, profit status (for-profit, non-profit), and hospital-based versus freestanding facility.

Statistical Analyses

Patient and dialysis-facility characteristics at dialysis start were summarized overall and by region (New York, New England, Southeast, and Ohio River Valley) using analysis of variance and chi-square tests for continuous and categorical variables, respectively. Waterfall plots illustrate the distribution of these percentages of each of our outcomes at the facility-level by region. An intraclass correlation coefficient, accounting for patient mix (race and ethnicity, age, sex, cause of ESKD, comorbidities, pre-ESKD nephrology care, insurance status, and neighborhood socioeconomic factors) was used to estimate the

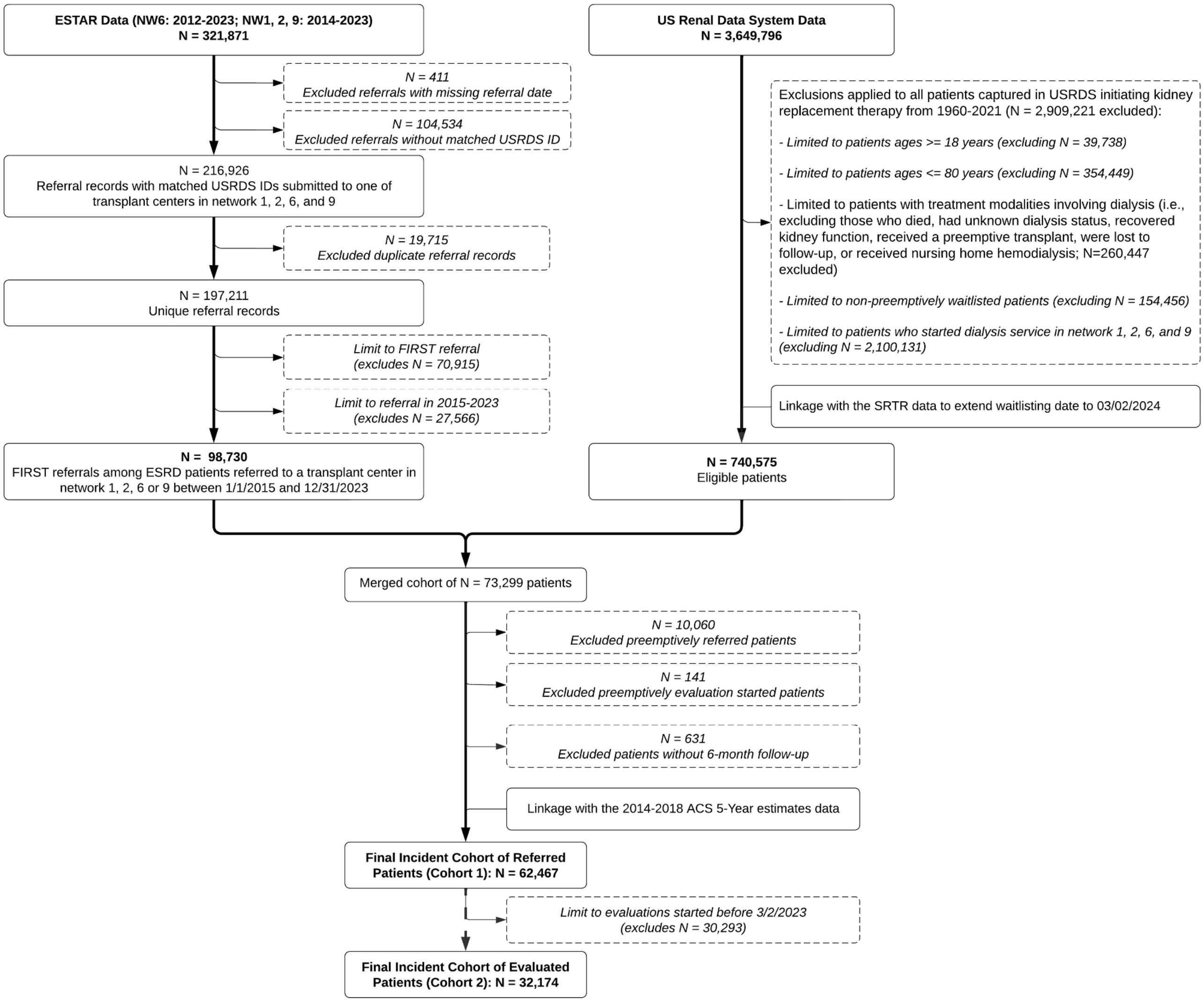

Figure 1. Flow diagram of study inclusion and exclusion criteria for study population (2015–2023). ESRD, end-stage renal disease; USRDS, US Renal Data System.

proportion of total variance in the outcomes that is attributable to clustering of patients within the same dialysis facility, reflecting the extent to which the observed variation was independent of similarities in outcomes among patients treated at the same facility. Facilities were stratified into tertiles based on these percentages, overall and within each region. Facility and aggregated patient characteristics were compared to assess whether they differed by high, middle, and low tertiles overall, and whether these patterns varied by region. To further examine regional differences, we used cumulative incidence functions to estimate the probabilities of each outcome by region, treating death as a competing risk and censoring for loss to follow-up or study end. Unadjusted and adjusted Fine and Grey models,[29] examined the association between region (using the Southeast as a reference, given previous research on referral and evaluation in this region[5]) and time to each event. We calculated crude and adjusted subdistribution hazard ratios with 95% CI for each outcome, accounting for death as a competing risk, and including a random intercept for facility-level heterogeneity and interaction terms by region.

Given the extended follow-up period of this study and our interest in understanding whether temporal changes in referral volume may influence observed outcomes, we conducted a sensitivity analysis to examine annual counts of transplant referrals from 2015 to 2023 across all 4 regions and within each region.

SAS 9.4 (SAS Institute Inc.) was used for data cleaning and analyses. R version 4.3.1 (R Foundation for Statistical Computing, Vienna, Austria) was used for data visualization.

RESULTS

Baseline Characteristics

Among the 62,467 referred individuals in E-STAR, the mean age at dialysis start was 53 years (SD: 14;

Table 1. Baseline dialysis facility– and patient-level characteristics of patients referred for a transplant: 2015–2023

	Total study Population ($N = 62,467$)	ESRD Network: New England $n = 8797$	New York $n = 9893$	Southeast $n = 30,874$	Ohio River Valley $n = 12,903$
Facility-level characteristics[a]					
Number of patients per facility, mean (SD)[b]	88.4 (56.9)	96.1 (56.2)	120.1 (74.1)	83.6 (50.8)	70.3 (44.4)
Patient to social worker ratio, mean (SD)[c]	64.3 (33.3)	68.3 (34.1)	80.2 (40.1)	63.1 (31.5)	52.4 (27.8)
Freestanding facility, *n* (%)[d]	57,380 (91.9%)	7592 (86.3%)	7747 (78.3%)	29,939 (97.0%)	12,102 (93.8%)
Profit status, *n* (%)[e]					
Non-profit	10,262 (16.4%)	1465 (16.7%)	3152 (31.9%)	4126 (13.4%)	1519 (11.8%)
For-profit	52,048 (83.3%)	7261 (82.5%)	6703 (67.8%)	26,722 (86.6%)	11,362 (88.1%)
Characteristics of patients within facility					
Mean age, yrs, mean (SD)	52.7 (13.9%)	53.0 (14.2)	52.7 (0.5%)	52.8 (13.8)	52.3 (14.0)
Age category, yrs, *n* (%)[f]					
18–30	4434 (7.1%)	700 (8.0%)	707 (7.1%)	2,062 (6.7%)	965 (7.5%)
30–40	7494 (12.0%)	986 (11.2%)	1179 (11.9%)	3703 (12.0%)	1626 (12.6%)
40–50	11,805 (18.9%)	1516 (17.2%)	1839 (18.6%)	6031 (19.5%)	2419 (18.7%)
50–60	16,329 (26.1%)	2299 (26.1%)	2588 (26.2%)	8071 (26.1%)	3371 (26.1%)
60–70	15,847 (25.4%)	2297 (26.1%)	2525 (25.5%)	7758 (25.1%)	3267 (25.3%)
70–80	6391 (10.2%)	977 (11.1%)	1028 (10.4%)	3155 (10.2%)	1231 (9.5%)
Male sex, *n* (%)	38,088 (61.0%)	5600 (63.7%)	6263 (63.3%)	18,181 (58.9%)	8044 (62.3%)
Race/ethnicity, *n* (%)[g]					
Black	31,780 (50.9%)	2414 (27.4%)	4305 (43.5%)	20,043 (64.9%)	5018 (38.9%)
White, Hispanic	4039 (6.5%)	1102 (12.5%)	1537 (15.5%)	982 (3.2%)	418 (3.2%)
White, non-Hispanic	23,570 (37.7%)	4605 (52.3%)	2850 (28.8%)	8935 (28.9%)	7180 (55.6%)
Other race/ethnicity	2659 (4.3%)	429 (4.9%)	1156 (11.7%)	834 (2.7%)	240 (1.9%)
Attributed cause of ESKD, *n* (%)[h]					
Diabetes	26,767 (42.8%)	3813 (43.3%)	4239 (42.8%)	12,890 (41.8%)	5825 (45.1%)
Hypertension	19,528 (31.3%)	1842 (20.9%)	2751 (27.8%)	11,559 (37.4%)	3376 (26.2%)
Glomerulonephritis	7361 (11.8%)	1432 (16.3%)	1279 (12.9%)	2997 (9.7%)	1653 (12.8%)
Cystic Kidney	1470 (2.4%)	325 (3.7%)	253 (2.6%)	525 (1.7%)	367 (2.8%)
Other	7253 (11.6%)	1368 (15.6%)	1351 (13.7%)	2865 (9.3%)	1669 (12.9%)
Facility % of incident patient clinical and laboratory measures					
Comorbidities, *n* (%)					
Obese (BMI $\geq$ 35 kg/m^2)	15,893 (25.4%)	1779 (20.2%)	1993 (20.1%)	8304 (26.9%)	3817 (29.6%)
Congestive heart failure	14,453 (23.1%)	2136 (24.3%)	2178 (22.0%)	7044 (22.8%)	3095 (24.0%)
Atherosclerotic heart disease	5800 (9.3%)	1270 (14.4%)	1283 (13.0%)	1981 (6.4%)	1266 (9.8%)
Other cardiac disease	8784 (14.1%)	1403 (15.9%)	1192 (12.0%)	4069 (13.2%)	2120 (16.4%)
Cerebrovascular disease (stroke)	4299 (6.9%)	586 (6.7%)	637 (6.4%)	2196 (7.1%)	880 (6.8%)
Peripheral vascular disease	4300 (6.9%)	915 (10.4%)	670 (6.8%)	1766 (5.7%)	949 (7.4%)
Hypertension	55,556 (88.9%)	7391 (84.0%)	8789 (88.8%)	27,978 (90.6%)	11,398 (88.3%)
Diabetes	34,156 (54.7%)	4510 (51.3%)	5177 (52.3%)	17,333 (56.1%)	7136 (55.3%)
Chronic obstructive pulmonary disease	3571 (5.7%)	554 (6.3%)	453 (4.6%)	1571 (5.1%)	993 (7.7%)
Tobacco use	4916 (7.9%)	625 (7.1%)	484 (4.9%)	2513 (8.1%)	1294 (10.0%)
Cancer	2537 (4.1%)	452 (5.1%)	397 (4.0%)	1085 (3.5%)	603 (4.7%)
Patient socioeconomic characteristics					
Pre-ESKD nephrology care, *n* (%)	40,362 (64.6%)	6057 (68.9%)	5805 (58.7%)	19,773 (64.0%)	8727 (67.6%)
Patient has been informed of kidney transplant options, *n* (%)[i]	54,165 (86.7%)	6835 (77.7%)	8970 (90.7%)	26,996 (87.4%)	11,364 (88.1%)
Primary health insurance provider, *n* (%)[j]					
Medicaid	19,048 (30.5%)	3578 (40.7%)	4505 (45.5%)	6814 (22.1%)	4151 (32.2%)
Medicare	17,140 (27.4%)	2098 (23.8%)	2033 (20.5%)	9417 (30.5%)	3592 (27.8%)
Employer group	14,984 (24.0%)	1961 (22.3%)	2283 (23.1%)	7236 (23.4%)	3504 (27.2%)
Other coverage	4788 (7.7%)	618 (7.0%)	710 (7.2%)	2630 (8.5%)	830 (6.4%)
No coverage	6001 (9.6%)	268 (3.0%)	312 (3.2%)	4647 (15.1%)	774 (6.0%)
Patient neighborhood (ZIP code) characteristics[k]					
Average % black, mean[l] (SD)	29.2 (25.9)	14.2 (18.2)	28.3 (27.7)	36.8 (24.2)	21.9 (26.3)
Average % high school graduates, mean[m] (SD)	85.5 (7.5)	87.0 (8.1)	83.3 (8.8)	85.1 (6.8)	87.4 (6.7)

(Continued on following page)

Table 1. (Continued) Baseline dialysis facility– and patient-level characteristics of patients referred for a transplant: 2015–2023

	Total study Population (N = 62,467)	ESRD Network New England n = 8797	New York n = 9893	Southeast n = 30,874	Ohio River Valley n = 12,903
Neighborhood poverty (% ZIP code residents below poverty)[n], n (%)					
< 20% below poverty	38,678 (61.9%)	6523 (74.2%)	6336 (64.0%)	17,663 (57.2%)	8156 (63.2%)
≥ 20% below poverty	23,162 (37.1%)	2181 (24.8%)	3521 (35.6%)	12,778 (41.4%)	4682 (36.3%)

BMI, body mass index (calculated as weight in kg divided by height in m squared); ESKD, end-stage kidney disease.
[a]Obtained from data from the CMS ESRD Annual Facility Survey and the CDC Dialysis Surveillance Survey within the USRDS facility dataset.
[b]Information on number of patients within dialysis facility missing for 157 patients (0.3%).
[c]Number of patients for every 1 social worker. Information on dialysis facility patient-to-social worker ratio was missing for 735 patients (1.2%). Calculated only among those facilities that have social workers and whose information on the number of patients and social workers was not missing.
[d]157 (0.3%) missing facility type.
[e]157 (0.3%) missing facility profit status.
[f]Infomation on patient age at kidney replacement therapy initiation missing for 167 patients (0.3%).
[g]Race and ethnicity information missing for 419 patients (0.7%).
[h]Patient attributable cause missing for 88 patients (0.1%).
[i]Information on whether patient has been informed of kidney transplant options missing for 2460 patients (3.9%).
[j]Insurance information missing for 506 patients (0.8%).
[k]Obtained from American Community Survey Data, 2014-2018.
[l]601 (1.0%) missing average percent black.
[m]601 (1.0%) missing average percentage of high school graduates.
[n]Information on neighborhood poverty missing for 627 (1.0%).
Data shown as the total number of patients (No.) and the percentage (%), unless indicated otherwise.

Table 1). In the Southeast, 64.9% of referred patients were Black, whereas in New England (53.9%) and the Ohio River Valley (55.9%), the majority were non-Hispanic White. New York had a greater proportion of individuals identified as Hispanic White and other racial and ethnic groups compared to other regions. Among the 2471 referring dialysis facilities, 83.5% were for-profit, 92.1% were freestanding, and the mean patient–to–social worker ratio was 64.3. Other baseline characteristics were largely similar across regions (Table 1).

Dialysis Facility–Level Variation in Proportions of Evaluation Start and Waitlisting

Among 2471 dialysis facilities, the median percentage of patients starting the evaluation within 6 months was 50.0% (interquartile range: 33.3%–64.3%). The median within-facility proportions of evaluation start within 6 months of referral were lowest in the Ohio River Valley at 33.3% (18.2%−50.0%) and greatest in New York, at 66.7% (50.0%−76.7%). The median proportion of patients starting the evaluation within 6 months of referral was 52.7% (39.1%−66.7%) in New England and 50% (38.5%−60.0%) in the Southeast. For waitlisting within 1 year of evaluation start among 2188 facilities, the median percentage was 50.0% (38.9%−72.4%), 50.0% (33.3%−75%), 50.0% (33.3%−70.0%), and 31.9% (20%−43.8%) in New England, New York, the Ohio River Valley, and the Southeast, respectively. Across all regions, both outcomes varied significantly across the dialysis facilities, ranging from 0% to 100% (Figure 2). After accounting for patient mix, facility-level clustering explained 12.2% (95% CI: 10.5–13.5) of the variation in evaluation start and 8.2% (95% CI: 6.7–9.2) of the variation in waitlisting.

Characteristics of facilities in the highest (i.e., greatest proportion of individuals with evaluation start within 6 months among those referred) versus the lowest tertile of evaluation start proportions varied. For example, facilities in the lowest tertile had a higher patient–to–social worker ratio (49.2 [95% CI: 47.13–51.28) vs. 46.26 [43.71–48.82]), a higher proportion of adults aged 60 to 80 years, fewer Black adults (40.0% [95% CI: 37.7–42.3] vs. 45.0% [42.8–47.2]), a greater proportion of adults with diabetes as the attributed cause of ESKD (42.0% [40.3–43.6] vs. 36.4% [34.9–38.0]), and higher prevalence of most comorbidities examined. The lowest tertile had a higher proportion of adults with Medicare or no health insurance coverage at dialysis start, whereas employer-sponsored insurance was more common in the highest tertile. Facilities in the lowest-tertile treated adults residing in neighborhoods with fewer Black residents (21.0% [19.7–22.3] vs. 25.9% [24.5–27.3]), higher poverty (36.8% [34.6–39.1] vs. 29.2% [27.2–31.1]), and had a greater mean patient volume and a higher proportion of for-profit dialysis centers (82.4% vs. 73.5%; Table 2). Characteristics of facilities in the lowest tertile of waitlisting proportions were similar to those with low evaluation start (Table 3).

Differences between facilities with low or high tertiles of evaluation start and waitlisting proportions were observed across regions, most notably when comparing characteristics of facilities in New England and the Ohio River Valley (results not shown). In these regions, facilities in the lowest tertile for evaluation

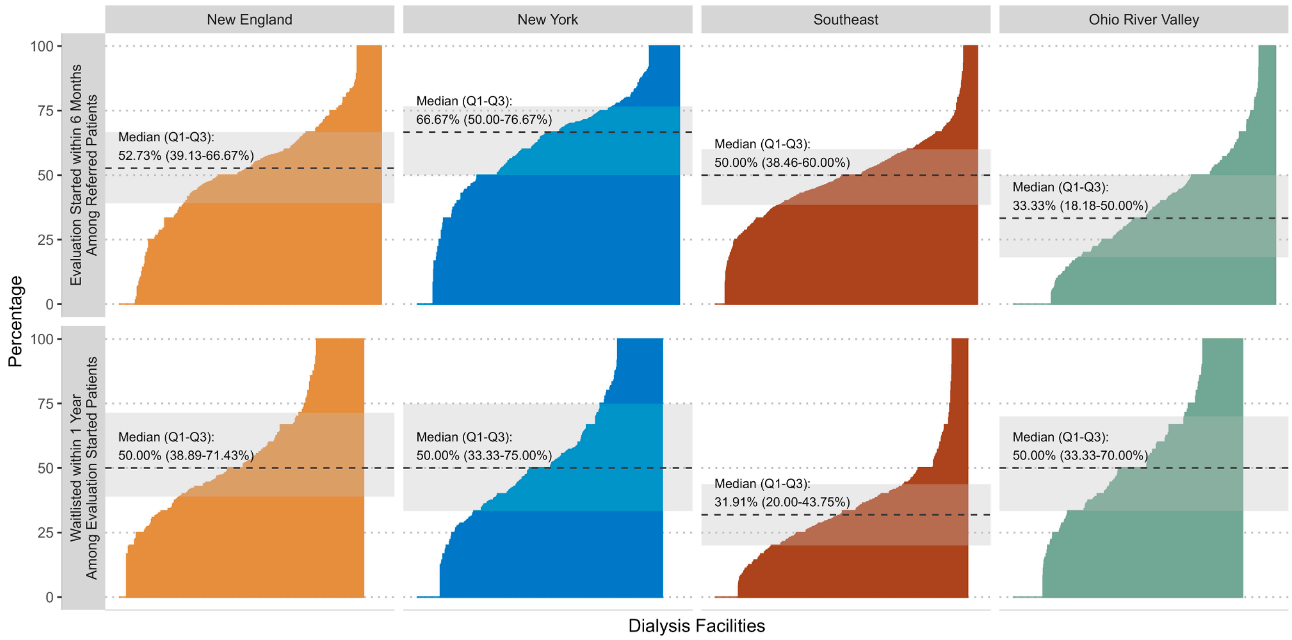

Figure 2. Percentage of patients that started the evaluation within 6 months of referral for kidney transplantation and waitlisted within 1 year of evaluation start within dialysis facilities in ESRD Networks 1, 2, 6, and 9: 2015–2024.[a, b, c]. [a]Each bar represents an individual dialysis facility. Dialysis facilities are ordered sequentially based on the percentage of patients with each outcome. Each figure additionally displays the median (dotted line) and interquartile range (Q1–Q3) for the outcomes within each region. [b]Small dialysis facilities (number of dialysis patients < 20) were excluded. [c]The denominator for calculating each outcome differed depending on data availability from each transplant center. A detailed description of data availability for each participating center is presented in Supplementary Table S1.

start had a higher proportion of older adults, whereas no age differences were observed in the Southeast. Differences in insurance coverage among patients in the lowest tertile in New England and the Ohio River Valley differed compared with the other 2 regions: facilities in the lowest tertile for evaluation start in New York and the Southeast had a higher proportion of patients with Medicaid, whereas no significant difference in this insurance group were observed in New England and the Ohio River Valley.

Facility-level characteristics within tertiles varied by region. For-profit dialysis centers were more common in the lowest tertile of evaluation start and waitlisting proportions in New England, New York, and the Ohio River Valley, but in the highest tertile in the Southeast. Similarly, facilities in the lowest tertile of waitlisting proportions in New England, New York, and the Ohio River Valley had higher mean patient volumes and patient–to–social worker ratios, whereas these characteristics were greater in the highest tertile in the Southeast.

Results examining the cumulative incidence of our outcomes (Supplementary Table S5; Supplementary Figures S1 and S2), along with unadjusted and multivariable-adjusted competing risk analyses comparing access to each outcome for individuals in the Southeast versus the other 3 regions, yielded consistent findings (Supplementary Table S6).

Sensitivity Analysis

Annual counts of referral volumes remained relatively stable from 2015 to 2018, peaked in 2019, and declined sharply beginning in 2020, with modest recovery observed in 2022 and 2023. These patterns were consistent across regions (Supplementary Figure S3).

DISCUSSION

This is the first study to characterize regional differences in dialysis facility–level variation in early transplant access, specifically, evaluation start and waitlisting, across 4 major US regions using the only source of linked, prewaitlisting data in the nation. We show substantial variation both across and within regions, with the proportion of individuals starting their evaluation ranging from 0% to 100% across facilities and regional medians spanning from 33.3% in the Ohio River Valley to 66.7% in New York. Median within-facility 1-year waitlisting proportions (among those referred) were relatively similar in New England, New York, and the Ohio River Valley (∼ 50%) but markedly lower in the Southeast (31.9%), a region with historically low waitlisting.[17]

Our findings suggest that regional variation is not solely attributable to patient mix but reflects structural differences in health systems, dialysis facility characteristics, and the social context in which patients live.

Table 2. Characteristics of dialysis facilities with low, moderate, and high evaluation start for kidney transplantation within 6 months of referral: 2015–2023

Characteristics	Overall	Tertile of transplant evaluation start, median (range) Lowest 25.00 (0–39.13)	Middle 50.00 (39.29–58.18)	Highest 71.10 (58.33–100)	*P*-value[a]
Facilities, *n*	2471	822	819	830	
Total number of patients	62467	16945	26389	19133	
Facility-level characteristics					
No. of patients per facility, mean (95% CI)	56.11 (54.28–57.95)	46.88 (44.2–49.55)	62.89 (59.91–65.86)	58.49 (54.79–62.2)	< 0.001
Patient to social worker ratio, mean (95% CI)	48.78 (47.51–50.05)	41.31 (39.45–43.16)	52.52 (50.47–54.57)	52.4 (49.84–54.96)	< 0.001
Freestanding facility, *n* (%)	2081 (86.06)	708 (88.39)	723 (89.37)	650 (80.45)	< 0.001
Profit Status, *n* (%)					< 0.001
Non-profit	507 (20.97)	141 (17.6)	152 (18.79)	214 (26.49)	
For-profit	1911 (79.03)	660 (82.4)	657 (81.21)	594 (73.51)	
Facility incident patient-level characteristics					
Age category in yrs, mean % (95% CI)					
18–30	10.12 (9.37–10.86)	9.18 (7.86–10.5)	8.47 (7.54–9.39)	12.67 (11.13–14.21)	< 0.001
30–40	13.27 (12.63–13.9)	13.4 (12.18–14.61)	12.11 (11.35–12.88)	14.27 (13.01–15.53)	0.02
40–50	18.35 (17.69–19.02)	18.83 (17.48–20.18)	17.96 (17.13–18.79)	18.27 (17.06–19.47)	0.57
50–60	24.52 (23.81–25.22)	24.2 (22.89–25.51)	25.46 (24.55–26.38)	23.89 (22.51–25.27)	0.17
60–70	23.93 (23.21–24.65)	23.78 (22.4–25.16)	25.74 (24.75–26.73)	22.3 (20.98–23.62)	0.001
70–80	9.82 (9.33–10.31)	10.61 (9.66–11.57)	10.26 (9.57–10.95)	8.59 (7.72–9.46)	0.002
Male sex, mean % (95% CI)	62 (61.17–62.82)	61.66 (60.07–63.25)	61.67 (60.59–62.74)	62.66 (61.09–64.23)	0.53
Race/ethnicity, mean % (95% CI)					
Black	44.36 (43.08–45.63)	40.04 (37.74–42.34)	47.96 (45.89–50.02)	45.01 (42.79–47.24)	< 0.001
Hispanic White	6.06 (5.57–6.55)	4.38 (3.63–5.14)	4.67 (4.04–5.29)	9.08 (8.01–10.15)	< 0.001
White, non-Hispanic	45.81 (44.51–47.1)	53.04 (50.71–55.37)	43.87 (41.86–45.88)	40.65 (38.36–42.93)	< 0.001
Other	3.78 (3.39–4.16)	2.54 (1.93–3.14)	3.51 (2.97–4.05)	5.26 (4.45–6.07)	< 0.001
Attributed cause of ESKD, mean % (95% CI)					
Diabetes	40.16 (39.27–41.04)	41.98 (40.3–43.67)	42.15 (40.97–43.33)	36.38 (34.75–38.02)	< 0.001
Hypertension	29.23 (28.35–30.11)	28.89 (27.28–30.51)	30.27 (29.03–31.51)	28.54 (26.84–30.24)	0.25
Glomerulonephritis	13.75 (13.04–14.47)	12.6 (11.34–13.86)	12.25 (11.36–13.14)	16.37 (14.91–17.84)	< 0.001
Cystic kidney	2.82 (2.5–3.13)	2.9 (2.23–3.56)	2.58 (2.2–2.95)	2.98 (2.43–3.52)	0.56
Other	14.04 (13.35–14.73)	13.62 (12.34–14.91)	12.75 (11.88–13.63)	15.73 (14.38–17.08)	0.002
Facility % of incident patient clinical and laboratory measures					
Comorbidities, mean % (95% CI)					
Obese (BMI $\geq$ 35 kg/m^2)	25.95 (25.2–26.7)	29.4 (27.89–30.9)	26.47 (25.52–27.41)	22.06 (20.72–23.4)	< 0.001
Congestive heart failure	22.29 (21.56–23.03)	24.47 (23.01–25.93)	22.57 (21.54–23.59)	19.89 (18.59–21.18)	< 0.001
Atherosclerotic heart disease	9.75 (9.15–10.34)	10.41 (9.29–11.53)	9.18 (8.37–10)	9.67 (8.54–10.79)	0.25
Other cardiac disease	15.04 (14.38–15.7)	16.75 (15.44–18.06)	15.1 (14.22–15.99)	13.3 (12.1–14.49)	< 0.001
Cerebrovascular disease (stroke)	6.74 (6.33–7.16)	7.48 (6.6–8.36)	7.08 (6.53–7.64)	5.69 (4.99–6.39)	0.001
Peripheral vascular disease	7.1 (6.61–7.59)	8.28 (7.26–9.29)	6.96 (6.29–7.63)	6.09 (5.28–6.9)	0.002
Hypertension	89.43 (88.88–89.97)	89.41 (88.36–90.47)	89.89 (89.15–90.64)	88.97 (87.96–89.99)	0.40
Diabetes	53.36 (52.46–54.26)	55.46 (53.74–57.18)	54.46 (53.25–55.67)	50.21 (48.55–51.88)	< 0.001
Chronic obstructive pulmonary disease	6.23 (5.81–6.64)	7.99 (7.18–8.81)	6.15 (5.58–6.71)	4.58 (3.86–5.29)	< 0.001
Tobacco use	8.13 (7.63–8.62)	9.87 (8.86–10.87)	9.17 (8.4–9.93)	5.39 (4.63–6.14)	< 0.001
Cancer	4.4 (4.04–4.77)	4.84 (4.14–5.54)	3.98 (3.57–4.39)	4.39 (3.66–5.12)	0.1688
Patient socioeconomic characteristics	90.3 (89.61–90.98)	88.81 (87.45–90.17)	88.8 (87.63–89.96)	93.26 (92.29–94.22)	< 0.001
Patient has been informed of kidney transplant options, mean % (95% CI)					
Pre-ESKD nephrology care, mean % (95% CI)	90.3 (89.61–90.98)	88.81 (87.45–90.17)	88.8 (87.63–89.96)	93.26 (92.29–94.22)	0.08
No					0.49
Yes	16.94 (16.29–17.6)	16.06 (14.82–17.3)	17.89 (16.9–18.88)	16.88 (15.71–18.05)	0.12
Unknown	65.18 (64.19–66.17)	65.63 (63.78–67.47)	65.59 (64.16–67.03)	64.33 (62.51–66.16)	
Primary health insurance provider, mean % (95% CI)	17.88 (16.95–18.8)	18.31 (16.56–20.06)	16.52 (15.19–17.84)	18.79 (17.07–20.5)	0.42
Medicaid					0.006
Medicare	29.4 (28.52–30.29)	29.81 (28.21–31.42)	28.56 (27.34–29.78)	29.84 (28.11–31.56)	< 0.001
Employer group	29.9 (29.07–30.73)	31.81 (30.24–33.37)	29.23 (28.16–30.3)	28.7 (27.07–30.34)	0.45

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Table 2. (Continued) Characteristics of dialysis facilities with low, moderate, and high evaluation start for kidney transplantation within 6 months of referral: 2015–2023

		Tertile of transplant evaluation start, median (range)			
Characteristics	Overall	Lowest 25.00 (0–39.13)	Middle 50.00 (39.29–58.18)	Highest 71.10 (58.33–100)	*P*-value[a]
Other coverage	24.53 (23.76–25.31)	22.1 (20.68–23.52)	24.74 (23.64–25.84)	26.7 (25.22–28.18)	< 0.001
No coverage	7.94 (7.43–8.45)	7.47 (6.6–8.35)	8.14 (7.35–8.94)	8.2 (7.23–9.17)	< 0.001
Patient neighborhood (ZIP code) characteristics					
Average % Black, mean (95% CI)	24.29 (23.52–25.05)	20.99 (19.7–22.27)	25.92 (24.64–27.21)	25.94 (24.56–27.32)	< 0.001
Average % high school graduates, mean (95% CI)	86.1 (85.9–86.29)	86.15 (85.84–86.46)	86.05 (85.73–86.38)	86.08 (85.72–86.44)	0.92
Neighborhood poverty (% ZIP code residents below poverty), mean % (95% CI)	24.29 (23.52–25.05)	20.99 (19.7–22.27)	25.92 (24.64–27.21)	25.94 (24.56–27.32)	
< 20% below poverty	65.72 (64.53–66.91)	63.16 (60.94–65.38)	63.1 (61.15–65.06)	70.84 (68.9–72.78)	< 0.001
≥ 20% below poverty	34.28 (33.09–35.47)	36.84 (34.62–39.06)	36.9 (34.94–38.85)	29.16 (27.22–31.1)	< 0.001

BMI, body mass index (calculated as weight in kg divided by height in m squared); CI, confidence interval; ESKD, end-stage kidney disease.
[a]Statistical significance: $P < 0.05$.

For example, facilities with the lowest proportions of evaluation start in the Ohio River Valley were more likely to serve older, predominantly non-Hispanic White populations with higher comorbidity burdens and fewer resources. In contrast, New York facilities had the highest proportion of individuals starting the evaluation despite serving more socioeconomically disadvantaged patient populations, potentially because of greater urban density, more transplant centers, and better transportation infrastructure.[30–32] A review by Harding *et al.*[13] reported several nonmedical barriers to prewaitlisting steps, including distance to the transplant center, travel time, and transportation access. Transportation barriers may further contribute to the observed regional differences in our outcomes, because decreased access to transportation resources is linked with missed appointments and delayed health care access.[32] Moreover, associations between public or no insurance, higher neighborhood poverty, and lower access to transplant varied by region and were not consistently observed across all regions, reinforcing the notion that the observed variation both within and between regions could be reflective of underlying differences in center-level characteristics and practice patterns.

Importantly, characteristics of facilities with high and low evaluation start and waitlisting proportions differed by region, suggesting that region-specific strategies may be needed. For example, for-profit status and higher patient–to–social worker ratios were associated with lower dialysis facility–level transplant access performance in New England, New York, and the Ohio River Valley, but not in the Southeastern US. These findings support a more nuanced view of quality improvement: interventions to improve access need to be tailored regionally rather than nationally standardized.

Numerous dialysis facility–level factors unmeasured in the present study may drive regional variation in referred patients starting the evaluation in a timely manner. One of the most common contributors to patient drop-off after referral is a lack of understanding of the evaluation process.[33–35] A recent study of individuals with chronic kidney disease across these same 4 regions highlighted variability in education practices about transplantation for patients between health systems as a major barrier to the pursuit of a kidney transplant.[36] Further, it may be reasonable to infer that the observed regional variation may be attributable to differences in the resources and quality of care provided by dialysis facilities to patients pursuing transplantation.[37–39] Previous studies[40] have shown that, despite Centers for Medicare and Medicaid Services–mandated participation, the implementation of quality improvement initiatives to improve access varies considerably across centers. In addition to variability in patient education and knowledge, transplant-center–specific policies and practices related to the prioritization of referrals[41] and referral closure likely have a large role in evaluation start and dialysis facility practices post-referral. Although not examined in the present study, facility-level and regional variation in evaluation start may also be partially explained by increases in referrals driven by increases in incentives for nephrologists and dialysis facilities to promote transplant access.[23–25] Though intended to increase access, they may inadvertently create bottlenecks in the evaluation process due to constraints on clinician staffing and availability.[35,42–44]

Our findings have immediate relevance to emerging federal efforts such as the Centers for Medicare and Medicaid Services Increasing Organ Transplant Access payment model,[26] which began in July 2025, the Organ Procurement and Transplantation Network Modernization Act,[45] and planned national prewaitlisting data

Table 3. Characteristics of dialysis facilities with low, moderate, and high waitlisting within 1 year of evaluation start: 2015–2024

Characteristic	Overall	Tertile of transplant evaluation start, median (range)			*P*-value[a]
		Lowest 20 (0–32.5)	Middle 41.67 (32.56–50)	Highest 75 (50.55–100)	
Facilities, *n*	2290	763	789	738	
Total number of patients	32174	10956	14239	6979	
Facility-level characteristics					
Number of patients per facility, mean (95% CI)	58.43 (56.53–60.34)	57.42 (54.71–60.13)	69.26 (65.81–72.72)	47.45 (43.94–50.97)	< 0.001
Patient to social worker ratio, mean (95% CI)	50.48 (49.16–51.79)	49.2 (47.13–51.28)	55.17 (52.97–57.36)	46.26 (43.71–48.82)	< 0.001
Freestanding facility, *n* (%)	1945 (86.44)	710 (93.79)	722 (91.74)	513 (72.66)	< 0.001
Profit status, *n* (%)					
Non-profit	464 (20.62)	96 (12.68)	120 (15.25)	248 (35.13)	< 0.001
For-profit	1786 (79.38)	661 (87.32)	667 (84.75)	458 (64.87)	< 0.001
Facility incident patient-level characteristics					
Age category in yrs, mean % (95% CI)					
18–30	10.79 (9.96–11.62)	6.08 (5.12–7.03)	7.42 (6.65–8.19)	19.26 (17.14–21.38)	< 0.001
30–40	14.25 (13.46–15.04)	10.61 (9.5–11.71)	13.71 (12.71–14.71)	18.6 (16.77–20.43)	< 0.001
40–50	18.42 (17.65–19.19)	17.4 (16.06–18.74)	18.92 (17.97–19.88)	18.95 (17.29–20.61)	0.18
50–60	25.15 (24.26–26.04)	27.67 (26.07–29.28)	26.4 (25.26–27.54)	21.21 (19.39–23.03)	< 0.001
60–70	24.23 (23.35–25.11)	28.51 (26.91–30.12)	26.02 (24.82–27.22)	17.89 (16.24–19.55)	< 0.001
70–80	7.16 (6.62–7.69)	9.73 (8.52–10.95)	7.53 (6.83–8.23)	4.09 (3.34–4.84)	< 0.001
Male sex, mean % (95% CI)	63.39 (62.38–64.4)	60.53 (58.76–62.3)	63.03 (61.79–64.28)	66.73 (64.57–68.9)	< 0.001
Race, mean % (95% CI)					
Black	44.64 (43.23–46.05)	53.01 (50.53–55.49)	44.07 (41.88–46.26)	36.56 (34.05–39.08)	< 0.001
Hispanic White	6.78 (6.16–7.4)	5.78 (4.7–6.86)	6.12 (5.37–6.88)	8.52 (7.18–9.86)	0.001
White, non-Hispanic	44.56 (43.14–45.99)	38.06 (35.67–40.45)	45.93 (43.72–48.13)	49.85 (47.11–52.6)	< 0.001
Other	4.02 (3.58–4.46)	3.15 (2.47–3.83)	3.88 (3.3–4.47)	5.06 (4.07–6.05)	0.002
Attributed cause of ESKD, mean % (95% CI)					
Diabetes	39 (37.97–40.04)	42.74 (40.92–44.57)	41.85 (40.51–43.19)	32.1 (30.02–34.18)	< 0.001
Hypertension	29.06 (28.02–30.11)	34.23 (32.31–36.15)	29.38 (27.96–30.81)	23.39 (21.4–25.38)	< 0.001
Glomerulonephritis	14.87 (14.04–15.69)	9.21 (8.14–10.28)	13.08 (12.13–14.04)	22.61 (20.68–24.54)	< 0.001
Cystic kidney	2.95 (2.58–3.32)	2.26 (1.7–2.83)	2.89 (2.42–3.37)	3.72 (2.89–4.56)	0.01
Other	14.11 (13.32–14.91)	11.56 (10.3–12.82)	12.79 (11.86–13.71)	18.18 (16.34–20.01)	< 0.001
Facility % of incident patient clinical and laboratory measures					
Comorbidities, mean % (95% CI)					
Obese (BMI ≥ 35 kg/m^2)	23.5 (22.61–24.38)	26.91 (25.24–28.57)	24.51 (23.36–25.66)	18.87 (17.14–20.6)	< 0.001
Congestive heart failure	19.89 (19.06–20.73)	23.37 (21.77–24.98)	20.53 (19.45–21.61)	15.58 (13.99–17.17)	< 0.001
Atherosclerotic heart disease	8.73 (8.08–9.39)	8.74 (7.51–9.96)	8.72 (7.83–9.6)	8.75 (7.47–10.04)	1.00
Other cardiac disease	13.81 (13.06–14.55)	14.42 (13.04–15.79)	13.99 (12.92–15.06)	12.97 (11.52–14.42)	0.29
Cerebrovascular disease (stroke)	5.46 (5.04–5.89)	6.64 (5.81–7.46)	5.84 (5.26–6.43)	3.83 (3.04–4.62)	< 0.001
Peripheral vascular disease	6.27 (5.73–6.81)	6.63 (5.55–7.71)	6.33 (5.61–7.05)	5.84 (4.84–6.83)	0.50
Hypertension	89.28 (88.62–89.95)	90.23 (89.14–91.31)	89.17 (88.26–90.09)	88.42 (86.97–89.87)	0.10
Diabetes	52.15 (51.08–53.21)	58.31 (56.5–60.11)	53.81 (52.47–55.16)	43.94 (41.75–46.14)	< 0.001
Chronic obstructive pulmonary disease	4.65 (4.2–5.1)	5.74 (4.84–6.64)	4.98 (4.33–5.63)	3.16 (2.39–3.94)	< 0.001
Tobacco use	6.87 (6.32–7.43)	8.84 (7.63–10.04)	6.67 (5.98–7.36)	5.06 (4.15–5.97)	< 0.001
Cancer	4.12 (3.68–4.55)	4.45 (3.62–5.28)	3.92 (3.38–4.47)	3.99 (3.12–4.85)	0.57
Patient socioeconomic characteristics					
Patient has been informed of kidney transplant options, mean % (95% CI)	91.06 (90.32–91.8)	89.27 (87.81–90.72)	91.3 (90.24–92.36)	92.71 (91.41–94.02)	0.001
Pre-ESKD nephrology care, mean % (95% CI)					
No	17.79 (16.96–18.61)	20.13 (18.53–21.73)	18.71 (17.6–19.82)	14.37 (12.84–15.91)	< 0.001
Yes	66.43 (65.3–67.55)	62.85 (60.75–64.96)	67.53 (65.99–69.07)	68.94 (66.79–71.09)	< 0.001
Unknown	15.79 (14.82–16.75)	17.02 (15.19–18.84)	13.76 (12.47–15.05)	16.68 (14.81–18.56)	0.01
Primary health insurance provider, mean % (95% CI)					
Medicaid	27.77 (26.74–28.8)	28.23 (26.39–30.08)	27.74 (26.33–29.14)	27.32 (25.23–29.41)	0.78
Medicare	27.82 (26.83–28.8)	30.38 (28.59–32.16)	26.81 (25.6–28.02)	26.24 (24.18–28.31)	0.001
Employer group	28 (27.01–28.99)	22.33 (20.82–23.84)	28.36 (27.1–29.62)	33.49 (31.28–35.69)	< 0.001
Other coverage	8.02 (7.43–8.62)	7.62 (6.73–8.51)	8.8 (7.9–9.69)	7.61 (6.32–8.9)	0.18
No coverage	8.4 (7.81–8.98)	11.45 (10.24–12.65)	8.3 (7.49–9.11)	5.34 (4.4–6.28)	< 0.001
Patient neighborhood (ZIP code) characteristics					
Average % black, mean (95% CI)	24.44 (23.63–25.25)	30.08 (28.58–31.57)	24.48 (23.14–25.82)	18.56 (17.34–19.77)	< 0.001
Average % high school graduates, mean (95% CI)	86.08 (85.87–86.29)	85.26 (84.92–85.61)	86.32 (86–86.65)	86.66 (86.24–87.08)	< 0.001

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Table 3. (Continued) Characteristics of dialysis facilities with low, moderate, and high waitlisting within 1 year of evaluation start: 2015–2024

Characteristic	Overall	Tertile of transplant evaluation start, median (range)			*P*-value[a]
		Lowest 20 (0–32.5)	Middle 41.67 (32.56–50)	Highest 75 (50.55–100)	
Neighborhood poverty (% ZIP code residents below poverty), mean % (95% CI)					
$<$ 20% below poverty	66.09 (64.78–67.4)	59.43 (57.06–61.8)	66.73 (64.75–68.71)	72.3 (69.93–74.68)	$<$ 0.001
$\geq$ 20% below poverty	33.91 (32.6–35.22)	40.57 (38.2–42.94)	33.27 (31.29–35.25)	27.7 (25.32–30.07)	$<$ 0.001

BMI, body mass index (calculated as weight in kg divided by height in m squared); CI, confidence interval; ESKD, end-stage kidney disease.
[a]Statistical significance: $P < 0.05$.

coalition efforts by the Health Resources and Services Administration.[46,47] These initiatives aim to improve access and efficiency in transplant access, yet national surveillance data currently lack granular prewaitlisting data on referral and evaluation start. This data availability gap is compounded by widespread variation in clinical thresholds for acceptance for waitlisting by transplant centers, which makes it difficult for referring providers to assess which patients are eligible or where patients with certain comorbidities, such as obesity, should be referred. The Health Resources and Services Administration's forthcoming prewaitlisting data collection efforts and increased transparency requirements introduced by the Increasing Organ Transplant Access should help provide greater insights into these eligibility differences and improve our understanding of access among those referred. Results from this study underscore the importance of prewaitlisting data for identifying underperforming facilities and targeting quality improvement interventions upstream in the transplant process. Although the present analysis focused on geographic variation in outcomes at the dialysis facility–level, McPherson *et al.*[19] report the critical contributions of both dialysis and transplant centers to access disparities, also highlighting the need for interventions that address factors within both settings. These findings further reinforce the need for improved coordination between dialysis and transplant centers, emphasized by recent federal mandates[23,27] and Centers for Medicare and Medicaid Services policy reform initiatives, such as the Kidney Care Choice.[24] Our results highlight the need for the development of quality metrics focused on prewaitlisting care, which would incentivize dialysis centers to enhance collaboration and ensure timely referral, evaluation, and waitlisting.

Key strengths of this study include the use of E-STAR, a novel and comprehensive multicenter dataset encompassing $>$ 60,000 patients across more than 2400 dialysis facilities, and its linkage to national registry data for robust follow-up. However, our findings must be interpreted in the context of several limitations. First, E-STAR only includes 36 centers that voluntarily submit data to E-STAR (out of 47 transplant centers within these 4 regions), which may limit generalizability. Second, without complete population-based data in these regions, we may be underestimating regional proportions of our outcomes by excluding patients evaluated or waitlisted at non-E-STAR centers.[19] However, the number of non-E-STAR dialysis facilities across our 4 regions was small, suggesting that E-STAR provides a robust and broadly representative dataset for examining regional variation in early transplant access despite incomplete coverage. In addition, the observed variation aligns with national studies of geographic variation in other transplant steps.[8,21,48,49] Third, we excluded preemptively referred, evaluated, waitlisted, and transplanted patients because they did not receive dialysis care before referral, consistent with our aim to examine dialysis facility–level variation. Although this approach may limit generalizability to the broader transplant candidate population, examining delays in evaluation after dialysis initiation can reveal missed opportunities for earlier transplant evaluation, referral, and care coordination. Future analyses should examine variation in transplant center–level access, including preemptively referred, evaluated, and waitlisted patients, and assess access to transplant steps among preemptive patients to provide a more comprehensive picture of transplant access across the continuum of kidney disease care. Fourth, the lack of a standardized definition of evaluation start could confound findings of variation in proportions, as could differences in how centers define referral and close referrals. However, 94% of E-STAR centers define evaluation start as the patient's initial contact with the center. We relied on patient covariate data at dialysis initiation, which may not reflect all factors and time-varying factors influencing access. Lastly, overlapping implementation of value-based care models (e.g., Kidney Care Choice and the End-Stage Renal Disease Treatment Choices), the new distance-based allocation policy (KAS 250),[50] and the COVID-19 pandemic during the study period may have influenced care patterns in ways not fully captured in our data.[51]

In summary, substantial variation in the timely start of evaluation and eventual waitlisting exists between individuals treated for kidney failure within dialysis facilities across 4 US regions, with barriers differing by step and region. These findings demonstrate how national prewaitlisting surveillance data is essential for us to gain a better understanding of this variation and the interventions needed, including policy changes to improve access to the national transplant waitlist.

DISCLOSURE

All the authors declared no competing interests.

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DATA AVAILABILITY STATEMENT

The data reported here have been supplied in part by the US Renal Data System. Deidentified data from the Early Steps to Transplant Access Registry are available upon request and with a signed data use agreement with the Regenstrief Institute and Indiana University.

AUTHOR CONTRIBUTIONS

JB and MD had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design; acquisition, analysis, or interpretation of data; and critical revision of the manuscript for important intellectual content were by all the authors. Drafting of the manuscript was by JB, REP, MD, and JLH. Statistical analysis was by JB and MD. REP and SOP obtained funding. Administrative, technical, or material support: REP, JB, MD, JLH, KD, AW, and SOP.

SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

Definition of Transplant Medical Evaluation Start.

Figure S1. Cumulative incidence of evaluation start within 6 months of referral among those referred for a kidney transplantation (dashed line), accounting for the competing risk of death (solid line), displayed by end-stage renal disease network.

Figure S2. Cumulative incidence of waitlisting within 1 year of evaluation start among those who started the evaluation for a kidney transplantation (dashed line), accounting for the competing risk of death (solid line), displayed by end-stage renal disease network.

Figure S3. Annual number of transplant referrals by ESRD Network, 2015–2023.

Table S1. Characteristics of dialysis facilities referring to E-STAR versus those without a corresponding referral record in E-STAR.

Table S2. Overview of data availability for each outcome by deidentified transplant center: logistic regression analysis.

Table S3. Overview of data availability for each outcome by deidentified transplant center: multivariable-adjusted competing risk analysis.

Table S4. Overview of evaluation start definition by deidentified transplant center.

Table S5. Cumulative incidence of evaluation start within 6 months of referral among those referred for a kidney transplantation and waitlisting within 1 year of evaluation start among those that started the evaluation, accounting for the competing risk of death, displayed by end-stage renal disease network.

Table S6. Competing risks modeling results for the association of ESRD Network with evaluation start among those referred and waitlisting among those who started evaluation in ESRD Networks 1, 2, 6, and 9: 2015–2024.

STROBE Checklist.

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