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# Association Between Dialysis Facility Ownership and Access to Kidney Transplantation

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**IMPORTANCE** For-profit (vs nonprofit) dialysis facilities have historically had lower kidney transplantation rates, but it is unknown if the pattern holds for living donor and deceased donor kidney transplantation, varies by facility ownership, or has persisted over time in a nationally representative population.

**OBJECTIVE** To determine the association between dialysis facility ownership and placement on the deceased donor kidney transplantation waiting list, receipt of a living donor kidney transplant, or receipt of a deceased donor kidney transplant.

**DESIGN, SETTING, AND PARTICIPANTS** Retrospective cohort study that included 1 585 947 patients treated at 6512 US dialysis facilities. Adult patients with incident end-stage kidney disease from the US Renal Data System (2000-2016) were linked with facility ownership (Dialysis Facility Compare) and characteristics (Dialysis Facility Report).

**EXPOSURES** The primary exposure was dialysis facility ownership, which was categorized as nonprofit small chains, nonprofit independent facilities, for-profit large chains (>1000 facilities), for-profit small chains (<1000 facilities), and for-profit independent facilities.

**MAIN OUTCOMES AND MEASURES** Access to kidney transplantation was defined as time from initiation of dialysis to placement on the deceased donor kidney transplantation waiting list, receipt of a living donor kidney transplant, or receipt of a deceased donor kidney transplant. Cumulative incidence differences and multivariable Cox models assessed the association between dialysis facility ownership and each outcome.

**RESULTS** Among 1 585 947 patients, the median age was 65 years (interquartile range, 54-75 years), with 55.8% male, and 28.4% non-Hispanic black patients. Eighty-eight percent of patients received care at a for-profit dialysis facility. A total of 115 650 patients (7.3%) received care at 435 nonprofit small chain facilities; 66 539 (4.2%) at 325 nonprofit independent facilities; 527 458 (33.3%) at 2239 facilities of large for-profit chain 1; 525 997 (33.2%) at 2082 facilities of large for-profit chain 2; 245 633 (15.5%) at 997 for-profit small chain facilities; and 104 670 (6.6%) at 434 for-profit independent facilities. During the study period, 230 202 patients (14.5%) were placed on the deceased donor waiting list, 39 767 (2.5%) received a living donor kidney transplant, and 88 431 (5.6%) received a deceased donor kidney transplant. For-profit facilities had lower 5-year cumulative incidence differences for each outcome vs nonprofit facilities (deceased donor waiting list: −2.6% [95% CI, −2.8% to −2.4%]; receipt of a living donor kidney transplant: −0.9% [95% CI, −1.0% to −0.8%]; and receipt of a deceased donor kidney transplant: −1.4% [95% CI, −1.5% to −1.3%]). Adjusted Cox analyses showed lower relative rates for each outcome among patients treated at all for-profit vs all nonprofit dialysis facilities: deceased donor waiting list (hazard ratio [HR], 0.87 [95% CI, 0.86 to 0.88]); receipt of a living donor kidney transplant (HR, 0.82 [95% CI, 0.80 to 0.84]); and receipt of a deceased donor kidney transplant (HR, 0.83 [95% CI, 0.81 to 0.84]).

**CONCLUSIONS AND RELEVANCE** Among US patients with end-stage kidney disease, receiving dialysis at for-profit facilities compared with nonprofit facilities was associated with a lower likelihood of accessing kidney transplantation. Given the possibility of residual confounding, the clinical and policy implications of the results are uncertain.

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Supplemental content

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Kidney transplantation is the preferred treatment for most of the 700 000 adults with end-stage kidney disease (ESKD) in the United States as of 2016.[1-3] However, only 14% of patients with incident ESKD are placed on the deceased donor kidney transplantation waiting list or receive transplants within 1 year of ESKD diagnosis.[2] The Centers for Medicare & Medicaid Services (CMS) requires dialysis facilities to provide transplant education and help interested patients pursue kidney transplantation.[4] The CMS amended the final rule for the End-Stage Renal Disease Prospective Payment System in 2018 by proposing a new dialysis facility quality metric to the End-Stage Renal Disease Quality Incentive Program to monitor the percentage of prevalent patients with ESKD on the waiting list for transplantation.[5] In a July 2019 presidential executive order, the CMS also proposed the End-Stage Renal Disease Treatment Choices Model to improve access to kidney transplantation as part of the administration's Advancing American Kidney Health initiative.[6]

Evidence suggests for-profit dialysis facilities have a lower standardized transplantation ratio,[7] and their patients are less likely to be waitlisted compared with nonprofit facilities.[8,9] Physicians at for-profit dialysis facilities are less likely to have detailed discussions with patients about transplantation or involve families in the discussion.[10] This could lead to limited access to living donor kidney transplantation at for-profit dialysis facilities. Encouragement to pursue living donor kidney transplantation is highly advisable due to the limited supply of organs; no published study has assessed this relationship.

It has been suggested that for-profit dialysis facilities strive to reduce operating costs by limiting the provision of low-margin services[11-13] (such as extended transplant discussions with patients and their families) in the interest of increasing returns to investors,[14] and may impede their patients' access to transplantation. This study aimed to determine the association between dialysis facility ownership and placement on the deceased donor kidney transplantation waiting list, receipt of a living donor kidney transplant, or receipt of a deceased donor kidney transplant. Changes over time in these associations also were examined.

### Key Points

**Question** Is dialysis facility ownership associated with access to kidney transplantation?

**Findings** In this retrospective cohort study that included 1 585 947 patients with end-stage kidney disease treated at 6512 US dialysis facilities from 2000-2016, patients receiving dialysis at for-profit facilities vs nonprofit facilities had significantly lower 5-year cumulative incidence rates for placement on the deceased donor kidney transplantation waiting list (−2.6%), receipt of a living donor kidney transplant (−0.9%), and receipt of a deceased donor kidney transplant (−1.4%).

**Meaning** Receiving dialysis at for-profit facilities in the United States was associated with lower kidney transplantation rates.

## Methods

### Data Sources

A waiver of informed consent was granted for this retrospective, deidentified study (Emory University institutional review board decision No. 63645). All patients with incident ESKD from the publicly available US Renal Data System[2] (USRDS) database (January 1, 2000-December 31, 2016) were merged with dialysis facility-level data from the Dialysis Facility Compare (2016) and the Dialysis Facility Report (2013-2016) CMS data sets. The USRDS collects information on US patients with ESKD at the start of long-term dialysis or receipt of a kidney transplant from the CMS-2728 form; it is prelinked with the United Network for Organ Sharing data on kidney transplantation waiting list and transplant events.

Dialysis Facility Compare reports the dialysis facility's profit status and corporate ownership. The Dialysis Facility Report captures information on facility-level patient characteristics (mean age, percentage of males, race), mortality, treatment patterns, and transplantation rates. Patient observations from the USRDS and dialysis facility-level information from the Dialysis Facility Compare and the Dialysis Facility Report were linked using the facility's CMS certification number. To obtain information on rurality, patient zip codes were linked to 2013 Rural Urban Continuum Codes from the US Department of Agriculture. Addresses from the Dialysis Facility Report were geocoded and used to calculate the distance from each facility to its nearest transplant center, in miles.

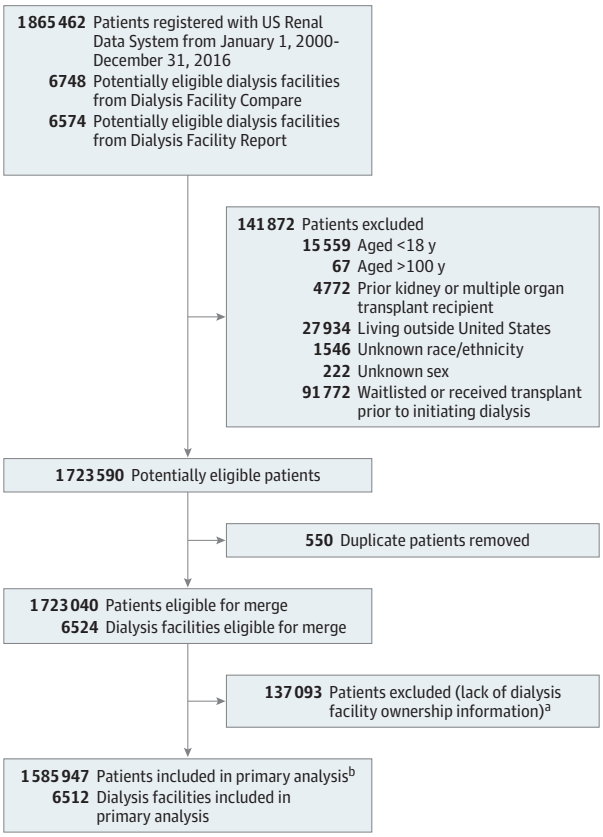
### Study Population

All incident patients undergoing dialysis registered with the USRDS between January 1, 2000, and December 31, 2016, were considered for inclusion. Patients were excluded if they were younger than 18 years or older than 100 years, had a previous transplant or received multiple organ transplants, resided outside the 50 US states at the time of dialysis start, had unknown race/ethnicity or sex, or were placed on the waiting list or received a transplant prior to starting dialysis. Facilities with records in both the Dialysis Facility Compare and Dialysis Facility Report data sets were eligible for merging with the USRDS patient-level data (**Figure 1**).

### Study Variables

The primary exposure was dialysis facility profit status and chain ownership obtained from the Dialysis Facility Compare data set. Facility profit status was defined as for-profit or nonprofit. Nonprofit facilities were defined as either small chain facilities or independent facilities based on Dialysis Facility Compare's use of the term *chain organization*. Within the for-profit facility ownership categories, chain ownership was collapsed for each chain reported in Dialysis Facility Compare. For-profit chains with more than 1000 facilities were categorized as large chains; DaVita and Fresenius Medical Care (referred to as large chain 1 and large chain 2, respectively) were the only 2 chains with more than 1000 facilities and were categorized separately. For-profit chains with less than 1000 dialysis facilities were categorized collectively as small chains. The remaining facilities were classified as for-profit independent facilities. Patients were assigned to the dialysis facility from

Figure 1. Data Merge and Cohort Selection to Assess the Association Between Dialysis Facility Ownership and Access to Kidney Transplantation




[a] There were 2961 dialysis facilities within the US Renal Data System that could not be linked to the Dialysis Facility Compare and Dialysis Facility Report cohort. There were 13 facilities that were in the Dialysis Facility Compare and Dialysis Facility Report cohort that could not be linked to the US Renal Data System.

[b] Only a single observation for when the event (placement on the deceased donor kidney transplantation waiting list or receipt of a kidney transplant) occurred was included. The last observation was included for patients who died or were censored at the end of the study (December 31, 2016).

which they were receiving treatment when the outcome of interest occurred (ie, placement on the deceased donor kidney transplantation waiting list, receipt of a living donor kidney transplant, receipt of a deceased donor kidney transplant, death, or study end), and contributed all their person-time from dialysis start to event of interest to this facility.

The primary outcome was access to kidney transplantation, which was defined as placement on the deceased donor kidney transplantation waiting list, receipt of a living donor kidney transplant, or receipt of a deceased donor kidney transplant, each analyzed separately. If a patient was waitlisted and received a living or deceased donor kidney transplant, they contributed an event to each model. Patients were censored for either death or the end of the study (December 31, 2016), or the transplant date. The time to an event was calculated from the dialysis start date to the event date or censor date.

Clinical and demographic characteristics of patients were obtained from the USRDS data and collected from the CMS-2728 form by a dialysis facility staff member at dialysis start. Known risk factors for delayed transplantation were considered, including age at the start of dialysis, sex, race/ethnicity (both were classified by dialysis facility staff in fixed categories: sex as either male or female; race/ethnicity as either non-Hispanic white, non-Hispanic black, Hispanic white, or other defined as either Asian, Middle Eastern, Native American, Pacific Islander, or multiracial), rural/urban status, health insurance, primary cause of ESKD, dialysis modality (in-center hemodialysis, peritoneal dialysis, and home hemodialysis), and the presence of comorbidities such as body mass index greater than 35 (calculated as weight in kilograms divided by height in meters squared), cardiovascular disease, diabetes, and hypertension.

Due to the select all that apply format of the comorbidity section on the CMS-2728 form,[5] comorbidities were coded as "yes" if a response was recorded or "no" if a response was missing. The primary cause of ESKD was categorized as diabetes, hypertension, glomerulonephritis, or other disease. Cardiovascular disease was defined as the presence of any of the following cardiac or pulmonary conditions: congestive heart failure, atherosclerotic heart disease, pulmonary vascular disease, cerebrovascular disease, chronic obstructive pulmonary disease, or other cardiac disease.

Dialysis facility-level characteristics were obtained from either the Dialysis Facility Compare or Dialysis Facility Report data sets. Patient-level variables from the USRDS were aggregated to define the facility-level number of patients and the percentage of patients reported by the facility that were not informed of kidney transplantation due to medical reasons. The Dialysis Facility Report provided the facility-level number of social workers, the ratio of patients to social workers, the ratio of patients to staff, the standardized mortality ratio, and the ESRD Network geographic areas.

The hospitalization rate per 100 person-years was obtained from the Dialysis Facility Compare data set. Transplant-center affiliation was defined through the United Network for Organ Sharing transplant center ID; and the hospital affiliation of a facility was defined by its CMS certification number. The addresses from the Dialysis Facility Compare data set were geocoded and used to calculate the distance from each facility to its nearest transplant center in miles.

## Statistical Analysis

A descriptive analysis was performed for the overall population and comparisons between facility ownership were determined using either the $\chi^2$ test (for categorical variables), the Kruskal-Wallis test (for nonparametric continuous variables presented as median interquartile range [IQR]), or the *t* test (for parametric continuous variables presented as mean [SD]). Cumulative incidence differences and 95% CIs were calculated using the Aalen-Johansen estimator at follow-up years 3, 5, and 10 and accounted for the competing risk of death.[15] The number needed to treat for each outcome was calculated using the inverse of the 5-year cumulative incidence difference.

To examine whether the cumulative incidence difference between facilities was constant by calendar year, we stratified the cohort into 2-year increments. Follow-up time was truncated for each period on December 31 of each 2-year period, and the unadjusted 2-year incidence rates (per 100 person-years) for placement on the deceased donor kidney transplantation waiting list, receipt of a living donor kidney transplant, and receipt of a deceased donor kidney transplant were calculated by dividing the count of events for incident patients by the number of incident patients in the dialysis facility ownership group for each interval. The incident rate differences (per 100 person-years) were calculated as the 2-year incidence difference between all nonprofit and all for-profit facilities.

Bivariable Cox proportional hazard models were used to determine the crude association between covariates and access to transplantation. Cox models were used to determine the crude and adjusted association between dialysis facility ownership and each outcome. Multiple imputation using the fully conditional specification implemented by the chained equations (MICE) algorithm were performed for missing covariate data. For continuous and categorical variables, Ridge Bayesian linear regression, allowing for posterior sampling and random forest, respectively, was conducted.[16]

We used robust sandwich covariance matrix estimates to account for intracluster dependence[17] of patients within dialysis facilities. The adjusted Cox proportional hazard models in this study were developed using a 4-step process: (1) bivariable association between dialysis facility ownership and outcomes of interest, (2) adjustment for patient demographics (age, sex, and race/ethnicity), (3) adjustment for clinical characteristics, and (4) additional adjustment for socioeconomic variables. We tested the proportional hazards assumption by examining the significance of the Schoenfeld residuals with ranked follow-up time, and all proportionality assumptions were met.

Several sensitivity analyses were conducted to ensure the robustness of the results. Supplemental descriptive statistics and multivariable Cox models were generated for this population and were stratified by whether a patient switched dialysis facilities during the study follow-up. Dialysis facility switching was classified by comparing the patients' first vs last dialysis facility. Sensitivity analyses examined cumulative incidence differences. Cox models were used to assess a cohort of "ideal kidney transplant candidates" that excluded patients (1) aged 66 years or older; (2) diagnosed with peripheral vascular disease, coronary heart failure, or cerebrovascular disease; or (3) not assessed for transplantation due to medical reasons (reported by dialysis facility staff on the CMS-2728 form). The Cox models assessed effect modification of geographic area and the association between facility affiliation with either a transplant center or hospital and each outcome.

Data management and statistical analysis were conducted using SAS version 9.4 (SAS Institute Inc) and Python version 3.6.8 (Python Software Foundation). Two-sided *P* values were used for all analyses and $P < .05$ was considered statistically significant.

## Results

There were 1 865 462 incident patients with ESKD registered with the USRDS between January 1, 2000, and December 31, 2016. Patients were excluded if (1) younger than 18 years (n = 15 559) or older than 100 years (n = 67), (2) had a prior kidney transplant or index multiple organ transplants (n = 4772), (3) were living outside the United States (n = 27 934), (4) had unknown race/ethnicity (n = 1546) or sex (n = 222), (5) were preemptively waitlisted or received a transplant prior to initiating dialysis (n = 91 722), (6) had duplicate observations that did not occur at the last treatment facility (n = 550), and (7) did not match to a dialysis facility within the Dialysis Facility Compare or Dialysis Facility Report data sets (n = 137 093), leaving a final cohort of 1 585 947 unique patients included in the primary analysis (Figure 1). The median age was 65 years (IQR, 54-75 years), with 55.8% male, and 28.4% non-Hispanic black patients. Multiple imputation was used in the Cox models to account for the following missing data: health insurance coverage: 121 115 patients (7.6%); type of dialysis: 7944 (0.5%); distance from assigned dialysis facility to nearest transplant center: 341 693 (21.5%); and metropolitan rural-urban classification: 127 712 (8.1%).

The 1 585 947 included patients had a median follow-up time to placement on waiting list or censor date of 1.8 years (IQR, 0.7-4.0 years) and a median follow-up time to transplant or censor date of 2.3 years (IQR, 0.8-4.6 years). The majority of patients with ESKD received care at for-profit large chains with more than 1000 facilities (for-profit large chain 1: n = 527 458 [33.3%] at 2239 facilities; for-profit large chain 2: n = 525 997 [33.2%] at 2082 facilities; $P < .001$; **Table 1**). Nonprofit dialysis facilities had a slightly lower percentage of non-Hispanic black patients compared with for-profit facilities (26.4% vs 28.7%, respectively; $P < .001$), and there was a higher percentage of patients in the South treated at for-profit facilities compared with nonprofit facilities (42.7% vs 26.4%; $P < .001$) (Table 1 and eFigure in the Supplement).

Patient comorbidities were mostly similar across dialysis facility ownership categories. Treatment location for approximately 84.5% of patients diagnosed with hypertension ranged from 83.1% at nonprofit independent facilities to 85.6% at for-profit small chain facilities ($P < .001$). However, for patients diagnosed with diabetes, treatment location ranged from 44.0% at nonprofit independent facilities to 49.7% at for-profit independent facilities ($P < .001$). A higher percentage of patients treated at nonprofit independent facilities (8.6%), nonprofit small chain facilities (7.0%), and for-profit independent facilities (7.0%) were reported by facility staff as not being informed of kidney transplant options because of medical reasons compared with patients treated at facilities of for-profit large chain 1 (4.1%), facilities of for-profit large chain 2 (4.9%), and for-profit small chain facilities (4.8%) ($P < .001$). All nonprofit facilities had a median hospitalization rate of 178.1 (IQR, 148.3-209.9) per 100 person-years compared with the higher rate of 189.8 (IQR, 151.5-224.9) per 100 person-years for all for-profit facilities.

Table 1. Patient- and Facility-Level Characteristics at Start of Dialysis Within the US Renal Data System Overall and Stratified by Dialysis Facility Ownership, 2000-2016[a]

| | | Nonprofit Dialysis Facilities[c] | | For-Profit Dialysis Facilities[c] | | | | All Facilities | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristics[b] | Total | Small Chains | Independent | Large Chain 1 | Large Chain 2 | Small Chains | Independent | Nonprofit | For-Profit |
| Facilities | 6512 (100) | 435 (6.7) | 325 (5.0) | 2239 (34.4) | 2082 (32.0) | 997 (15.3) | 434 (6.7) | 760 (11.7) | 5752 (88.3) |
| Patients | 1 585 947 (100) | 115 650 (7.3) | 66 539 (4.2) | 527 458 (33.3) | 525 997 (33.2) | 245 633 (15.5) | 104 670 (6.6) | 182 189 (11.5) | 1 403 758 (88.5) |
| **Patient-Level Characteristics at Start of Dialysis[b]** | | | | | | | | | |
| Age, median (IQR), y | 65 (54-75) | 65 (53-75) | 64 (53-75) | 65 (54-75) | 65 (54-75) | 65 (54-75) | 66 (55-76) | 64 (53-75) | 65 (54-75) |
| Age group, y | | | | | | | | | |
| 18-29 | 39 947 (2.5) | 3246 (2.8) | 2275 (3.4) | 13 602 (2.6) | 12 717 (2.4) | 5797 (2.4) | 2310 (2.2) | 5521 (3.0) | 34 426 (2.5) |
| 30-39 | 80 423 (5.1) | 6182 (5.3) | 3688 (5.5) | 26 950 (5.1) | 26 536 (5.0) | 12 457 (5.1) | 4610 (4.4) | 9870 (5.4) | 70 553 (5.0) |
| 40-49 | 166 844 (10.5) | 12 405 (10.7) | 7339 (11) | 55 707 (10.6) | 55 147 (10.5) | 26 306 (10.7) | 9940 (9.5) | 19 744 (10.8) | 147 100 (10.5) |
| 50-59 | 301 882 (19.0) | 22 175 (19.2) | 12 747 (19.2) | 101 154 (19.2) | 99 642 (18.9) | 47 090 (19.2) | 19 074 (18.2) | 34 922 (19.2) | 266 960 (19.0) |
| 60-69 | 389 925 (24.6) | 28 086 (24.3) | 15 681 (23.6) | 129 473 (24.5) | 130 166 (24.7) | 60 730 (24.7) | 25 789 (24.6) | 43 767 (24) | 346 158 (24.7) |
| ≥70 | 606 926 (38.3) | 43 556 (37.7) | 24 809 (37.3) | 200 572 (38.0) | 201 789 (38.4) | 93 253 (38.0) | 42 947 (41.0) | 68 365 (37.5) | 538 561 (38.4) |
| Sex | | | | | | | | | |
| Male | 885 666 (55.8) | 65 253 (56.4) | 37 486 (56.3) | 296 416 (56.2) | 291 779 (55.5) | 136 453 (55.6) | 58 279 (55.7) | 102 739 (56.4) | 782 927 (55.8) |
| Female | 700 281 (44.2) | 50 397 (43.6) | 29 053 (43.7) | 231 042 (43.8) | 234 218 (44.5) | 109 180 (44.4) | 46 391 (44.3) | 79 450 (43.6) | 620 831 (44.2) |
| Race/ethnicity | | | | | | | | | |
| Non-Hispanic white | 848 747 (53.5) | 66 313 (57.3) | 37 026 (55.6) | 274 902 (52.1) | 299 549 (56.9) | 120 494 (49.1) | 50 463 (48.2) | 103 339 (56.7) | 745 408 (53.1) |
| Non-Hispanic black | 450 456 (28.4) | 30 642 (26.5) | 17 535 (26.4) | 148 084 (28.1) | 153 156 (29.1) | 72 362 (29.5) | 28 677 (27.4) | 48 177 (26.4) | 402 279 (28.7) |
| Hispanic white | 198 737 (12.5) | 9606 (8.3) | 7053 (10.6) | 74 517 (14.1) | 56 507 (10.7) | 33 247 (13.5) | 17 807 (17.0) | 16 659 (9.1) | 182 078 (13.0) |
| Other[d] | 88 007 (5.5) | 9089 (7.9) | 4925 (7.4) | 29 955 (5.7) | 16 785 (3.2) | 19 530 (8.0) | 7723 (7.4) | 14 014 (7.7) | 73 993 (5.3) |
| Insurance coverage[e] | | | | | | | | | |
| Medicare | 557 522 (38.1) | 41 487 (38.8) | 22 514 (36.2) | 177 850 (36.8) | 192 326 (39.3) | 87 387 (38.6) | 35 958 (36.8) | 64 001 (37.8) | 493 521 (38.1) |
| Medicaid | 401 193 (27.4) | 27 718 (25.9) | 18 258 (29.4) | 137 068 (28.4) | 124 308 (25.4) | 61 494 (27.2) | 32 347 (33.1) | 45 976 (27.2) | 355 217 (27.4) |
| Employer | 281 271 (19.2) | 20 772 (19.4) | 9991 (16.1) | 93 144 (19.3) | 101 229 (20.7) | 41 889 (18.5) | 14 246 (14.6) | 30 763 (18.2) | 250 508 (19.3) |
| None | 110 222 (7.5) | 8752 (8.2) | 5932 (9.5) | 37 504 (7.8) | 32 672 (6.7) | 16 880 (7.5) | 8482 (8.7) | 14 684 (8.7) | 95 538 (7.4) |
| Other[f] | 114 624 (7.8) | 8206 (7.7) | 5485 (8.8) | 37 179 (7.7) | 38 634 (7.9) | 18 552 (8.2) | 6568 (6.7) | 13 691 (8.1) | 100 933 (7.8) |
| Attributed cause of ESKD | | | | | | | | | |
| Diabetes | 739 365 (46.6) | 53 794 (46.5) | 28 963 (43.5) | 247 599 (46.9) | 244 573 (46.5) | 115 388 (47.0) | 49 048 (46.9) | 82 757 (45.4) | 656 608 (46.8) |
| Hypertension | 467 546 (29.5) | 29 059 (25.1) | 16 695 (25.1) | 154 816 (29.4) | 158 858 (30.2) | 75 905 (30.9) | 32 213 (30.8) | 45 754 (25.1) | 421 792 (30) |
| Other disease | 126 377 (8.0) | 11 447 (9.9) | 6462 (9.7) | 41 878 (7.9) | 41 162 (7.8) | 18 293 (7.4) | 7135 (6.8) | 17 909 (9.8) | 108 468 (7.7) |
| Glomerulonephritis | 252 659 (15.9) | 21 350 (18.5) | 14 419 (21.7) | 83 165 (15.8) | 81 404 (15.5) | 36 047 (14.7) | 16 274 (15.5) | 35 769 (19.6) | 216 890 (15.5) |
| Dialysis type[g] | | | | | | | | | |
| In-center hemodialysis | 1 430 060 (90.6) | 103 298 (89.8) | 59 361 (90.6) | 474 497 (90.5) | 482 450 (92.0) | 222 687 (90.9) | 87 767 (84.5) | 162 659 (90.0) | 1 267 401 (90.7) |
| Peritoneal dialysis | 126 472 (8.0) | 10 873 (9.4) | 5518 (8.4) | 45 291 (8.6) | 36 147 (6.9) | 20 296 (8.3) | 8347 (8) | 16 391 (9.1) | 110 081 (7.9) |
| Home hemodialysis | 21 471 (1.4) | 924 (0.8) | 677 (1.0) | 4573 (0.9) | 5657 (1.1) | 1879 (0.8) | 7761 (7.5) | 1601 (0.9) | 19 870 (1.4) |

(continued)

Table 1. Patient- and Facility-Level Characteristics at Start of Dialysis Within the US Renal Data System Overall and Stratified by Dialysis Facility Ownership, 2000-2016[a] (continued)

| | | Nonprofit Dialysis Facilities[c] | | For-Profit Dialysis Facilities[c] | | | | All Facilities | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristics[b] | Total | Small Chains | Independent | Large Chain 1 | Large Chain 2 | Small Chains | Independent | Nonprofit | For-Profit |
| **Patient-Level Comorbidities at Start of Dialysis and Measures of Access to Transplantation[b]** | | | | | | | | | |
| Hypertension | 1 340 677 (84.5) | 98 111 (84.8) | 55 281 (83.1) | 442 125 (83.8) | 445 676 (84.7) | 210 312 (85.6) | 89 172 (85.2) | 153 392 (84.2) | 1 187 285 (84.6) |
| Diabetes | 754 173 (47.6) | 54 874 (47.4) | 29 298 (44.0) | 250 509 (47.5) | 247 669 (47.1) | 119 850 (48.8) | 51 973 (49.7) | 84 172 (46.2) | 670 001 (47.7) |
| Congestive heart failure | 506 735 (32.0) | 38 545 (33.3) | 22 022 (33.1) | 163 597 (31.0) | 168 870 (32.1) | 78 030 (31.8) | 35 671 (34.1) | 60 567 (33.2) | 446 168 (31.8) |
| BMI >35[h] | 294 399 (18.6) | 20 469 (17.7) | 11 721 (17.6) | 96 223 (18.2) | 102 573 (19.5) | 45 117 (18.4) | 18 296 (17.5) | 32 190 (17.7) | 262 209 (18.7) |
| Other cardiac disease | 213 292 (13.4) | 16 380 (14.2) | 9001 (13.5) | 66 690 (12.6) | 71 077 (13.5) | 33 778 (13.8) | 16 366 (15.6) | 25 381 (13.9) | 187 911 (13.4) |
| Atherosclerotic heart disease | 212 058 (13.4) | 17 744 (15.3) | 11 157 (16.8) | 63 190 (12.0) | 70 815 (13.5) | 32 090 (13.1) | 17 062 (16.3) | 28 901 (15.9) | 183 157 (13.0) |
| Peripheral vascular disease | 204 339 (12.9) | 16 466 (14.2) | 9339 (14.0) | 64 100 (12.2) | 69 603 (13.2) | 30 976 (12.6) | 13 855 (13.2) | 25 805 (14.2) | 178 534 (12.7) |
| Cerebrovascular disease | 147 567 (9.3) | 12 208 (10.6) | 6246 (9.4) | 45 750 (8.7) | 49 704 (9.4) | 22 855 (9.3) | 10 804 (10.3) | 18 454 (10.1) | 129 113 (9.2) |
| COPD | 144 929 (9.1) | 11 969 (10.3) | 6415 (9.6) | 46 187 (8.8) | 48 685 (9.3) | 21 511 (8.8) | 10 162 (9.7) | 18 384 (10.1) | 126 545 (9.0) |
| Cancer | 112 074 (7.1) | 9790 (8.5) | 5425 (8.2) | 35 433 (6.7) | 37 122 (7.1) | 16 822 (6.8) | 7482 (7.1) | 15 215 (8.4) | 96 859 (6.9) |
| Tobacco use | 96 975 (6.1) | 9165 (7.9) | 4079 (6.1) | 31 274 (5.9) | 32 837 (6.2) | 14 063 (5.7) | 5557 (5.3) | 13 244 (7.3) | 83 731 (6.0) |
| Nephrology care before ESKD[i] | 673 753 (67.3) | 53 593 (72.3) | 27 741 (65.0) | 218 940 (66.0) | 222 337 (68.5) | 107 127 (66.8) | 44 015 (65.3) | 81 334 (69.6) | 592 419 (67.0) |
| Period of dialysis, median (IQR), y | | | | | | | | | |
| Before placement on waiting list[j] | 1.8 (0.7-4.0) | 1.8 (0.7-4.0) | 1.8 (0.6-4.2) | 1.9 (0.7-4.1) | 1.8 (0.7-4) | 1.8 (0.7-4) | 1.7 (0.6-3.9) | 1.8 (0.6-4.1) | 1.8 (0.7-4) |
| Before first transplant[k] | 2.3 (0.8-4.6) | 2.3 (0.9-4.6) | 2.3 (0.8-4.8) | 2.3 (0.9-4.6) | 2.2 (0.8-4.5) | 2.2 (0.8-4.5) | 2.1 (0.7-4.4) | 2.3 (0.9-4.7) | 2.3 (0.8-4.6) |
| Not informed of transplant options due to medical reasons[l] | 80 392 (5.1) | 8109 (7.0) | 5717 (8.6) | 21 705 (4.1) | 25 702 (4.9) | 11 877 (4.8) | 7282 (7.0) | 13 826 (7.6) | 66 566 (4.7) |
| **Dialysis Facility-Level Characteristics** | | | | | | | | | |
| Patients per facility, median (IQR) | 61 (40-88) | 63 (35-103) | 60 (40-87) | 63 (36-101) | 63 (35-117) | 61 (41-87) | 59 (40-85) | 60 (39-89) | 63 (38-92) |
| Patients:staff, median (IQR)[m] | 3.4 (2.7-4.1) | 2.9 (2.3-3.6) | 3.5 (2.8-4.2) | 3.1 (2.4-3.8) | 2.6 (2-3.2) | 3.6 (2.9-4.3) | 3.4 (2.8-4) | 3.5 (2.8-4.3) | 3.0 (2.3-3.8) |
| Social workers per facility, median (IQR)[m] | 1 (0-1) | 1 (0-1) | 1 (0-1) | 1 (0-1) | 1 (1-2) | 1 (0-1) | 1 (0-1) | 1 (1-1) | 1 (1-1) |
| Patients:social workers per facility, median (IQR)[m] | 64.5 (48-83) | 62.3 (46-84) | 65 (48-83) | 65 (50.7-85) | 58 (40-83) | 66 (50-83) | 64 (48-82.5) | 63.5 (48-84) | 63 (43-86) |
| Hospitalization rate/100 person-years, median (IQR)[n] | 177.6 (148.7-211.1) | 165.9 (141.5-197.1) | 179.2 (149.7-212.3) | 165.9 (140.9-202.5) | 165.8 (143.6-189.1) | 181 (152.2-214.6) | 177.4 (148.3-210.2) | 178.1 (148.3-209.9) | 189.8 (151.5-224.9) |
| Standardized mortality ratio, mean (SD)[m] | 1 (0.3) | 1 (0.3) | 1 (0.3) | 1 (0.3) | 1 (0.4) | 1.1 (0.3) | 1 (0.3) | 1 (0.4) | 1.1 (0.5) |

(continued)

Table 1. Patient- and Facility-Level Characteristics at Start of Dialysis Within the US Renal Data System Overall and Stratified by Dialysis Facility Ownership, 2000-2016[a] (continued)

| | | Nonprofit Dialysis Facilities[c] | | For-Profit Dialysis Facilities[c] | | | | All Facilities | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristics[b] | Total | Small Chains | Independent | Large Chain 1 | Large Chain 2 | Small Chains | Independent | Nonprofit | For-Profit |
| ESRD Network geographic areas[m] | | | | | | | | | |
| Northeast[o] | 256 713 (16.2) | 14 129 (12.2) | 30 612 (46) | 72 108 (13.7) | 83 566 (15.9) | 26 875 (10.9) | 29 423 (28.1) | 44 741 (24.6) | 211 972 (15.1) |
| South[p] | 648 194 (40.9) | 38 633 (33.4) | 9547 (14.3) | 201 176 (38.1) | 233 900 (44.5) | 130 452 (53.1) | 34 486 (32.9) | 48 180 (26.4) | 600 014 (42.7) |
| Midwest[q] | 352 713 (22.2) | 27 174 (23.5) | 17 255 (25.9) | 122 923 (23.3) | 145 967 (27.8) | 20 358 (8.3) | 19 036 (18.2) | 44 429 (24.4) | 308 284 (22.0) |
| West[r] | 328 327 (20.7) | 35 714 (30.9) | 9125 (13.7) | 131 251 (24.9) | 62 564 (11.9) | 67 948 (27.7) | 21 725 (20.8) | 44 839 (24.6) | 283 488 (20.2) |
| Metropolitan rural-urban classification[s] | 1 227 252 (84.2) | 85 840 (81.6) | 47 934 (79.2) | 418 162 (86.1) | 401 324 (82.6) | 189 403 (84.2) | 84 589 (87.9) | 133 774 (80.7) | 1 093 478 (84.6) |
| Distance from assigned facility to nearest transplant center, median (IQR), m[t] | 17 (6.3-53.8) | 15.5 (3.5-56.4) | 17.3 (6.5-53.2) | 15.5 (4.9-56.6) | 12.3 (2.3-54.9) | 15.1 (6.7-45.2) | 21.2 (6.5-60.1) | 16.4 (6.1-56.6) | 14.9 (6.6-53) |

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; ESKD, end-stage kidney disease; ESRD, end-stage renal disease; IQR, interquartile range.

[a] Data are expressed as No. (%) unless otherwise indicated. Patients were assigned to the last dialysis facility from which they were receiving treatment when the outcome event of interest occurred.

[b] Baseline patient characteristics were obtained at the time the CMS-2728 form was completed.

[c] $P<.001$ for all comparisons across nonprofit and for-profit facility ownership categories. The $P$ values were calculated using the $\chi^2$ test for categorical variables, the Kruskal-Wallis for nonparametric continuous variables, and the $t$ test for parametric continuous variables.

[d] Defined as Asian, Middle Eastern, Native American, Pacific Islander, or multiracial.

[e] There were missing data for 121 115 patients (7.6%).

[f] This category was collected and defined on the CMS-2728 form and was not further defined.

[g] There are missing data for 7944 patients (0.5%).

[h] Calculated as weight in kilograms divided by height in meters squared.

[i] There were missing data for 584 744 patients (36.9%).

[j] Calculated as the time receiving dialysis from the first date of dialysis treatment to either the date of first placement on the deceased donor kidney transplantation waiting list, at the end of the study, or time of death.

[k] Calculated as the time receiving dialysis from the first date of dialysis treatment to either the date of first transplant (living or deceased donor kidney transplant), at the end of the study, or at time of death.

[l] Obtained from item 27 on the CMS-2728 form. The attending physician recorded no if the patient had not been informed of their transplant options and entered all the reasons why a kidney transplant was not an option for the patient at that time.

[m] Obtained from the Dialysis Facility Report, 2013-2016.

[n] Obtained from the Dialysis Facility Compare, 2016.

[o] Network 1: Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont; Network 2: New York; Network 3: New Jersey; and Network 4: Delaware and Pennsylvania.

[p] Network 5: District of Columbia, Maryland, Virginia, and West Virginia; Network 6: Georgia, North Carolina, and South Carolina; Network 7: Florida; Network 8: Alabama, Mississippi, and Tennessee; Network 13: Arkansas, Louisiana, and Oklahoma; and Network 14: Texas.

[q] Network 9/10: Illinois, Indiana, Kentucky, and Ohio; Network 11: Michigan, Minnesota, North Dakota, South Dakota, and Wisconsin; and Network 12: Iowa, Kansas, Missouri, and Nebraska.

[r] Network 15: Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming; Network 16: Alaska, Idaho, Montana, Oregon, and Washington; Network 17: Hawaii and northern California; and Network 18: southern California.

[s] Obtained from the US Department of Agriculture Rural and Urban Continuum Code. There were missing data for 127 712 patients (8.1%).

[t] Calculated using the dialysis facility address from Dialysis Facility Compare (2013-2016) and the nearest transplant center address from the Scientific Registry of Transplant Recipients. There were missing data for 341 693 patients (21.5%).

## Primary Analysis

A total of 230 202 patients (14.5%) with incident ESKD were placed on the deceased donor kidney transplantation waiting list, 39 767 (2.5%) received a living donor kidney transplant, and 88 431 (5.6%) received a deceased donor kidney transplant. The percentage of patients placed on the deceased donor kidney transplantation waiting list during the study period was 16.8% for those treated at nonprofit small chain facilities, 17.2% for those treated at nonprofit independent dialysis facilities, 14.7% for those treated at facilities of for-profit large chain 1, 14.0% for those treated at facilities of for-profit large chain 2, 14.2% for those treated at for-profit small chain facilities, and 12.9% for those treated at for-profit independent facilities (**Table 2**). There was a lower percentage of patients treated at all for-profit facilities vs all nonprofit facilities who received a living donor kidney transplant (2.4% vs 3.3%, respectively) or a deceased donor kidney transplant (5.4% vs 7.0%).

In bivariable Cox proportional hazard models, patients younger than 60 years had an increased probability of being placed on the deceased donor kidney transplantation waiting list, receiving a living donor kidney transplant, or receiving a deceased donor kidney transplant. Compared with patients with ESKD caused by diabetes, those with ESKD attributed to glomerulonephritis were more likely to be placed on the deceased donor kidney transplantation waiting list (hazard ratio [HR], 1.20 [95% CI, 1.19-1.22]), to receive a living donor kidney transplant (HR, 2.26 [95% CI, 2.19-2.32]), or to receive a deceased donor kidney transplant (HR, 1.13 [95% CI, 1.11-1.15]) (Table 2).

The crude and adjusted time to event associations between dialysis facility ownership and placement on the deceased donor kidney transplantation waiting list, receipt of a living donor kidney transplant, and receipt of a deceased donor kidney transplant appear in **Table 3**. Nonprofit small chain dialysis facilities were used as the reference group. Patients receiving dialysis at all for-profit facilities vs all nonprofit facilities had lower 5-year cumulative incidence of placement on the deceased donor kidney transplantation waiting list (cumulative incidence difference, −2.6% [95% CI, −2.8% to −2.4%]), receipt of a living donor kidney transplant (−0.9% [95% CI, −1.0% to −0.8%]), and receipt of a deceased donor kidney transplant (−1.4% [95% CI, −1.5% to −1.3%]).

Compared with patients treated at nonprofit small chain dialysis facilities, patients were less likely to be placed on the deceased donor kidney transplantation waiting list at nonprofit independent facilities (HR, 0.93 [95% CI, 0.91-0.96]), facilities of for-profit large chain 1 (HR, 0.84 [95% CI, 0.82-0.85]), at facilities of for-profit large chain 2 (HR, 0.86 [95% CI, 0.85-0.88]), for-profit small chain dialysis facilities (HR, 0.85 [95% CI, 0.83-0.86]), and for-profit independent chain facilities (HR, 0.79 [95% CI, 0.77-0.80]) (Table 3). Patients treated at all for-profit facilities were less likely to receive a living donor kidney transplant compared with patients treated at all nonprofit facilities (HR, 0.82 [95% CI, 0.80-0.84]).

Patients treated at nonprofit independent facilities (HR, 0.89 [95% CI, 0.86-0.93]), facilities of for-profit large chain 1 (HR, 0.78 [95% CI, 0.76-0.80]), facilities of for-profit large chain 2 (HR, 0.82 [95% CI, 0.80-0.84]), for-profit small chain dialysis facilities (HR, 0.80 [95% CI, 0.78-0.83]), and for-profit independent chain facilities (HR, 0.73 [95% CI, 0.71-0.76) were less likely to receive a deceased donor kidney transplant compared with their counterparts in nonprofit small chain dialysis facilities. Based on 5-year cumulative incidence differences between for-profit and nonprofit facilities, the number needed to treat for placement on the deceased donor kidney transplantation waiting list is 38.5 (95% CI, 35.7-41.7); for receipt of a living donor kidney transplant, 111.1 (95% CI, 100.0-125.0); and for receipt of a deceased donor kidney transplant, 71.4 (95% CI, 66.7-83.3).

Two-year event incidence rates during the study period showed a general decrease during the last 17 years across dialysis facility ownership categories in patient placement on the deceased donor kidney transplantation waiting list (**Figure 2**A), receipt of a living donor kidney transplant (Figure 2B), and receipt of a deceased donor kidney transplant (Figure 2C). From 2001-2016, for-profit dialysis facilities had a lower 2-year incidence rate per 100 person-years for each event compared with other dialysis facility ownership categories. The for-profit vs nonprofit facility rate differences ranged from −1.83 to −2.89 per 100 person-years for placement on the deceased donor kidney transplantation waiting list; −0.27 to −0.88 per 100 person-years for receipt of a living donor kidney transplant; and −0.14 to −0.43 per 100 person-years for receipt of a deceased donor kidney transplant (Figure 2).

Overall, 77.0% of patients did not switch dialysis facilities during the study period, 19.7% switched facilities within the same profit status, 1.1% switched from for-profit facilities to nonprofit facilities, and 2.2% switched from nonprofit facilities to for-profit facilities (eTable 1 in the Supplement). Among the patients who switched facilities, the median time from first to last facility was 1.2 years (IQR, 0.3-3.2 years).

## Sensitivity Analyses

The sensitivity analysis for the association between switching dialysis facilities and the outcomes of interest, stratified by the last dialysis facility where the patients received treatment appears in eTable 2 in the Supplement. Patients who switched from a nonprofit facility to a for-profit facility were less likely to be placed on the deceased donor kidney transplantation waiting list or receive a living or deceased donor kidney transplant compared with patients who started and continued treatment at for-profit facilities. For example, patients who switched from a nonprofit facility to a for-profit large chain 2 facility had a lower hazard of being placed on the deceased donor kidney transplantation waiting list (HR, 0.73 [95% CI, 0.70-0.77]) than patients who started and continued dialysis at the same for-profit large chain 2 facility.

The sensitivity analysis among the ideal kidney transplant candidate cohort reported similar relative risks to the primary analysis (eTable 3 in the Supplement). The 5-year cumulative incidence differences between all nonprofit facilities and all for-profit facilities were higher in the ideal cohort analysis for placement on the deceased donor kidney transplantation waiting list (−4.7% [95% CI, −5.1% to −4.3%]), receipt of a living donor kidney transplant (−2.2% [95% CI, −2.4% to −2.0%]),

Table 2. Patient Characteristics and Crude Hierarchical Cox Proportional Hazard Ratios (HRs) Among Patients Who Were Placed on the Deceased Donor Waiting List, Received a Living Donor Kidney Transplant, or Received a Deceased Donor Kidney Transplant During Follow-up, 2000-2016

| | Censored Date (n = 1 339 822)[b] | Placement on the Deceased Donor Waiting List (n = 230 202) (14.5%) | | Receipt of a Living Donor Kidney Transplant (n = 39 767) (2.5%) | | Receipt of a Deceased Donor Kidney Transplant (n = 88 431) (5.6%) | |
|---|---|---|---|---|---|---|---|
| Characteristics[a] | No. (%) | No. (%) | HR (95% CI)[c] | No. (%) | HR (95% CI)[d] | No. (%) | HR (95% CI)[e] |
| **Dialysis Facility Ownership[f]** | | | | | | | |
| Nonprofit | | | | | | | |
| Small chains (n = 109 030) | 94 710 (81.3) | 19 388 (16.8) | 1 [Reference] | 3599 (3.1) | 1 [Reference] | 8068 (7.0) | 1 [Reference] |
| Independent facilities (n = 78 287) | 54 098 (82.1) | 11 425 (17.2) | 1.02 (1.00-1.05) | 2418 (3.6) | 1.16 (1.10-1.22) | 4606 (6.9) | 0.95 (0.91-0.98) |
| For-profit | | | | | | | |
| Large chain 1 (n = 483 988) | 444 763 (84.1) | 77 457 (14.7) | 0.87 (0.86-0.88) | 13 061 (2.5) | 0.80 (0.77-0.83) | 28 997 (5.5) | 0.79 (0.77-0.81) |
| Large chain 2 (n = 482 689) | 447 204 (85.0) | 73 557 (14.0) | 0.84 (0.82-0.85) | 12 996 (2.5) | 0.81 (0.78-0.84) | 29 065 (5.5) | 0.82 (0.80-0.84) |
| Small chains (n = 225 890) | 208 796 (84.9) | 34 881 (14.2) | 0.85 (0.84-0.87) | 5386 (2.2) | 0.72 (0.69-0.75) | 12963 (5.3) | 0.78 (0.76-0.80) |
| Independent facilities (n = 98 680) | 90 251 (85.9) | 13494 (12.9) | 0.79 (0.77-0.81) | 2307 (2.2) | 0.74 (0.71-0.78) | 4732 (4.5) | 0.70 (0.67-0.72) |
| All facilities | | | | | | | |
| Nonprofit (n = 187 317) | 148 808 (81.8) | 30 813 (16.9) | 1 [Reference] | 6017 (3.3) | 1 [Reference] | 12 674 (7.0) | 1 [Reference] |
| For-profit (n = 1 291 247) | 1 191 014 (84.7) | 199 389 (14.2) | 0.84 (0.83-0.85) | 33 750 (2.4) | 0.74(0.72-0.76) | 75 757 (5.4) | 0.81 (0.80-0.83) |
| **Patient-Level Characteristics at Start of Dialysis[a]** | | | | | | | |
| Age group, y | | | | | | | |
| 18-29 | 18 115 (45.1) | 19 435 (48.7) | 3.52 (3.46-3.57) | 6688 (16.7) | 8.57 (8.28-8.87) | 8930 (22.4) | 3.69 (3.60-3.79) |
| 30-39 | 46 039 (57) | 30 062 (37.4) | 2.58 (2.54-2.61) | 6944 (8.6) | 4.39 (4.25-4.54) | 15 090 (18.8) | 3.09 (3.02-3.16) |
| 40-49 | 111 540 (66.7) | 50 917 (30.5) | 2.11 (2.09-2.14) | 8820 (5.3) | 2.71 (2.62-2.8) | 21 244 (12.7) | 2.19 (2.15-2.24) |
| 50-59 | 230 202 (76.1) | 68 739 (22.8) | 1.63 (1.61-1.65) | 9594 (3.2) | 1.73 (1.67-1.78) | 24 400 (8.1) | 1.60 (1.57-1.63) |
| 60-69 | 337 103 (86.4) | 51 336 (13.2) | 1 [Reference] | 6442 (1.7) | 1 [Reference] | 15 907 (4.1) | 1 [Reference] |
| ≥70 | 596 823 (98.3) | 9713 (1.6) | 0.14 (0.14-0.14) | 1279 (0.2) | 0.16 (0.15-0.17) | 2860 (0.5) | 0.17 (0.16-0.18) |
| Sex | | | | | | | |
| Male | 732 462 (82.6) | 143 360 (16.2) | 1 [Reference] | 25 056 (2.8) | 1 [Reference] | 55 153 (6.2) | 1 [Reference] |
| Female | 607 360 (86.6) | 86 842 (12.4) | 0.74 (0.73-0.75) | 14 711 (2.1) | 0.73 (0.72-0.75) | 33 278 (4.8) | 0.73 (0.72-0.74) |
| Race/ethnicity | | | | | | | |
| Non-Hispanic white | 743 871 (87.6) | 94 333 (11.1) | 1 [Reference] | 24 070 (2.8) | 1 [Reference] | 37 662 (4.4) | 1 [Reference] |
| Non-Hispanic black | 372 522 (82.6) | 75 335 (16.7) | 1.60 (1.58-1.62) | 6833 (1.5) | 0.88 (0.85-0.90) | 30 127 (6.7) | 0.97 (0.95-0.99) |
| Hispanic white | 154 980 (77.9) | 41 647 (21.0) | 1.26 (1.24-1.27) | 6384 (3.2) | 0.42 (0.41-0.43) | 13 883 (7) | 0.93 (0.92-0.94) |
| Other[g] | 68 449 (77.6) | 18 887 (21.5) | 1.72 (1.69-1.75) | 2480 (2.8) | 0.8 (0.76-0.83) | 6759 (7.7) | 1.15 (1.12-1.18) |

(continued)

Table 2. Patient Characteristics and Crude Hierarchical Cox Proportional Hazard Ratios (HRs) Among Patients Who Were Placed on the Deceased Donor Waiting List, Received a Living Donor Kidney Transplant, or Received a Deceased Donor Kidney Transplant During Follow-up, 2000-2016 (continued)

| | Censored Date (n = 1 339 822)[b] | Placement on the Deceased Donor Waiting List (n = 230 202) (14.5%) | | Receipt of a Living Donor Kidney Transplant (n = 39 767) (2.5%) | | Receipt of a Deceased Donor Kidney Transplant (n = 88 431) (5.6%) | |
|---|---|---|---|---|---|---|---|
| Characteristics[a] | No. (%) | No. (%) | HR (95% CI)[c] | No. (%) | HR (95% CI)[d] | No. (%) | HR (95% CI)[e] |
| Insurance coverage[h] | | | | | | | |
| Medicare | 523 873 (93.9) | 32 125 (5.8) | 0.21 (0.21-0.21) | 4162 (0.7) | 0.13 (0.13-0.13) | 10 436 (1.9) | 0.23 (0.22-0.23) |
| Medicaid | 350 092 (87.2) | 48 047 (12) | 0.39 (0.39-0.40) | 5065 (1.3) | 0.19 (0.19-0.20) | 17 384 (4.3) | 0.38 (0.38-0.39) |
| Employer | 188 633 (66.9) | 85 285 (30.3) | 1 [Reference] | 20 120 (7.2) | 1 [Reference] | 35 269 (12.5) | 1 [Reference] |
| None | 84 516 (76.5) | 23 896 (21.7) | 0.66 (0.65-0.67) | 4882 (4.4) | 0.4 (0.39-0.41) | 9225 (8.4) | 0.61 (0.59-0.62) |
| Other[i] | 84 039 (73.1) | 28 875 (25.2) | 0.69 (0.68-0.70) | 3955 (3.5) | 0.62 (0.61-0.64) | 12 593 (11) | 0.66 (0.64-0.67) |
| Attributed cause of ESKD | | | | | | | |
| Diabetes | 635 886 (85.9) | 93 731 (12.7) | 1 [Reference] | 11 551 (1.6) | 1 [Reference] | 35 096 (4.7) | 1 [Reference] |
| Hypertension | 407 180 (87) | 58 510 (12.5) | 1.02 (1.01-1.03) | 7948 (1.7) | 1.12 (1.09-1.15) | 22 056 (4.7) | 0.98 (0.96-0.99) |
| Other disease | 81 416 (64.2) | 42 622 (33.7) | 2.68 (2.65-2.72) | 12 036 (9.5) | 5.49 (5.36-5.64) | 17 183 (13.6) | 2.18 (2.14-2.22) |
| Glomerulonephritis | 215 340 (85.1) | 35 339 (14) | 1.20 (1.19-1.22) | 8232 (3.3) | 2.26 (2.19-2.32) | 14 096 (5.6) | 1.13 (1.11-1.15) |
| Dialysis type[j] | | | | | | | |
| In-center hemodialysis | 1 233 891 (85.7) | 183 951 (12.9) | 1 [Reference] | 30 151 (2.1) | 1 [Reference] | 70 769 (4.9) | 1 [Reference] |
| Peritoneal dialysis | 80 153 (67.5) | 43 033 (34) | 3.07 (3.04-3.11) | 8830 (7) | 3.37 (3.29-3.45) | 16 303 (12.9) | 3.25 (3.19-3.30) |
| Home hemodialysis | 18 126 (81.4) | 3036 (14.1) | 1.06 (1.03-1.10) | 680 (3.2) | 1.49 (1.38-1.60) | 1187 (5.5) | 1.12 (1.06-1.19) |
| **Patient-Level Comorbidities at Start of Dialysis and Measures of Access to Transplantation[a]** | | | | | | | |
| Hypertension | 1 128 747 (84.1) | 198 759 (14.8) | 1.10 (1.08-1.11) | 32 849 (2.5) | 0.81 (0.78-0.83) | 75 898 (5.7) | 1.09 (1.07-1.11) |
| Diabetes | 654 471 (86.7) | 90 979 (12.1) | 0.73 (0.73-0.74) | 10 846 (1.4) | 0.43 (0.42-0.44) | 32 087 (4.3) | 0.78 (0.77-0.79) |
| Congestive heart failure | 470 493 (92.8) | 34 624 (6.8) | 0.42 (0.42-0.43) | 4082 (0.8) | 0.29 (0.28-0.30) | 10 983 (2.2) | 0.42 (0.41-0.43) |
| BMI >35[k] | 252 592 (85.7) | 40 538 (13.8) | 0.86 (0.85-0.87) | 5453 (1.9) | 0.64 (0.62-0.66) | 13 089 (4.4) | 0.66 (0.65-0.67) |
| Other cardiac disease | 198 921 (93.2) | 13 865 (6.5) | 0.49 (0.49-0.50) | 1711 (0.8) | 0.37 (0.35-0.39) | 3801 (1.8) | 0.48 (0.46-0.50) |
| Atherosclerotic heart disease | 196 907 (92.8) | 14 527 (6.9) | 0.48 (0.47-0.49) | 1874 (0.9) | 0.37 (0.35-0.39) | 3999 (1.9) | 0.43 (0.42-0.45) |
| Peripheral vascular disease | 191 295 (93.6) | 12 235(6) | 0.41 (0.41-0.42) | 1559 (0.8) | 0.32 (0.30-0.34) | 3852 (1.9) | 0.42 (0.40-0.43) |
| Cerebrovascular disease | 137 902 (93.4) | 9182 (6.2) | 0.44 (0.43-0.45) | 1093 (0.7) | 0.31 (0.30-0.33) | 2970 (2.0) | 0.44 (0.42-0.45) |
| COPD | 139 627 (96.3) | 5056 (3.5) | 0.27 (0.26-0.27) | 642 (0.4) | 0.21 (0.20-0.23) | 1536 (1.1) | 0.29 (0.28-0.31) |
| Cancer | 106 282 (94.8) | 5541 (4.9) | 0.39 (0.38-0.40) | 1023 (0.9) | 0.45 (0.42-0.48) | 1783 (1.6) | 0.42 (0.40-0.44) |
| Tobacco use | 85 789 (88.4) | 10 396 (10.7) | 0.69 (0.68-0.71) | 1574 (1.6) | 0.62 (0.59-0.65) | 4056 (4.2) | 0.73 (0.71-0.76) |
| Nephrology care before ESKD[l] | 563 025 (83.5) | 104 630 (15.5) | 1.08 (1.07-1.09) | 16 029 (2.4) | 1.17 (1.14-1.20) | 35 110 (5.2) | 1.22 (1.20-1.24) |

(continued)

Table 2. Patient Characteristics and Crude Hierarchical Cox Proportional Hazard Ratios (HRs) Among Patients Who Were Placed on the Deceased Donor Waiting List, Received a Living Donor Kidney Transplant, or Received a Deceased Donor Kidney Transplant During Follow-up, 2000-2016 (continued)

| | Censored Date (n = 1 339 822)[b] | Placement on the Deceased Donor Waiting List (n = 230 202) (14.5%) | | Receipt of a Living Donor Kidney Transplant (n = 39 767) (2.5%) | | Receipt of a Deceased Donor Kidney Transplant (n = 88 431) (5.6%) | |
|---|---|---|---|---|---|---|---|
| Characteristics[a] | No. (%) | No. (%) | HR (95% CI)[c] | No. (%) | HR (95% CI)[d] | No. (%) | HR (95% CI)[e] |
| Not informed of transplant options due to medical reasons[m] | 79 115 (98.4) | 1249 (1.6) | 0.14 (0.13-0.14) | 130 (0.2) | 0.09 (0.08-0.11) | 365 (0.5) | 0.14 (0.13-0.16) |
| **Dialysis Facility-Level Characteristics** | | | | | | | |
| ESRD Network geographic areas[n] | | | | | | | |
| Northeast[o] | 214 134 (83.3) | 40 332 (15.7) | 1 [Reference] | 7225 (2.8) | 1 [Reference] | 14 493 (5.6) | 1 [Reference] |
| South[p] | 553 665 (85.3) | 89 416 (13.8) | 0.82 (0.81-0.83) | 12 986 (2) | 0.68 (0.66-0.70) | 35 497(5.5) | 0.89 (0.87-0.91) |
| Midwest[q] | 302 964 (85.8) | 44 526 (12.6) | 0.77 (0.76-0.78) | 10 528 (3) | 1.06 (1.03-1.10) | 19 758 (5.6) | 1.01 (0.98-1.03) |
| West[r] | 269 059 (81.9) | 55 928 (17.0) | 1.01 (1.00-1.03) | 9028 (2.7) | 0.9 (0.88-0.93) | 18 683 (5.7) | 0.87 (0.85-0.80) |
| Metropolitan rural-urban classification[s] | | | | | | | |
| Metropolitan area | 1 113 610 (90.6) | 100 764 (8.2) | 1 [Reference] | 19 507 (1.6) | 1 [Reference] | 40 624 (3.3) | 1 [Reference] |
| Rural area | 213 671 (92.3) | 14 835 (6.4) | 0.41 (0.39-0.40) | 3415 (1.5) | 0.58 (0.56-0.60) | 6235 (2.7) | 0.49 (0.48-0.51) |
| Distance from assigned facility to nearest transplant center, median (IQR), m[t] | 17.8 (6.4-54.8) | 14.1 (5.3-46.8) | 1 (1-1) | 14.4 (5.4-46.0) | 1 (1-1) | 13.5 (4.9-45.4) | 1 (1-1) |

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; ESKD, end-stage kidney disease; ESRD, end-stage renal disease; IQR, interquartile range.

[a] Baseline characteristics were obtained at the time the CMS-2728 form was completed.

[b] Defined as death or end of follow-up (December 31, 2016).

[c] Univariate Cox proportional hazard model determined the association between patient- and facility-level characteristics and placement on the deceased donor waiting list. Time to follow-up was defined as start of dialysis to placement on waiting list or censor date (end of study or death).

[d] Univariate Cox proportional hazard model determined the association between patient- and facility-level characteristics and receipt of a living donor kidney transplant. Time to follow-up was defined as start of dialysis to living donor kidney transplant or censor date (end of study or death).

[e] Univariate Cox proportional hazard model determined the association between patient- and facility-level characteristics receipt of a deceased donor kidney transplant. Time to follow-up was defined as start of dialysis to deceased donor kidney transplant or censor date (end of study or death).

[f] Patients were assigned to the last dialysis facility from which they were receiving treatment when the outcome event of interest occurred.

[g] Defined as Asian, Middle Eastern, Native American, Pacific Islander, or multiracial.

[h] There were missing data for 121 115 patients (7.6%).

[i] This category was collected and defined on the CMS-2728 form and was not further defined.

[j] There were missing data for 7944 patients (0.5%).

[k] Calculated as weight in kilograms divided by height in meters squared.

[l] There were missing data for 587 744 patients (36.9%).

[m] Obtained from item 27 on the CMS-2728 form. The attending physician recorded no if the patient had not been informed of their transplant options and entered all the reasons why a kidney transplant was not an option for the patient at that time.

[n] Obtained from the Dialysis Facility Report, 2013-2016.

[o] Network 1: Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont; Network 2: New York; Network 3: New Jersey; and Network 4: Delaware and Pennsylvania.

[p] Network 5: District of Columbia, Maryland, Virginia, and West Virginia; Network 6: Georgia, North Carolina, and South Carolina; Network 7: Florida; Network 8: Alabama, Mississippi, and Tennessee; Network 13: Arkansas, Louisiana, and Oklahoma; and Network 14: Texas.

[q] Network 9/10: Illinois, Indiana, Kentucky, and Ohio; Network 11: Michigan, Minnesota, North Dakota, South Dakota, and Wisconsin; and Network 12: Iowa, Kansas, Missouri, and Nebraska.

[r] Network 15: Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming; Network 16: Alaska, Idaho, Montana, Oregon, and Washington; Network 17: Hawaii and northern California; and Network 18: southern California.

[s] Obtained from the US Department of Agriculture Rural and Urban Continuum Code. There were missing data for 127 712 patients (8.1%).

[t] Calculated using the dialysis facility address from Dialysis Facility Compare (2013-2016) and the nearest transplant center address from the Scientific Registry of Transplant Recipients. There were missing data for 341 693 patients (21.5%).

Table 3. Crude and Adjusted Hierarchical Cox Proportional Hazard Ratios Between Dialysis Facility Ownership and Placement on the Deceased Donor Kidney Transplantation Waiting List, Receipt of a Living Donor Kidney Transplant, or Deceased Donor Kidney Transplant by Patient-Level and Facility-Level Characteristics, 2000-2016[a]

| | Cumulative Incidence Difference, % (95% CI)[b] | | | Hazard Ratio (95% CI) | | | |
|---|---|---|---|---|---|---|---|
| | At 3 y | At 5 y | At 10 y | Crude Model (n = 1 585 947) | Adjusted for Demographics (n = 1 585 947)[c] | + Clinical Characteristics (n = 1 585 947)[d] | + Socioeconomic and Geographic Characteristics (n = 1 585 947)[e] |
| **Placement on Deceased Donor Kidney Transplantation Waiting List (n = 230 202)** | | | | | | | |
| Nonprofit dialysis facilities | | | | | | | |
| Small chains | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| Independent | 0.3 (−0.1 to 0.6) | 0.3 (−0.1 to 0.6) | 0.5 (0.1 to 0.9) | 1.02 (1.00 to 1.05) | 0.98 (0.96 to 1.01) | 0.99 (0.97 to 1.01) | 0.93 (0.91 to 0.96) |
| For-profit dialysis facilities | | | | | | | |
| Large chain 1 | −2.1 (−2.3 to −1.8) | −2.0 (−2.3 to −1.8) | −1.8 (−2.0 to −1.5) | 0.87 (0.86 to 0.88) | 0.86 (0.85 to 0.88) | 0.85 (0.84 to 0.86) | 0.84 (0.82 to 0.85) |
| Large chain 2 | −2.6 (−2.8 to −2.4) | −2.7 (−3.0 to −2.5) | −2.6 (−2.9 to −2.4) | 0.84 (0.82 to 0.85) | 0.86 (0.84 to 0.87) | 0.87 (0.86 to 0.89) | 0.86 (0.85 to 0.88) |
| Small chains | −2.3 (−2.6 to −2.1) | −2.4 (−2.6 to −2.1) | −2.2 (−2.5 to −2.0) | 0.85 (0.84 to 0.87) | 0.84 (0.83 to 0.86) | 0.84 (0.83 to 0.86) | 0.85 (0.83 to 0.86) |
| Independent | −3.5 (−3.8 to −3.2) | −3.7 (−4.0 to −3.4) | −3.7 (−4.0 to −3.4) | 0.79 (0.77 to 0.81) | 0.81 (0.79 to 0.83) | 0.82 (0.81 to 0.84) | 0.79 (0.77 to 0.80) |
| All facilities | | | | | | | |
| Nonprofit | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| For-profit | −2.5 (−2.7 to −2.3) | −2.6 (−2.8 to −2.4) | −2.5 (−2.7 to −2.3) | 0.84 (0.83 to 0.85) | 0.86 (0.85 to 0.87) | 0.86 (0.85 to 0.87) | 0.87 (0.86 to 0.88) |
| **Receipt of a Living Donor Kidney Transplant (n = 39 767)** | | | | | | | |
| Nonprofit dialysis facilities | | | | | | | |
| Small chains | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| Independent | 0.4 (0.3 to 0.6) | 0.5 (0.3 to 0.7) | 0.6 (0.4 to 0.8) | 1.16 (1.10 to 1.22) | 1.11 (1.05 to 1.17) | 1.10 (1.05 to 1.16) | 1.04 (0.99 to 1.09) |
| For-profit dialysis facilities | | | | | | | |
| Large chain 1 | −0.6 (−0.7 to −0.5) | −0.7 (−0.8 to −0.5) | −0.6 (−0.7 to −0.5) | 0.80 (0.77 to 0.83) | 0.84 (0.81 to 0.87) | 0.84 (0.81 to 0.88) | 0.83 (0.80 to 0.86) |
| Large chain 2 | −0.6 (−0.7 to −0.5) | −0.7 (−0.8 to −0.6) | −0.7 (−0.8 to −0.5) | 0.81 (0.78 to 0.84) | 0.85 (0.82 to 0.88) | 0.89 (0.85 to 0.92) | 0.84 (0.81 to 0.87) |
| Small chains | −0.9 (−1.0 to −0.8) | −0.9 (−1.1 to −0.8) | −0.9 (−1.1 to −0.8) | 0.72 (0.69 to 0.75) | 0.78 (0.74 to 0.81) | 0.79 (0.76 to 0.83) | 0.83 (0.79 to 0.86) |
| Independent | −0.9 (−1.0 to −0.7) | −0.9 (−1.1 to −0.8) | −0.9 (−1.1 to −0.8) | 0.74 (0.71 to 0.78) | 0.84 (0.80 to 0.88) | 0.87 (0.82 to 0.91) | 0.86 (0.82 to 0.91) |
| All facilities | | | | | | | |
| Nonprofit | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| For-profit | −0.8 (−0.9 to −0.8) | −0.9 (−1.0 to −0.8) | −0.9 (−1.0 to −0.8) | 0.74 (0.72 to 0.76) | 0.8 (0.78 to 0.82) | 0.82 (0.80 to 0.84) | 0.82 (0.80 to 0.84) |

(continued)

Table 3. Crude and Adjusted Hierarchical Cox Proportional Hazard Ratios Between Dialysis Facility Ownership and Placement on the Deceased Donor Kidney Transplantation Waiting List, Receipt of a Living Donor Kidney Transplant, or Deceased Donor Kidney Transplant by Patient-Level and Facility-Level Characteristics, 2000-2016[a] (continued)

| | Cumulative Incidence Difference, % (95% CI)[b] | | | Hazard Ratio (95% CI) | | | |
|---|---|---|---|---|---|---|---|
| | At 3 y | At 5 y | At 10 y | Crude Model (n = 1 585 947) | Adjusted for Demographics (n = 1 585 947)[c] | + Clinical Characteristics (n = 1 585 947)[d] | + Socioeconomic and Geographic Characteristics (n = 1 585 947)[e] |
| **Receipt of a Deceased Donor Kidney Transplant (n = 88 431)** | | | | | | | |
| Nonprofit dialysis facilities | | | | | | | |
| Small chains | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| Independent | −0.3 (−0.4 to −0.1) | −0.4 (−0.6 to −0.2) | 0 (−0.2 to 0.3) | 0.95 (0.91 to 0.98) | 0.92 (0.89 to 0.96) | 0.93 (0.90 to 0.97) | 0.89 (0.86 to 0.93) |
| For-profit dialysis facilities | | | | | | | |
| Large chain 1 | −1.0 (−1.1 to −0.9) | −1.5 (−1.7 to −1.4) | −1.5 (−1.7 to −1.3) | 0.79 (0.77 to 0.81) | 0.8 (0.78 to 0.82) | 0.8 (0.78 to 0.82) | 0.78 (0.76 to 0.80) |
| Large chain 2 | −0.9 (−1.0 to −0.7) | −1.4 (−1.5 to −1.2) | −1.6 (−1.8 to −1.4) | 0.82 (0.80 to 0.84) | 0.84 (0.82 to 0.86) | 0.87 (0.85 to 0.89) | 0.82 (0.80 to 0.84) |
| Small chains | −1.0 (−1.2 to −0.9) | −1.7 (−1.9 to −1.5) | −1.7 (−1.9 to −1.5) | 0.78 (0.76 to 0.80) | 0.8 (0.78 to 0.82) | 0.80 (0.78 to 0.82) | 0.80 (0.78 to 0.83) |
| Independent | −1.4 (−1.6 to −1.3) | −2.4 (−2.6 to −2.2) | −2.7 (−2.9 to −2.4) | 0.70 (0.67 to 0.72) | 0.74 (0.72 to 0.77) | 0.76 (0.73 to 0.79) | 0.73 (0.71 to 0.76) |
| All facilities | | | | | | | |
| Nonprofit | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| For-profit | −0.9 (−1.0 to −0.8) | −1.4 (−1.5 to −1.3) | −1.7 (−1.8 to −1.5) | 0.81 (0.80 to 0.83) | 0.84 (0.82 to 0.85) | 0.84 (0.83 to 0.86) | 0.83 (0.81 to 0.84) |

[a] Patients were assigned to the last dialysis facility from which they were receiving treatment when the outcome event of interest occurred.

[b] Calculated using the Aalen-Johansen estimator and was adjusted for competing risk of death.

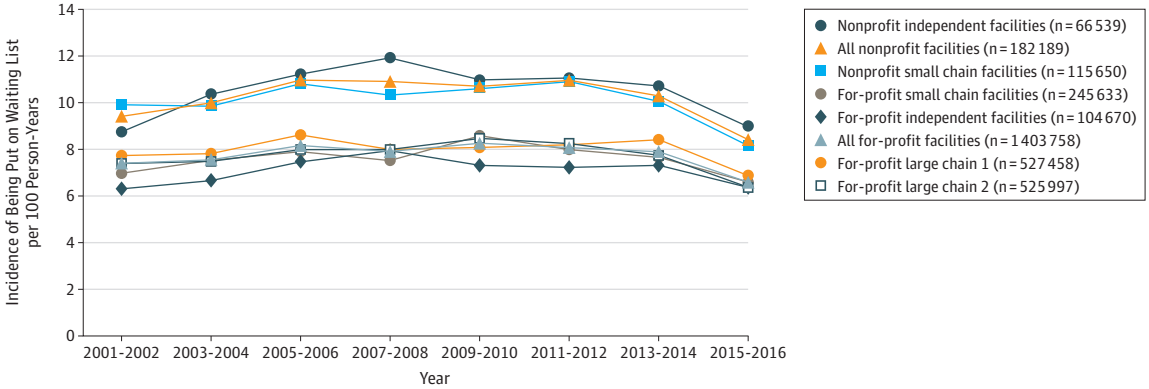
[c] Age, sex, and race reported at dialysis start.

[d] Body mass index greater than 35, attributed cause of end-stage kidney disease, congestive heart failure, atherosclerotic heart disease, other cardiac disease, cerebrovascular disease, peripheral vascular disease, hypertension, diabetes, chronic obstructive pulmonary disease, tobacco use, cancer reported at dialysis start, and type of dialysis. Multiple imputation was used because of missing data for type of dialysis (7805 patients; 0.5%).

[e] End-Stage Renal Disease Network geographic area of assigned facility; insurance coverage reported at dialysis start; facility located in metropolitan, rural-urban classification; distance from assigned dialysis facility to the nearest transplant center; and not informed of transplant options due to medical reasons. Multiple imputation was used because of missing data for insurance coverage (121 115 patients; 7.6%); nephrology care before ESKD (584,744 patients; 36.9%); type of dialysis (7944 patients; 0.5%); distance from assigned dialysis facility to nearest transplant center (341 693 patients; 21.5%); and metropolitan, rural-urban classification (127 712 patients; 8.0%).

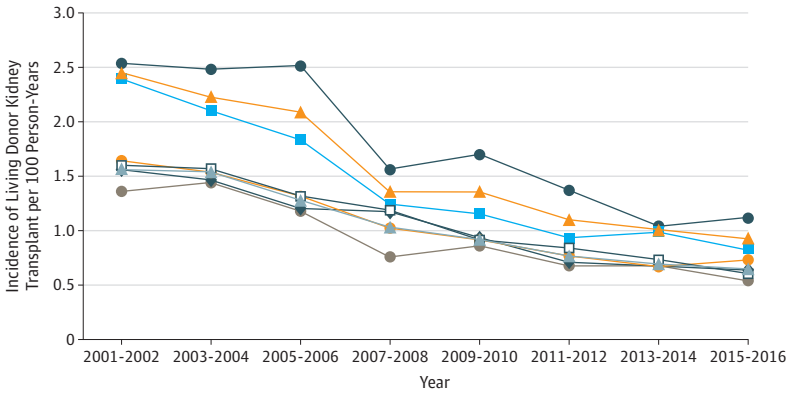
Figure 2. Two-Year Incidence Rates and Rate Differences for Kidney Transplant, 2001-2016

A Placement on deceased donor kidney transplantation waiting list



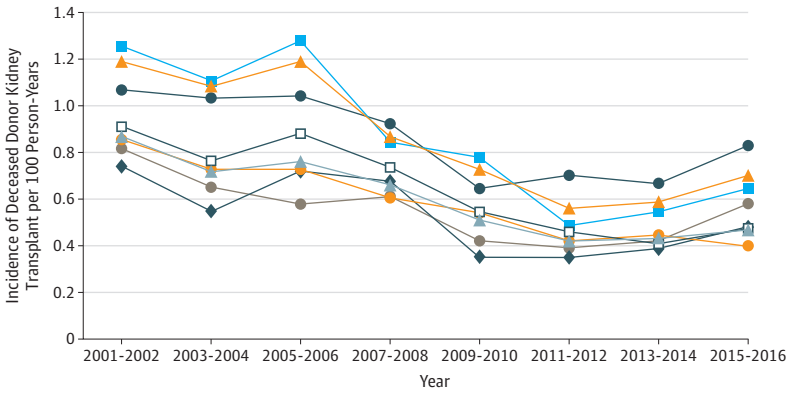

| Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| All nonprofit facilities | 9.48 | 10.03 | 10.96 | 10.90 | 10.75 | 10.96 | 10.29 | 8.39 |
| All for-profit facilities | 7.40 | 7.57 | 8.16 | 7.93 | 8.26 | 8.07 | 7.93 | 6.56 |
| Rate differences | -2.08 | -2.46 | -2.80 | -2.97 | -2.49 | -2.89 | -2.36 | -1.83 |

B Receipt of a living donor kidney transplant




| Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| All nonprofit facilities | 2.45 | 2.23 | 2.08 | 1.35 | 1.36 | 1.10 | 1.01 | 0.92 |
| All for-profit facilities | 1.57 | 1.53 | 1.28 | 1.04 | 0.91 | 0.77 | 0.69 | 0.65 |
| Rate differences | -0.88 | -0.70 | -0.80 | -0.31 | -0.45 | -0.33 | -0.32 | -0.27 |

C Receipt of deceased donor kidney transplant




| Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| All nonprofit facilities | 1.19 | 1.08 | 1.19 | 0.86 | 0.73 | 0.56 | 0.59 | 0.70 |
| All for-profit facilities | 0.87 | 0.72 | 0.76 | 0.66 | 0.51 | 0.42 | 0.43 | 0.47 |
| Rate differences | -0.32 | -0.36 | -0.43 | -0.20 | -0.22 | -0.14 | -0.16 | -0.23 |

Follow-up time was truncated on December 31 of each 2-year period. The unadjusted 2-year incidence rates (per 100 person-years) for placement on the deceased donor waiting list, receipt of a living donor kidney transplant, and receipt of a deceased donor kidney transplant were calculated by dividing the count of events for incident patients by the number of incident patients in the dialysis facility ownership group for each interval. The 2-year incident rate differences (per 100 person-years) were calculated between all nonprofit facilities and all for-profit facilities.

and receipt of a deceased donor kidney transplant (−2.9% [95% CI, −3.2% to −2.6%]). The sensitivity analyses found consistent results of lower rates for each outcome among nonprofit facilities vs for-profit facilities regardless of geographic area (eTable 4 in the Supplement). A reclassification based on either transplant center–affiliated dialysis facilities (eTable 5 in the Supplement) or hospital-affiliated dialysis facilities (eTable 6 in the Supplement) by profit status showed similar associations between nonprofit facilities and placement on the deceased donor kidney transplantation waiting list, receipt of a living donor kidney transplant, and receipt of a deceased donor kidney transplant.

## Discussion

Among US patients with incident ESKD, nonprofit dialysis facilities had a higher percentage of patients who were placed on the deceased donor kidney transplantation waiting list, who received a living donor kidney transplant, and who received a deceased donor kidney transplant compared with the other dialysis facility ownership categories. However, the differences between nonprofit and other dialysis facility ownership categories for all outcomes were small.

To our knowledge, no studies have examined the relationship between dialysis facility profit status and both a living donor or a deceased donor kidney transplantation, and only 2 studies have examined the relationship between facility profit status and placement on the deceased donor kidney transplantation waiting list, reporting that patients were less likely to be waitlisted if initially treated at for-profit dialysis facilities vs nonprofit facilities.[8,9] This study extends the work of Zhang et al[8] by using hierarchical survival analysis to examine how dialysis facility ownership is associated with living donor and deceased donor kidney transplant and placement on the deceased donor kidney transplantation waiting list in a large national cohort of patients with ESKD from 2000 to 2016.

A strength of this analysis vs prior research was a novel approach of assigning dialysis facilities to patients. Nearly 23.0% of patients switched dialysis facilities during follow-up; however, only 3.3% of patients switched dialysis facilities by profit status. Recognizing this fact, the typically short follow-up these patients have with their initial dialysis facilities (median, 1.1 years), and the intensity of clinical follow-up leading up to placement on the deceased donor kidney transplantation waiting list or receipt of a kidney transplant (median, 2.3 years to transplantation), indicate that the last facility where a patient was treated may be more representative of the preparatory transplant care he or she receives.

Patients undergoing home dialysis also were included in this study (9.4% of cohort). Patients who receive home dialysis are more likely to undergo transplantation,[18,19] but previous studies have excluded these patients.[8,9]

The sensitivity analysis that stratified patients by dialysis facility switch status showed that patients switching from nonprofit facilities to for-profit facilities were less likely to access transplantation vs patients who started and remained at the same nonprofit facility. The 2-year incidence rates for receipt of a living donor and a deceased donor kidney transplant decreased each year, and the incidence rate for placement on the deceased donor kidney transplantation waiting list increased from 2001-2014 and then decreased in 2015, congruent with declines observed in national reports.[2,20] The decrease in placement on the deceased donor kidney transplantation waiting list since the new kidney allocation system took place in December 2014 is similar to the decline reported in the study by Zhang et al[21] of 3.45 waitlisted events per month per 10 000 patients with ESKD. The profit-status disparity in the 2-year incidence rates for each outcome of interest persisted every year within this 17-year study cohort despite research identifying this problem nearly 2 decades ago.[9]

In 2014, the CMS began administering the In-Center Hemodialysis Consumer Assessment of Healthcare Providers and Systems (ICH CAHPS) survey to collect patient-reported satisfaction.[22] The Dialysis Facility Compare website allows users to review patient satisfaction scores for local facilities and state- and national-level metrics under the "survey of patients experiences" tab. Based on the ICH CAHPS survey responses, only an estimated 67% of patients reported that their nephrologists "always communicated well and cared for them as a person."[23] These national data are similar to previous reports that more than 30% of incident patients with ESKD were uninformed of transplant options[24] and nephrologists working at for-profit dialysis facilities were significantly less likely to spend longer than 20 minutes with their patients, counsel their patients about transplantation, or involve family members in the discussion.[10]

Clinician-level barriers, including clinician perception of the appropriateness of the possible transplantation,[25-27] poor medical follow-up, time spent with patients,[10] and format of transplant education,[10] may lead to delays in access to transplantation, and could explain some of these findings, but are unmeasured in national data. Additional barriers, such as resource allocation of staffing to enable transplant education, could also play a role because prior research found that increased staff may improve access to kidney transplantation.[7] Although this study reported more staff and social workers per patient at for-profit facilities vs nonprofit facilities, these findings did not explain the observed associations.

### Limitations

This study has several limitations. First, given the availability of the data, it was not possible to determine the differences between profit status and chain affiliations regarding staffing resources,[10,24,25,28,29] education policies,[30-33] and transplant referral practices,[34,35] all of which may be associated with increased access to kidney transplantation.

Second, although this analysis clustered dialysis facility ownership categories, we were unable to account for the nonrandom geographical location of for-profit and nonprofit chains, which may lead to unmeasured differences in patient characteristics across profit status categories.

Third, it is difficult to capture steps in the transplantation process that precede placement on the deceased donor kidney transplantation waiting list or receipt of a living donor or a deceased donor kidney transplant, such as transplant evalu-

ation or referral for a transplant evaluation, and the effects may not be consistent by transplant step. A study by Patzer et al[34] found that, among patients with ESKD in Georgia, the patients treated at for-profit facilities were more likely to be referred for a kidney transplant evaluation compared with patients treated at nonprofit facilities (odds ratio, 1.51 [95% CI, 1.20-1.91]), and there was no difference in placement on the deceased donor kidney transplantation waiting list among those referred within 1 year (odds ratio, 1.09 [95% CI, 0.83-1.44]). The sensitivity analyses found the association between profit vs nonprofit facilities and access to transplantation was consistent across all geographic areas; however, further research on transplant referral would permit analyses examining geographic differences in steps more closely aligned with dialysis facility behavior.[36]

Fourth, because of the wide variations in placement on the deceased donor kidney transplantation waiting list and in the practices of transplant centers across the United States,[37,38] and the limitation of patient-level data collected at the start of dialysis, this study was unable to identify the patients truly eligible for transplantation. The sensitivity analysis of an ideal kidney transplantation cohort showed higher cumulative incidence differences and relative risks reporting the profit status disparity as presented in our primary analysis.

Fifth, the inclusion of dialysis facility staff–reported race/ethnicity could create a misclassification bias. However, Roach et al[39] found high agreement between staff-reported race on the CMS-2728 form and patient-reported race in the Medicare enrollment database.

Sixth, the differences in the primary outcomes between for-profit and nonprofit facilities were small (0.9% to 2.6%). Given the observational nature of this study, residual confounding is of concern.

## Conclusions

Among US patients with end-stage kidney disease, receiving dialysis at for-profit facilities compared with nonprofit facilities was associated with a lower likelihood of accessing kidney transplantation. Given the possibility of residual confounding, the clinical and policy implications of the results are uncertain.

### ARTICLE INFORMATION

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**Author Contributions:** Drs Gander and Patzer 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.
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