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Patient Frailty and Functional Use of Hemodialysis Vascular Access: A Retrospective Study of the US Renal Data System

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Abstract

Rationale & Objective: Despite the high prevalence of frailty among dialysis patients, it is unknown whether frailty is associated with dialysis vascular access failure. This study examined the association between frailty and functional use of vascular access.

Study Design: Retrospective observational study.

Setting & Participants: Patients who initiated hemodialysis through a tunneled catheter in the US Renal Data System database from 2012 through 2017 and underwent subsequent creation of an arteriovenous fistula or graft.

Predictors: The "claims-based frailty indicator" (CFI) was calculated using a validated claims-based disability status model anchored to a well-described frailty phenotype.

Outcomes: Time to functional use for fistulas and grafts defined as the time from initiation of hemodialysis to treatments using the index vascular access with 2 needles.

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Supplementary Material

Supplementary File (PDF)

Analytical Approach: Fine and Gray competing risk models separately examining fistula and graft outcomes. Patient survival was modeled for the entire cohort using Cox proportional hazards regression.

Results: A total of 41,471 patients met inclusion criteria, including 33,212 who underwent fistula creation and 8,259 who underwent graft placement. Higher CFI quartiles were associated with a greater rate of mortality. Patients in the highest CFI quartile had more than 2 times the rate of mortality compared with patients in the lowest CFI quartile (hazard ratio [HR], 2.49 [95% CI, 2.41–2.58]). In multivariable analyses, the highest CFI quartile was significantly associated with longer time to functional use of fistulas (HR, 0.65 [95% CI, 0.62–0.69]) and grafts (HR, 0.88 [95% CI, 0.79–0.98]).

Limitations: Generalizability may be limited by the requirement of 12 months of Medicare claims availability before initiation of dialysis. There were no data on patient anatomic characteristics or surgeon characteristics and limited patient-specific sociodemographic data.

Conclusions: Higher degrees of frailty are associated with longer times to vascular access functional use. Frailty may be useful for informing clinical decision-making regarding choice of vascular access.

Frailty is defined as "a clinically recognizable state of increased vulnerability resulting from aging-associated decline in reserve and function across multiple physiologic systems such that the ability to cope with everyday or acute stressors is compromised."[1] More than 75% of patients receiving maintenance dialysis for kidney failure who are older than 60 years meet the criteria for frailty.[2–4] Frailty is associated with a more than 2-fold increase in 1-year mortality rate among patients receiving maintenance dialysis[2] and an increased risk of postoperative morbidity and mortality in patients undergoing oncologic, neurologic, colorectal, orthopedic, and vascular operations.[5–9] Frailty is an independent predictor of postoperative complications, including anastomotic leak after oncologic gastrointestinal surgery,[5] loosening and dislocation of the endoprosthesis after hip replacement,[8] and amputation after revascularization for chronic limb-threatening ischemia.[10]

Recent data demonstrate fistula nonmaturation rates as high as 60% within 5 months after the index operation.[11] Fistula maturation requires a number of physiologic processes to occur, including increase in blood volume flow, dilation of the fistula, and thickening of the fistula wall, that could be negatively affected by frailty. Despite the high prevalence of frailty among dialysis patients, it is unknown whether frailty is associated with dialysis vascular access failure. This study examined the association between frailty and vascular access outcomes.

Methods

Data and Population

Among patients who initiated hemodialysis with a dialysis catheter, we studied the association between frailty and the time to a mature access. We followed patients from the placement of their first fistula or graft (time zero) to functional use. We considered patients for study inclusion who initiated dialysis per the US Renal Data System (USRDS) database from January 1, 2012, through October 31, 2015. We linked patients' dialysis facility zip codes to local sociodemographic data using 5-year summary estimates from the American Community Survey,[12] a nationwide survey that collects and produces information on social, economic, housing, and demographic characteristics about the US population every year.

We imposed 6 inclusion criteria, beginning with (1) 12 months of fee-for-service Medicare coverage (Parts A and B as the primary payer) before the first day of dialysis; this was required because we used fee-for-service Medicare claims to compute a frailty score. Patients were also required (2) to have initiated hemodialysis with a tunneled catheter and (3) to have no fistula or graft creation in the 12 months before the start of dialysis. (4) Patients were not included who had a recorded maturing fistula/graft at initiation of dialysis, the most common clinical scenario in the United States. Restrictions 3 and 4 made it exceedingly unlikely that patients in our sample had a fistula/graft placement before initiating dialysis. (5) Creation of a fistula or graft after the initiation of hemodialysis was required to exclude patients who never had a fistula or graft placed after initiation of hemodialysis through a tunneled catheter. Finally, (6) analysis was restricted to the first episode of dialysis in patients who did not previously receive a kidney transplant. We followed patients through May 2018, the extent of CROWNWeb data availability in our dataset.

This study was approved by the University of Southern California Institutional Review Board (HS-18–00530). The requirement for individual-level informed consent was waived by the board because this was a study of deidentified data.

Variables

Our main outcomes were overall survival and time to functional use of a fistula or graft after placement (maturation). The baseline period (time zero) for each patient was the time of placement of the fistula or graft. We defined time to functional use as the amount of elapsed time between placement of the fistula or graft (baseline period) and hemodialysis using the index vascular access with 2 needles. We identified the index vascular placement using the Current Procedure Terminology codes 36818, 36819, 36820, 36821, and 36825 for fistulas and 36830 for grafts. We identified revision procedures using codes 36831, 36832, and 36833 for open surgical revisions and 36145, 75790, 36147, 36870, 35476, 75978, 35475, 75791, 75962, 37205, 75960, G0393, and G0392 for endovascular revisions. We used data from the CROWNWeb database to identify the month and year when a patient first used the vascular access with 2 needles. CROWNWeb began collecting monthly data on vascular access use for all patients undergoing maintenance dialysis irrespective of insurance coverage in 2012. Patients were followed until the end of the observation period (May 2018) or when they switched to peritoneal dialysis, received a successful kidney transplant, underwent repeat access creation before functional use of the index fistula/graft, or died, whichever occurred first.

The primary regressor (exposure) of interest was frailty. We calculated frailty scores by modifying a claims-based disability status model created by Segal et al for the dialysis population.[13,14] This model is the only validated model that calculates frailty using Medicare claims data and is anchored to a well-established frailty phenotype (as described by Fried et al[15]). The Segal model calculates the "claims-based frailty indicator" (CFI), which yields a continuous value with a minimum of 0 and a maximum of 1 (Table S1). Higher scores indicate greater frailty. The model uses claim diagnosis codes and procedure codes (International Classification Diseases, Ninth Revision, and Current Procedure Terminology/Healthcare Common Procedure Coding System codes) in categories of preventive services, evaluation and management visits, inpatient and outpatient encounters, minor or ambulatory procedures, major procedures, imaging, durable medical equipment use, and "other" to predict frailty. When Segal et al validated the model in a cancer population, the authors omitted indicators for malignancy. Following the same rationale, we included an indicator for malignancy and dropped the indicator for kidney disease. We treated the CFI as a categorical variable by dividing the population into quartiles. An analysis of the CFI and mortality was performed to assess whether the association between CFI and mortality was consistent with previously published results of frailty and mortality in the maintenance dialysis population.

The control variables were patient characteristics, dialysis facility characteristics, Medicare/ Medicaid dual eligibility, and facility-level zip code sociodemographic characteristics. Because patients might have varying durations of catheter dependence at the time of fistula/ graft placement (time zero), we included dialysis vintage at the time of fistula/graft creation, defined as the time from hemodialysis initiation to fistula/graft creation. Increasing time spent undergoing dialysis through a tunneled catheter may serve as a proxy for a number of factors, including access to care,[16] and may contribute to worse outcomes after vascular access creation.[17] Dialysis facility characteristics were obtained from the annual facility survey (Centers for Medicare & Medicaid Services form 2744), which provides the total number of patients and staffing full-time equivalents. We omitted comorbidities from the control variables because they are represented in the frailty index.

Statistical Analyses

Descriptive statistics were performed of patient demographic characteristics, comorbidities, dialysis facility characteristics, and zip code sociodemographic characteristics. Age was treated as a categorical variable based on clinically relevant categories of age. Time to functional use of fistulas and time to functional use of grafts were modeled in 2 separate cohorts using competing risk models following the Fine and Gray model,[18] with death before functional use of the fistula/graft modeled as a competing risk. Overall survival was modeled for the entire cohort using Cox proportional hazards models.

A number of sensitivity analyses were performed. The first limited the population to those 65 years and older. Those who qualify for Medicare before age 65 years and before dialysis dependence are disabled, have a higher comorbidity burden, and may have a higher risk of fistula nonmaturation. Inclusion of this population could bias the results toward lower rates of functional use. The second sensitivity analysis was performed by censoring those who had a new vascular access created before functional use at the end of the study period instead of at the time of new vascular access creation. Those who have another access created before achieving functional use of the index access were likely deemed as having failed index accesses. However, because we modeled the outcome of achieving functional use, the outcome was not achieved in these patients, and they could be censored at the time of a second access creation or at the end of the study period. Third, because the rate of functional graft use appeared low relative to published literature, we conducted a sensitivity analysis in which we considered reporting in CROWNWeb of "fistula utilization with two needles" after placement of a graft as evidence that the graft achieved functional use. All analyses were conducted using SAS 9.4 software (SAS Institute).

Results

Study Population

A total of 41,471 patients met inclusion criteria: 33,212 who received a fistula after initiating dialysis and 8,259 who received a graft after initiating dialysis (Fig 1). Among patients who underwent fistula creation, functional use of the fistula was achieved within the observation period in 18,895 (57%), compared with 5,604 (68%) in the graft group. The mean CFI score for the entire population was 0.17 (range, 0.0004–0.94). The minimum cutoff values for the second, third, and fourth quartiles were 0.06, 0.12, and 0.23, respectively. The prevalence of comorbidities increased with increasing CFI quartile, whereas dialysis facility characteristics varied by CFI quartile without clear trends by quartile (Table S2).

Time to Functional Use After Fistula Creation

The median CFI score in the group of patients who received a fistula was 0.10 (interquartile range, 0.05–0.20). The likelihood of being in a higher CFI quartile was greater with older age (Table 1). Patients in the highest frailty quartile were more likely to be female and had a high prevalence of comorbidities: malignancy (19%), congestive heart failure (72%), diabetes (67%), and peripheral vascular disease (24%; Table S3).

Among patients in the lowest frailty quartile, 59% and 72.7% were using their fistulas within 6 and 12 months of creation, respectively (Fig 2). The median time to fistula use for patients in whom functional use was achieved within 12 months of creation was 98 days. In contrast, in patients in the highest frailty quartile, 47.2% and 59.3% were using their fistulas within 6 and 12 months of creation, respectively.

On multivariable analysis of patients who underwent fistula creation, CFIs in higher quartiles were significantly associated with longer time to functional use in a dose-response manner (Table 2). Female sex was associated with a 23% (95% CI, 21%–25%) lower likelihood of functional use. Use of a hospital-based dialysis facility was also associated with lower likelihood of functional use. Increasing age, Asian (non-Hispanic) race, Hispanic ethnicity, and not-for-profit status of the dialysis facility were associated with shorter time to functional use, as was patient-to-staff ratio greater than 4.

Before achieving functional fistula use, 25% of patients required a revision procedure. Among patients in the highest frailty quartile, 25.4% underwent at least one revision before functional use, compared with 22.9% in the lowest frailty quartile. Those who required a revision procedure underwent a mean of 2.7 procedures. Among patients in the lowest frailty quartile, 6.4% and 18% died before using their fistula within 6 and 12 months of creation, respectively (Fig 2). Of patients in the highest frailty quartile, 9% and 24.2% died before using their fistula within 6 and 12 months of creation, respectively.

Time to Functional Use After Graft Creation

The median CFI score in the group of patients who received grafts was 0.14 (interquartile range, 0.07–0.26). Increasing age was associated with a greater likelihood of being in a higher CFI quartile (Table 3). Patients in the highest CFI quartile were significantly more likely to be female. Patients in the highest frailty quartile also had high prevalences of comorbidities: malignancy (18%), congestive heart failure (69%), diabetes (67%), and peripheral vascular disease (23%; Table S4).

Among patients in the lowest frailty quartile, 67.5% and 71.6% were using their graft within 6 and 12 months of creation, respectively (Fig 3). The median time to graft use for patients in whom functional graft use was achieved within 12 months of creation was 45 days. Of patients in the highest frailty quartile, 66.3% and 69.3% were using their grafts within 6 and 12 months of creation, respectively.

On multivariable analysis of patients who underwent graft placement, CFI was not associated with time to functional use except in the highest quartile (hazard ratio [HR], 0.88 [95% CI, 0.79–0.99]; Table 4). Increasing age and not-for-profit status of the dialysis facility were significantly associated with shorter time to functional use. A hospital-based dialysis facility setting was significantly associated with longer time to functional use.

Before achieving functional graft use, 9% of patients required a revision procedure. Of the patients in the highest frailty quartile, 8.1% underwent at least one revision before functional use, compared with 9.4% in the lowest frailty quartile. Those who required a revision procedure underwent a mean of 3.1 procedures. Among patients in the lowest frailty quartile, 7.6% and 15.1% died before using their graft within 6 and 12 months of creation, respectively (Fig 3). Of patients in the highest frailty quartile, 10.1% and 18.1% died before using their graft within 6 and 12 months of creation, respectively.

Overall Mortality

Among patients in the lowest frailty quartile, 14% and 22.4% died within 6 and 12 months of their first hemodialysis session, respectively (Fig 4). Of patients in the highest frailty quartile, 22.4% and 50.5% died within 6 and 12 months of their first hemodialysis session, respectively.

On multivariable analysis, increasing CFI quartile was associated with increasing risk of mortality in a dose-response fashion (Table 5). Patients in the highest CFI quartile had more than 2 times the risk of mortality as patients in the lowest CFI quartile (HR, 2.46 [95% CI, 2.38–2.55]). Female sex and non-White race were associated with lower risk of mortality, as was Medicare/Medicaid dual eligibility.

Sensitivity Analyses

Our results were robust to all sensitivity analyses. The analysis of the fistula population limited to those aged 65 years or older demonstrated no difference in the HR values for the frailty quartiles compared with the base analysis (Table S5). The analysis of the graft population limited to those aged 65 years or older demonstrated small relative differences in the HR values for the frailty quartiles compared with the base analysis, with the values remaining statistically nonsignificant (Table S6).

The analysis of the fistula population with those undergoing a second access creation before functional use of the index access censored at the end of the study period demonstrated small relative differences in the HR values for the frailty quartiles compared with the base analysis (HRs for quartile 4: 0.71 vs 0.66; HRs for quartile 3: 0.79 vs 0.76; Table S7). The same sensitivity analysis of the graft population demonstrated minimal differences in the HR values for the frailty quartiles compared with the base analysis, with the values remaining statistically nonsignificant (Table S8).

In 11.2% of all graft cases, we observed graft creation followed by reporting in CROWNWeb of fistula use with 2 needles (the analogous scenario was not observed for fistula creation). When we tested the sensitivity of our results to misclassifications in graft use, the 6-month rate of graft functional use increased from 67% to 74% in the lowest frailty quartile and from 66% to 71% in the highest frailty quartile. The 12-month rate of graft functional use increased from 70% to 74% in the lowest frailty quartile and from 68% to 74% in the highest frailty quartile. However, the change in classification did not change our results, with the overall association between CFI quartile and graft functional use being statistically nonsignificant ($P = 0.06$) and the HR values demonstrating minimal changes compared with the base model (Table S9).

Discussion

In this analysis, increased patient frailty, measured with a validated claims-based frailty index correlated with the Fried frailty score, was associated with lower likelihood of fistula functional use in a dose-response manner. Conversely, the association between frailty and lower likelihood of functional use of a graft was seen only in the highest CFI quartile. This is not surprising because the physiologic processes required for fistula maturation can be negatively affected by frailty. Grafts do not require these physiologic changes and require only that there be enough graft incorporation into the subcutaneous tissues before puncture to allow the puncture site to seal.

The probability of functional use of a fistula decreased with increasing CFI quartile (ie, increased frailty). Although the CFI has not been validated specifically in the dialysis population, the quartile cutoffs used in this study are consistent with the cutoffs suggested by Segal et al.[13,14] For instance, the cutoff for the third quartile in the present study (0.12) was exactly the value determined by Segal et al to have the highest sensitivity and specificity for identifying frailty.[13] The cutoff for the fourth quartile (0.23) was consistent with the cutoff value suggested by Segal et al (0.2) that was highly specific (91%) for frailty and significantly predicts 5-year mortality and 5-year hospital and nursing-home admissions. Consistent with other studies, the present study also demonstrated a dose-response increase in mortality, with the highest quartile of frailty associated with a nearly 250% increase in the risk of mortality.[2]

The recently revised NKF-KDOQI (National Kidney Foundation–Kidney Disease Outcomes Quality Initiative) clinical practice guideline for vascular access shifts recommendations away from a "fistula-first" approach toward a patient-centered approach that considers patient attributes and preferences.[19] The results of our study further emphasize the importance of individualizing vascular access decision-making to specific patient characteristics. Nevertheless, the Centers for Medicare & Medicaid Services (CMS) reimbursement policies continue to prioritize a fistula-first approach. The Quality Incentive Program includes a quality measure that rewards dialysis facilities with higher prevalence of patients undergoing dialysis through a fistula versus a graft.[20] Similarly, the Kidney Care Choices Model from the CMS Innovation Center, due to be implemented in 2022, also includes a measure related to an "optimal start" for dialysis that preferentially rewards a fistula-first practice. Our results suggest that frailty should be an important consideration in designing these payment models, and many patients, particularly those in the highest frailty quartiles, would not experience the putative benefits of a fistula-first policy.

Given the high 24-month mortality rates of patients in the third and fourth quartiles of frailty (57.9% and 67.8%, respectively), fistula creation might not be a reasonable consideration for many of these patients unless they have superior anatomy with a large-diameter nonsclerotic vein and a healthy inflow artery. Incorporating frailty could aid an already complex decision for patients who have high mortality and low access maturation rates. In addition to frailty, providers should consider other factors that may be associated with poor fistula maturation, including sex, race and ethnicity, diabetes, and peripheral vascular disease.[21–23] For some patients, the preferred first choice could be a graft, or, in the case of the most frail, a tunneled catheter. Further efforts to characterize the complex interaction of individual patient characteristics that predict mortality and likelihood of fistula maturation will aid in this decision-making process.

As a result of the study requirement of 12 months of Medicare claims availability before initiation of dialysis, the only patients who met the inclusion criteria were those older than 65 years or those who qualified for Medicare before age 65 years by virtue of disability. This excluded a majority of the hemodialysis population. It is possible that this may limit the generalizability of the study. However, the distribution of the CFI in our study population was consistent with the distribution described by Segal et al in the general populations that were included in their studies, suggesting that the studied population was representative of the dialysis population more generally with respect to frailty.[13] Although we excluded patients who had a fistula/graft creation during the 12 months of advanced chronic kidney disease before initiating dialysis, it is possible that there may be patients who had a fistula/graft for longer than 12 months. Given practice patterns in the United States, this clinical scenario is highly unlikely.

This retrospective study was subject to residual confounding by unmeasured factors that could not be adjusted for because of data limitations. The USRDS does not include data on patient anatomic characteristics or comorbidities not captured on intake or through billing codes; has limited patient-specific sociodemographic data beyond age, sex and race, and insurance status; and does not contain data on surgeon characteristics, anatomy, or prosthetic graft type, so these data could not be included in the analysis. It is possible that surgeons who are more skilled or have more experience may be able to achieve better vascular access outcomes irrespective of the patient characteristics. Further, the definition of functional use of vascular access in our study (successful hemodialysis using 2 needles in the vascular access) is limited by the information available from CROWNWeb. CROWNWeb does not include data on blood flow or treatment duration. It is possible that frail patients require reduced flow rates and longer treatment times to achieve the definition of functional use used in our study, but these nuanced data are not available from the dataset we used.

Because this was a retrospective cohort study, our results could have been confounded by selection bias; for instance, patients with a higher CFI were also more likely to undergo graft versus fistula creation. As such, the fistula and graft groups were analyzed separately. The sample size for the grafts was significantly smaller than for the fistulas. It is possible that the negative findings for the association between frailty and fistula functional use in the graft group represent a type II error due to limited statistical power. However, obtaining larger sample sizes of patients undergoing graft placement remains challenging because of the emphasis on fistulas and may require aggregation of data over longer periods of time. Because the USRDS did not begin collecting CROWNWeb data until 2012, obtaining additional data on graft use is difficult.

This study demonstrates that higher degrees of frailty are associated with longer times to fistula maturation. Frailty, if measured in a systematic clinical assessment, could be used to guide vascular access decision-making, and future studies of vascular access outcomes should include assessment of frailty. Efforts to identify an effective predictive model of fistula maturation failure should be continued.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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PLAIN-LANGUAGE SUMMARY

We examined outcomes after arteriovenous fistula and graft placement in patients who initiated hemodialysis and were recorded in the US Renal Data System database from January 1, 2012, through October 31, 2015. Patients were categorized into quartiles of frailty, which is a state of increased vulnerability resulting from decreased physiologic function. Our findings demonstrated that patients who were the most frail had a significantly lower likelihood of successfully using a fistula compared with patients who were the least frail. Patients who were the most frail were also at the highest risk of mortality, suggesting that patients who are the most frail may not derive benefit from creation of an arteriovenous fistula.

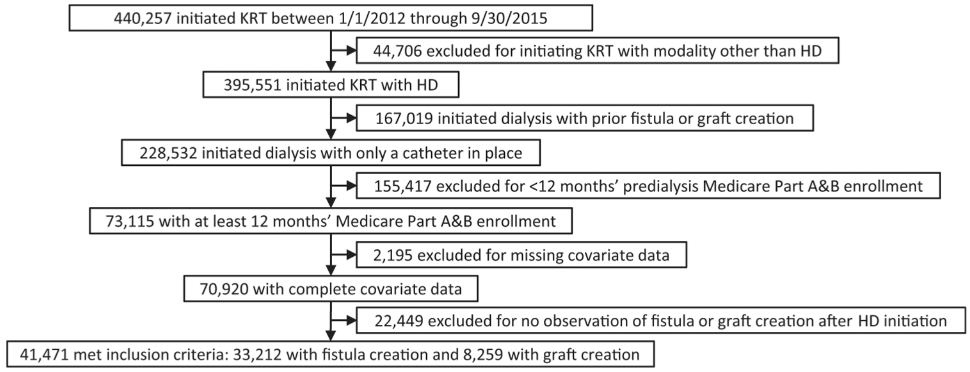

Figure 1.
Flow diagram of included and excluded cases.

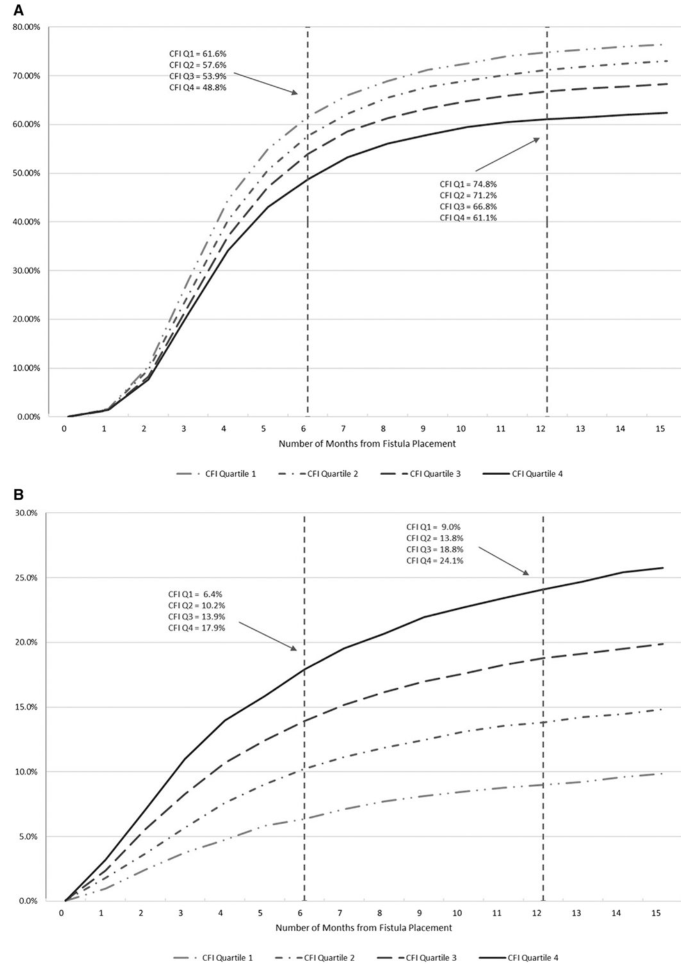

Figure 2.

Times to functional fistula use (A) and death before functional fistula use (B). Curves generated using the cumulative incidence function method. Abbreviation: CFI Q, claims-based frailty indicator quartile.

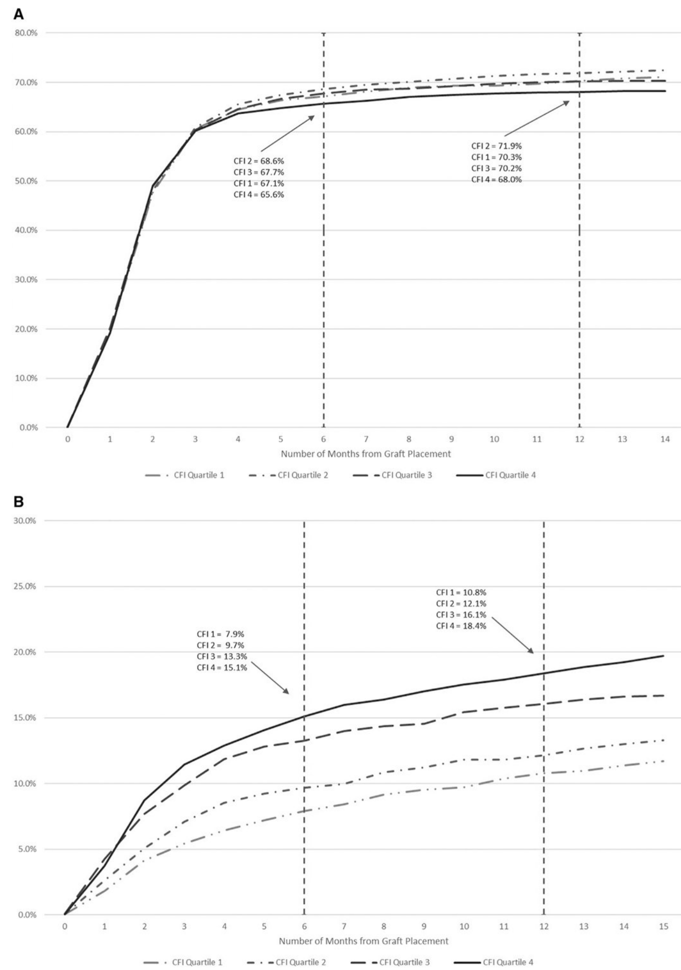

Figure 3.

Times to functional graft use (A) and death before functional graft use (B). Curves generated using the cumulative incidence function method. Abbreviation: CFI Q, claims-based frailty indicator quartile.

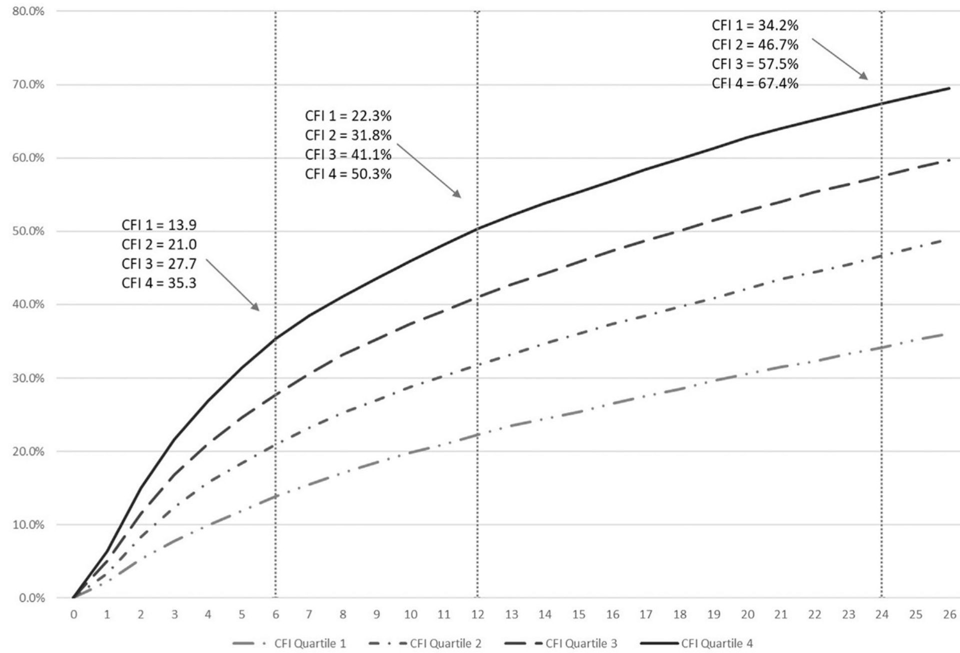

Figure 4.

Population mortality after first hemodialysis session. Curves generated using the cumulative incidence function method. Abbreviation: CFI Q, claims-based frailty indicator quartile.

Table 1.

Patient and Dialysis Facility Demographic Data for Fistula Group by Frailty Quartile

	CFI Quartile				
Characteristic	**1 (n = 9,578)**	**2 (n = 8,940)**	**3 (n = 8,025)**	**4 (n = 6,669)**	**P [a]**
Patient					
Age					<0.001
18–49 y	1,755 (18.3%)	35 (0.4%)	–[b]	–	
50–64 y	3,809 (39.8%)	1,480 (16.6%)	–	–	
65–74 y	3,777 (39.4%)	4,557 (51.0%)	2,797 (34.9%)	1,094 (16.4%)	
75–84 y	237 (2.5%)	2,809 (31.4%)	3,867 (48.2%)	3,472 (52.1%)	
≥85 y	0	59 (0.7%)	932 (11.6%)	2,018 (30.0%)	
Sex					<0.001
Male	6,371 (66.5%)	5,242 (58.6%)	4,298 (53.6%)	2,898 (43.5%)	
Female	3,207 (33.5%)	3,698 (41.4%)	3,727 (46.4%)	3,771 (56.5%)	
Race and ethnicity					<0.001
White, non-Hispanic	5,561 (58.1%)	5,860 (65.5%)	5,393 (67.2%)	4,284 (64.2%)	
Black, non-Hispanic	2,144 (22.4%)	1,796 (20.1%)	1,550 (19.3%)	1,520 (22.8%)	
Asian/Pacific Islander, non-Hispanic	137 (1.4%)	215 (2.4%)	245 (3.1%)	236 (3.5%)	
Hispanic	1,598 (16.7%)	927 (10.4%)	699 (8.7%)	515 (7.7%)	
Other	138 (1.4%)	142 (1.6%)	138 (1.7%)	114 (1.7%)	
Medicare/Medicaid dual eligibility					<0.001
No	5,377 (56.1%)	6,307 (70.5%)	5,920 (73.8%)	4,717 (70.7%)	
Yes	4,201 (43.9%)	2,633 (29.5%)	2,105 (26.2%)	1,952 (29.3%)	
Time to AVF/AFG creation, mo[c]	4.1 ± 5.8	3.8 ± 4.9	3.5 ± 4.1	3.5 ± 3.6	<0.001
Dialysis facility					
Profit status					0.7
For-profit	8,498 (88.7%)	7,948 (88.9%)	7,106 (88.5%)	5,947 (89.2%)	
Not for-profit	1,080 (11.3%)	992 (11.1%)	919 (11.5%)	722 (10.8%)	
Setting					0.2

	CFI Quartile				
Characteristic	**1 (n = 9,578)**	**2 (n = 8,940)**	**3 (n = 8,025)**	**4 (n = 6,669)**	***P*** [a]
Hospital-based	441 (4.6%)	357 (4.0%)	342 (4.3%)	282 (4.2%)	
Freestanding	9,137 (95.4%)	8,583 (96.0%)	7,683 (95.7%)	6,387 (95.8%)	
PD recipients per facility					<0.001
0	4,953 (51.7%)	4,471 (50.0%)	4,108 (51.2%)	3,456 (51.8%)	
1–10	1,973 (20.6%)	1,979 (22.1%)	1,827 (22.8%)	1,510 (22.6%)	
11–25	1,724 (18.0%)	1,651 (18.5%)	1,420 (17.7%)	1,145 (17.2%)	
26–50	726 (7.6%)	683 (7.6%)	550 (6.9%)	461 (6.9%)	
>50	202 (2.1%)	156 (1.7%)	120 (1.5%)	97 (1.5%)	
Patient to nurse ratio					0.04
>0–10	1,197 (12.5%)	1,162 (13.0%)	1,104 (13.8%)	910 (13.6%)	
>10–15	2,950 (30.8%)	2,909 (32.5%)	2,538 (31.6%)	2,108 (31.6%)	
>15–20	2,814 (29.4%)	2,495 (27.9%)	2,275 (28.3%)	1,913 (28.7%)	
>20	2,617 (27.3%)	2,374 (26.6%)	2,108 (26.3%)	1,738 (26.1%)	
Patient to staff ratio					0.1
>0–4	546 (5.7%)	558 (6.2%)	524 (6.5%)	445 (6.7%)	
>4–5	1,430 (14.9%)	1,346 (15.1%)	1,209 (15.1%)	973 (14.6%)	
>5–6	2,613 (27.3%)	2,447 (27.4%)	2,199 (27.4%)	1,809 (27.1%)	
>6–7	2,495 (26.0%)	2,384 (26.7%)	2,107 (26.3%)	1,798 (27.0%)	
>7–8	1,435 (15.0%)	1,200 (13.4%)	1,113 (13.9%)	953 (14.3%)	
>8	1,059 (11.1%)	1,005 (11.2%)	873 (10.9%)	691 (10.4%)	
Dialysis facility zip code sociodemographics					
Median income					<0.001
$0–<$25K	304 (3.2%)	210 (2.3%)	186 (2.3%)	155 (2.3%)	
$25K–<$50K	5,597 (58.4%)	4,978 (55.7%)	4,375 (54.5%)	3,468 (52.0%)	
$50K–<$75K	2,728 (28.5%)	2,608 (29.2%)	2,380 (29.7%)	2,061 (30.9%)	
$75K–<$100K	721 (7.5%)	892 (10.0%)	802 (10.0%)	714 (10.7%)	
≥$100K	228 (2.4%)	252 (2.8%)	282 (3.5%)	271 (4.1%)	
Population below poverty level					<0.001

	CFI Quartile				
Characteristic	**1 (n = 9,578)**	**2 (n = 8,940)**	**3 (n = 8,025)**	**4 (n = 6,669)**	***P*** [a]
0%–<15%	3,936 (41.1%)	4,171 (46.7%)	3,824 (47.7%)	3,326 (49.9%)	
15%–<25%	3,621 (37.8%)	3,180 (35.6%)	2,808 (35.0%)	2,289 (34.3%)	
≥25%	2,021 (21.1%)	1,589 (17.8%)	1,393 (17.4%)	1,054 (15.8%)	
Unemployment					<0.001
0%–<5%	547 (5.7%)	595 (6.7%)	587 (7.3%)	511 (7.7%)	
5%–<10%	4,676 (48.8%)	4,657 (52.1%)	4,197 (52.3%)	3,625 (54.4%)	
10%–<15%	3,197 (33.4%)	2,709 (30.3%)	2,384 (29.7%)	1,920 (28.8%)	
15%–<20%	865 (9.0%)	740 (8.3%)	636 (7.9%)	452 (6.8%)	
≥20%	293 (3.1%)	239 (2.7%)	221 (2.8%)	161 (2.4%)	
Population with at least high school diploma					<0.001
0%–<15%	5,187 (54.2%)	5,241 (58.6%)	4,885 (60.9%)	4,168 (62.5%)	
15%–<30%	3,642 (38.0%)	3,149 (35.2%)	2,686 (33.5%)	2,125 (31.9%)	
≥30%	749 (7.8%)	550 (6.2%)	454 (5.7%)	376 (5.6%)	
Median rent					<0.001
$0–<$500	115 (1.2%)	96 (1.1%)	73 (0.9%)	64 (1.0%)	
$500–<$750	3,741 (39.1%)	3,286 (36.8%)	2,962 (36.9%)	2,318 (34.8%)	
$750–<$1,000	3,353 (35.0%)	3,083 (34.5%)	2,650 (33.0%)	2,090 (31.3%)	
$1,000–<$1,250	1,377 (14.4%)	1,374 (15.4%)	1,241 (15.5%)	1,083 (16.2%)	
≥$1,250	992 (10.4%)	1,101 (12.3%)	1,099 (13.7%)	1,114 (16.7%)	

Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft; CFI, claims-based frailty indicator; PD, peritoneal dialysis.

[a] *P* values computed using Pearson χ^2 test for categorical variables and F test for continuous variables.

[b] Unreported values (−) indicate the cell represents <11 individuals, and the US Renal Data System restricts the reporting of data in such instances.

[c] Values presented as mean ± standard deviation.

Table 2.

Multivariable Analysis of Time to Functional Use for Patients Who Underwent Fistula Creation

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
Patient			
CFI quartile			<0.001
1	1.00 (reference)	–	
2	0.88 (0.84–0.91)	<0.001	
3	0.76 (0.72–0.80)	<0.001	
4	0.66 (0.62–0.70)	<0.001	
Time to fistula creation, per 1 mo longer	0.98 (0.98–0.99)	<0.001	–
Age			<0.001
18–49 y	1.00 (reference)	–	
50–64 y	1.01 (0.94–1.08)	0.8	
65–74 y	1.09 (1.01–1.17)	0.03	
75–84 y	1.13 (1.04–1.23)	0.003	
≥85 y	1.18 (1.07–1.30)	<0.001	
Female sex	0.77 (0.75–0.79)	<0.001	–
Race and ethnicity			<0.001
White, non-Hispanic	1.00 (reference)	–	
Black, non-Hispanic	1.03 (0.99–1.07)	0.1	
Asian/Pacific Islander, non-Hispanic	1.28 (1.18–1.40)	<0.001	
Hispanic	1.20 (1.14–1.26)	<0.001	
Other	1.22 (1.09–1.35)	<0.001	
Medicare/Medicaid dual eligibility	1.02 (0.99–1.05)	0.3	–
Dialysis facility			
Not-for-profit status	1.23 (1.16–1.30)	<0.001	–
Hospital-based (vs freestanding)	0.87 (0.79–0.95)	0.002	–
PD recipients per facility			0.8
0	1.00 (reference)	–	

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
1–10	0.99 (0.95–1.03)	0.6	
11–25	0.99 (0.95–1.03)	0.5	
26–50	0.97 (0.91–1.03)	0.3	
≥50	0.98 (0.88–1.09)	0.7	
Patient to nurse ratio			0.7
>0–10	1.00 (reference)	–	
>10–15	0.99 (0.94–1.05)	0.7	
>15–20	0.97 (0.90–1.03)	0.3	
>20	0.98 (0.91–1.04)	0.5	
Patient to staff ratio			0.06
>0–4	1.00 (reference)	–	
>4–5	1.12 (1.05–1.21)	0.002	
>5–6	1.11 (1.03–1.20)	0.006	
>6–7	1.12 (1.04–1.22)	0.004	
>7–8	1.13 (1.04–1.23)	0.005	
>8	1.12 (1.02–1.22)	0.02	
Dialysis facility zip code sociodemographics			
Median income			0.02
$0–<$25K	0.93 (0.84–1.02)	0.1	
$25K–<$50K	1.00 (reference)	–	
$50K–<$75K	0.97 (0.92–1.02)	0.2	
$75K–<$100K	1.01 (0.93–1.09)	0.9	
≥$100K	1.01 (0.99–1.23)	0.07	
Population below poverty level			0.1
0%–<15%	1.00 (reference)	–	
15%–<25%	0.96 (0.92–1.00)	0.05	
≥25%	0.97 (0.91–1.04)	0.4	
Unemployment			0.4
0%–<5%	1.00 (reference)	–	

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
5%–<10%	0.98 (0.92–1.04)	0.5	
10%–< 15%	1.00 (0.93–1.06)	0.9	
15%–<20%	0.97 (0.90–1.06)	0.5	
≥20%	0.91 (0.81–1.03)	0.1	
Population with at least high school diploma			0.5
0%–<15%	1.00 (reference)	–	
15%–<30%	1.02 (0.98–1.06)	0.4	
≥30%	1.04 (0.97–1.11)	0.3	
Median rent			0.1
$0–<$500	0.95 (0.82–1.10)	0.5	
$500–<$750	0.95 (0.90–1.00)	0.04	
$750–<$1,000	1.00 (0.95–1.04)	0.8	
$1,000–<$1,250	1.00 (reference)	–	
≥$1,250	1.00 (0.94–1.06)	0.9	

Abbreviations: CFI, claims-based frailty indicator; HR, hazard ratio; PD, peritoneal dialysis.

[a]Hazard ratios estimated using a Fine and Gray competing risks survival model with death modeled as a competing risk.

[b]Overall effect estimated using Wald χ^2 test of overall effects estimated for covariates with more than 2 levels.

Table 3.

Patient and Dialysis Facility Demographic Data for Graft Group by Frailty Quartile

	CFI Quartile				
Characteristic	**1 (n = 1,609)**	**2 (n = 1,877)**	**3 (n = 2,306)**	**4 (n = 2,467)**	***P*** [a]
Patient					
Age					<0.001
18–49 y	313 (19.5%)	11 (0.6%)	–[b]	–	
50–64 y	698 (43.4%)	355 (18.9%)	–	36 (1.5%)	
65–74 y	571 (35.5%)	905 (48.2%)	790 (34.3%)	378 (15.3%)	
75–84 y	27 (1.7%)	–	1,060 (46.0%)	1,261 (51.1%)	
≥85 y	–	–	299 (13.0%)	792 (32.1%)	
Sex					<0.001
Male	854 (53.1%)	865 (46.1%)	957 (41.5%)	773 (31.3%)	
Female	755 (46.9%)	1,012 (53.9%)	1,349 (58.5%)	1,694 (68.7%)	
Race and ethnicity					<0.001
White, non-Hispanic	812 (50.5%)	1,037 (55.2%)	1,337 (58.0%)	1,259 (51.0%)	
Black, non-Hispanic	555 (34.5%)	584 (31.1%)	687 (29.8%)	869 (35.2%)	
Asian, non-Hispanic	20 (1.2%)	52 (2.8%)	84 (3.6%)	129 (5.2%)	
Hispanic	208 (12.9%)	173 (9.2%)	180 (7.8%)	190 (7.7%)	
Other	14 (0.9%)	31 (1.7%)	18 (0.8%)	20 (0.8%)	
Medicare/Medicaid dual eligibility					<0.001
No	822 (51.1%)	1,212 (64.6%)	1,591 (69.0%)	1,608 (65.2%)	
Yes	787 (48.9%)	665 (35.4%)	715 (31.0%)	859 (34.8%)	
Time to AVF/AVG creation, mo[c]	4.9 ± 6.4	4.3 ± 5.6	4.0 ± 5.0	3.9 ± 4.0	<0.001
Dialysis facility					
Profit status					0.5
For-profit	1,465 (91.1%)	1,710 (91.1%)	2,082 (90.3%)	2,218 (89.9%)	
Not-for-profit	144 (8.9%)	167 (8.9%)	224 (9.7%)	249 (10.1%)	
Setting					0.7

	CFI Quartile				
Characteristic	**1 (n = 1,609)**	**2 (n = 1,877)**	**3 (n = 2,306)**	**4 (n = 2,467)**	***P*** [a]
Hospital-based	54 (3.4%)	67 (3.6%)	73 (3.2%)	74 (3.0%)	
Freestanding	1,555 (96.6%)	1,810 (96.4%)	2,233 (96.8%)	2,393 (97.0%)	
PD recipients per facility					0.7
0	869 (54.0%)	1,021 (54.4%)	1,265 (54.9%)	1,353 (54.8%)	
1–10	295 (18.3%)	389 (20.7%)	445 (19.3%)	458 (18.6%)	
11–25	282 (17.5%)	309 (16.5%)	402 (17.4%)	441 (17.9%)	
26–50	129 (8.0%)	125 (6.7%)	155 (6.7%)	169 (6.9%)	
>50	34 (2.1%)	33 (1.8%)	39 (1.7%)	46 (1.9%)	
Patient to nurse ratio					0.05
>0–10	156 (9.7%)	195 (10.4%)	255 (11.1%)	241 (9.8%)	
>10–15	505 (31.4%)	616 (32.8%)	728 (31.6%)	762 (30.9%)	
>15–20	472 (29.3%)	547 (29.1%)	697 (30.2%)	726 (29.4%)	
>20	476 (29.6%)	519 (27.7%)	626 (27.1%)	738 (29.9%)	
Patient to staff ratio					0.9
>0–4	98 (6.1%)	124 (6.6%)	132 (5.7%)	149 (6.0%)	
>4–5	214 (13.3%)	261 (13.9%)	315 (13.7%)	340 (13.8%)	
>5–6	406 (25.2%)	506 (27.0%)	624 (27.1%)	637 (25.8%)	
>6–7	458 (28.5%)	528 (28.1%)	628 (27.2%)	683 (27.7%)	
>7–8	243 (15.1%)	260 (13.9%)	360 (15.6%)	369 (15.0%)	
>8	190 (11.8%)	198 (10.5%)	247 (10.7%)	289 (11.7%)	
Dialysis facility zip code sociodemographics					
Median income					<0.001
\$0–<\$25K	71 (4.4%)	62 (3.3%)	78 (3.4%)	82 (3.3%)	
\$25K–<\$50K	937 (58.2%)	1,028 (54.8%)	1,198 (52.0%)	1,254 (50.8%)	
\$50K–<\$75K	446 (27.7%)	582 (31.0%)	715 (31.0%)	769 (31.2%)	
\$75K–<\$100K	130 (8.1%)	147 (7.8%)	230 (10.0%)	257 (10.4%)	
≥\$100K	25 (1.6%)	58 (3.1%)	85 (3.7%)	105 (4.3%)	
Population below poverty level					<0.001

	CFI Quartile				
Characteristic	**1 (n = 1,609)**	**2 (n = 1,877)**	**3 (n = 2,306)**	**4 (n = 2,467)**	***P*** [a]
0%–<15%	638 (39.7%)	839 (44.7%)	1,085 (47.1%)	1,168 (47.6%)	
15%–<25%	580 (36.0%)	688 (36.7%)	816 (35.4%)	828 (33.6%)	
≥25%	391 (24.3%)	350 (18.6%)	405 (17.6%)	471 (19.1%)	
Unemployment					<0.001
0%–<5%	76 (4.7%)	113 (6.0%)	139 (6.0%)	155 (6.3%)	
5%–<10%	746 (46.4%)	943 (50.2%)	1,198 (52.0%)	1,276 (51.7%)	
10%–<15%	528 (32.8%)	613 (32.7%)	702 (30.4%)	739 (30.0%)	
15%–<20%	187 (11.6%)	154 (8.2%)	184 (8.0%)	203 (8.2%)	
≥20%	72 (4.5%)	54 (2.9%)	83 (3.6%)	94 (3.8%)	
Population with at least high school diploma					<0.001
0%–<15%	815 (50.7%)	1,052 (56.0%)	1,339 (58.1%)	1,428 (57.9%)	
15%–<30%	661 (41.1%)	695 (37.0%)	836 (36.3%)	855 (34.7%)	
≥30%	133 (8.3%)	130 (6.9%)	131 (5.7%)	184 (7.5%)	
Median rent					<0.001
$0–<$500	18 (1.1%)	19 (1.0%)	24 (1.0%)	16 (0.6%)	
$500–<$750	582 (36.2%)	662 (35.3%)	765 (33.2%)	753 (30.5%)	
$750–<$1,000	622 (38.7%)	689 (36.7%)	830 (36.0%)	848 (34.4%)	
$1,000–<$1,250	226 (14.0%)	297 (15.8%)	377 (16.3%)	456 (18.5%)	
≥$1,250	161 (10.0%)	210 (11.2%)	310 (13.4%)	394 (16.0%)	

Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft; CFI, claims-based frailty indicator; PD, peritoneal dialysis.

[a] *P* values computed using Pearson χ^2 test for categorical variables and F test for continuous variables.

[b] Unreported values (–) indicate the cell represents <11 individuals, and the US Renal Data System restricts the reporting of data in such instances.

[c] Values given as mean ± standard deviation.

Table 4.

Multivariable Analysis of Time to Functional Use for Patients Who Underwent Graft Placement

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
Patient			
CFI quartile			0.09
1	1.00 (reference)	–	
2	0.98 (0.89–1.07)	0.7	
3	0.94 (0.85–1.03)	0.2	
4	0.88 (0.79–0.99)	0.03	
Time to graft creation, per 1 mo longer	1.00 (1.00–1.01)	0.3	–
Age			0.1
18–49 y	1.00 (reference)	–	
50–64 y	1.09 (0.94–1.27)	0.2	
65–74 y	1.18 (1.01–1.38)	0.03	
75–84 y	1.23 (1.04–1.45)	0.01	
≥85 y	1.23 (1.03–1.48)	0.02	
Female sex	0.98 (0.93–1.04)	0.5	–
Race and ethnicity			0.2
White, non-Hispanic	1.00 (reference)	–	
Black, non-Hispanic	1.02 (0.96–1.09)	0.5	
Asian/Pacific Islander, non-Hispanic	1.18 (1.02–1.36)	0.03	
Hispanic	1.05 (0.94–1.16)	0.4	
Other	0.94 (0.72–1.24)	0.7	
Medicare/Medicaid dual eligibility	1.03 (0.97–1.10)	0.3	–
Dialysis facility			
Not-for-profit status	1.34 (1.19–1.51)	<0.001	–
Hospital-based (vs freestanding)	0.65 (0.53–0.80)	<0.001	–
PD recipients per facility			0.6
0	1.00 (reference)	–	

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
1–10	1.00 (0.94–1.08)	0.9	
11–25	0.96 (0.89–1.03)	0.3	
26–50	0.96 (0.86–1.08)	0.5	
>50	1.10 (0.90–1.34)	0.4	
Patient to nurse ratio			0.3
>0–10	1.00 (reference)	–	
>10–15	1.05 (0.94–1.17)	0.4	
>15–20	1.08 (0.96–1.22)	0.2	
>20	1.02 (0.90–1.16)	0.8	
Patient to staff ratio			0.8
>0–4	1.00 (reference)	–	
>4–5	0.95 (0.82–1.09)	0.5	
>5–6	0.98 (0.85–1.12)	0.7	
>6–7	0.96 (0.83–1.10)	0.5	
>7–8	0.93 (0.80–1.09)	0.4	
>8	0.91 (0.77–1.08)	0.3	
Dialysis facility zip code sociodemographics			
Median income			0.2
$0–<$25K	0.97 (0.83–1.13)	0.7	
$25K–<$50K	1.00 (reference)	–	
$50K–<$75K	1.04 (0.95–1.13)	0.4	
$75K–<$100K	1.18 (1.02–1.37)	0.02	
≥$100K	1.03 (0.84–1.25)	0.8	
Population below poverty level			0.6
0%–<15%	1.00 (reference)	–	
15%–<25%	0.96 (0.89–1.05)	0.4	
≥25%	0.95 (0.85–1.07)	0.4	
Unemployment			0.04
0%–<5%	1.00 (reference)	–	

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
5%–<10%	1.06 (0.94–1.20)	0.4	
10%–<15%	1.03 (0.90–1.18)	0.6	
15%–<20%	1.20 (1.02–1.40)	0.03	
≥20%	1.20 (0.98–1.47)	0.08	
Population with at least high school diploma			0.3
0%–<15%	1.00 (reference)	–	
15%–<30%	0.96 (0.89–1.03)	0.2	
≥30%	1.01 (0.89–1.15)	0.8	
Median rent			0.05
$0–<$500	0.97 (0.72–1.31)	0.8	
$500–<$750	1.11 (1.00–1.22)	0.04	
$750–<$1,000	1.04 (0.95–1.13)	0.4	
$1,000–<$1,250	1.00 (reference)	–	
≥$1,250	0.92 (0.82–1.03)	0.2	

Abbreviations: CFI, claims-based frailty indicator; HR, hazard ratio; PD, peritoneal dialysis.

[a]Hazard ratios estimated using a Fine and Gray competing risks survival model with death modeled as a competing risk.

[b]Overall effect estimated using Wald χ^2 test of overall effects estimated for covariates with more than 2 levels.

Table 5.

Multivariable Analysis of Mortality

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
Patient			
CFI quartile			<0.001
1	1.00 (reference)	–	
2	1.43 (1.39–1.47)	<0.001	
3	1.87 (1.81–1.93)	<0.001	
4	2.46 (2.38–2.55)	<0.001	
Age			<0.001
18–49 y	1.00 (reference)	–	
50–64 y	1.22 (1.15–1.29)	<0.001	
65–74 y	1.16 (1.10–1.23)	<0.001	
75–84 y	1.22 (1.15–1.30)	<0.001	
≥85 y	1.42 (1.33–1.52)	<0.001	
Female sex	0.87 (0.85–0.89)	<0.001	–
Race and ethnicity			<0.001
White, non-Hispanic	1.00 (reference)	–	
Black, non-Hispanic	0.68 (0.66–0.69)	<0.001	
Asian/Pacific Islander, non-Hispanic	0.65 (0.61–0.69)	<0.001	
Hispanic	0.74 (0.72–0.77)	<0.001	
Other	0.69 (0.64–0.75)	<0.001	
Medicare/Medicaid dual eligibility	0.89 (0.87–0.91)	<0.001	–
Dialysis facility			
Not-for-profit status (vs for-profit)	0.94 (0.91–0.97)	<0.001	–
Hospital-based (vs freestanding)	1.00 (0.96–1.05)	0.9	–
PD recipients per facility			0.06
0	1.00 (reference)	–	
1–10	1.00 (0.98–1.02)	0.9	

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
11–25	0.97 (0.95–1.00)	0.03	
26–50	0.96 (0.93–1.00)	0.03	
>50	0.95 (0.89–1.02)	0.2	
Patient to nurse ratio			<0.001
>0–10	1.00 (reference)	–	
>10–15	0.97 (0.94–1.01)	0.1	
>15–20	0.93 (0.90–0.97)	<.001	
>20	0.93 (0.89–0.96)	<.001	
Patient to staff ratio			0.007
>0–4	1.00 (reference)	–	
>4–5	0.95 (0.91–0.99)	0.007	
>5–6	0.95 (0.92–1.00)	0.03	
>6–7	0.97 (0.93–1.02)	0.2	
>7–8	0.99 (0.94–1.04)	0.7	
>8	1.00 (0.95–1.05)	0.9	
Dialysis facility zip code sociodemographics			
Median income			0.9
$0–<$25K	1.03 (0.97–1.10)	0.3	
$25K–<$50K	1.00 (reference)	–	
$50K–<$75K	1.01 (0.98–1.04)	0.6	
$75K–<$100K	0.96 (0.92–1.00)	0.07	
≥$100K	0.96 (0.90–1.02)	0.2	
Population below poverty level			0.02
0%–<15%	1.00 (reference)	–	
15%–<25%	1.04 (1.01–1.07)	0.005	
≥25%	1.03 (0.99–1.07)	0.2	
Unemployment			0.6
0%–<5%	1.00 (reference)	–	
5%–<10%	1.01 (0.97–1.04)	0.7	

Characteristic	HR[a] (95% CI)	*P*	Overall Effect[b]
10%–< 15%	1.01 (0.97–1.05)	0.8	
15%–<20%	1.02 (0.97–1.07)	0.5	
≥20%	0.97 (0.90–1.04)	0.4	
Population with at least high school diploma			0.2
0%–<15%	1.00 (reference)	–	
15%–<30%	1.02 (1.00–1.04)	0.1	
≥30%	0.99 (0.95–1.04)	0.6	
Median rent			0.09
$0–<$500	1.01 (0.92–1.11)	0.8	
$500–<$750	0.98 (0.95–1.01)	0.2	
$750–<$1,000	0.97 (0.95–1.00)	0.07	
$1,000–<$1,250	1.00 (reference)	–	
≥$1,250	1.02 (0.99–1.06)	0.3	

Abbreviations: CFI, claims-based frailty indicator; PD, peritoneal dialysis.

[a] Hazard ratios computed using a Cox proportional hazards model, with mortality as the outcome of interest.

[b] Overall effect estimated using Wald χ^2 test of overall effects estimated for covariates with more than 2 levels.