Original Investigation

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Arteriovenous Fistula Use in the United States and Dialysis Facility–Level Comorbidity Burden

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Rationale & Objective: Patients with multiple comorbid conditions are less likely to use an arteriovenous fistula (AVF) for hemodialysis vascular access. Some dialysis facilities have high rates of AVF placement despite having patients with many comorbid conditions. This study describes variation in facility-level use of AVFs across the facility-level burden of patient comorbid conditions.

Study Design: Retrospective cohort study.

Setting & Participants: Medicare patients receiving hemodialysis for 1 year or more in US dialysis facilities.

Predictors: Facility-level burden of patient comorbid conditions; patient characteristics.

Outcomes: Odds of AVFs versus other access types; facility-level use of AVFs.

Analytical Approach: Facility-level comorbidity burden was calculated by summing individual comorbid conditions, determining the average per patient, then defining 11 groups based on facility percentile ranking. Generalized estimating equations with a logit link were used to estimate the odds of AVF placement at the patient level. For the facility-level analysis, a generalized estimating equation model with the identity link was fit to characterize the percentage of AVF use at each facility.

Results: Overall, AVF use was 65.8% in 315,919 prevalent hemodialysis patients among 5,813 facilities. After adjustment for patient characteristics, AVF use was 0.27, 0.30, 1.05, and 1.74 percentage points lower than the median among facilities in the 61st to 70th, 71st to 80th, 81st to 90th, and 91st to 99th percentiles of comorbidity, respectively, and 0.42, 0.63, 1.34, and 1.90 percentage points higher than the median among facilities in the 31st to 40th, 21st to 30th, 11th to 20th, and 1st to 10th percentiles of comorbidity, respectively. Facilities in the greater than 99th percentile of comorbidity burden had AVF use that was 3.47 percentage points lower than the median. Facilities in the less than 1st percentile of comorbidity burden had AVF use that was 2.64 percentage points greater than the median.

Limitations: Limited to Medicare dialysis-dependent patients treated for 1 year or more.

Conclusions: After adjustment for patient characteristics, we found small differences in facility rates of AVF use except in the extremes of high or low levels of comorbidity burden. Our study demonstrates that dialysis facilities with a relatively high patient comorbidity burden can achieve similar fistula rates as facilities with healthier patients. Although high comorbidity burden does not explain low facility AVF use, additional study is needed to understand differences in AVF use rates between facilities with similar comorbidity burdens.

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Arteriovenous fistula (AVF) is the preferred access type for hemodialysis patients because of superior patency, lower infection rates, and reduced mortality compared with tunneled catheters or arteriovenous grafts (AVGs).[1] Despite gains during the past decade in greater AVF use, concerns remain about vascular access options in patients with higher comorbidity burden. Both patient- and facility-level studies repeatedly show that patient comorbid conditions and other factors such as female sex, black race, and older age are associated with lower fistula use.[2-7] In these studies, comorbidity is often measured at dialysis incidence using the Centers for Medicare & Medicaid Services (CMS) Medical Evidence form 2728, which has a select group of conditions such as diabetes, heart failure, peripheral vascular disease, malignancy, and inability to ambulate/transfer, among others. Although this information is available for all patients who start maintenance dialysis, it does not capture all comorbid conditions at dialysis incidence or conditions that develop after the start of dialysis. Because up to 75% of patients initiate maintenance hemodialysis with a tunneled catheter, studies limited to vascular access in incident hemodialysis patients may be biased because patients who start dialysis with an AVF or AVG likely received substantial predialysis nephrology care.

Although individual patient comorbidity is a known risk factor for lower rates of fistula use, some dialysis facilities with robust processes for vascular access creation may overcome this barrier and create AVFs in sicker patients. For example, more frequent provider interactions for incident dialysis patients,[8] use of a vascular access coordinator,[9] and a dedicated surgeon[10-12] may help increase AVF use despite underlying patient comorbid conditions. One large dialysis organization reported that adjustment for patient case-mix had minimal impact on AVF use between facilities, suggesting that low AVF rates could not simply be attributable to higher comorbidity.[5] However, this study primarily used a patient-level analysis and was done at a time when overall AVF rates were substantially lower than they are today. It remains unclear to what extent facility-level patient comorbidity burden affects AVF rates at any given facility.

If the effect of individual comorbid conditions is additive, it could be expected that dialysis facilities with a higher burden of comorbid conditions would have lower AVF rates compared with facilities that have an overall lower burden of patient comorbid conditions. The goal of the current study is to use both incident and prevalent comorbid conditions to stratify dialysis facilities based on their overall comorbidity burden and then examine the association with facility-level AVF use. We conducted both patient- and facility-level analyses to compare the impact of patient- versus facility-level comorbidity on AVF use.

Methods

Study Population

We conducted a population-based study using CMS Medicare claims and clinical and administrative data from CROWNWeb for 5,813 US dialysis facilities with 11 or more patients from September 2014 through August 2015 (Fig 1). We included all adults in the United States receiving maintenance dialysis for 12 months or more and who had eligible Medicare claims for at least 6 months in the prior 12 months as of the beginning of each month in the study period. By only studying patients who survived the first 12 months of dialysis, our analyses better capture vascular access creation attributable to the dialysis facility rather than any predialysis care received. This 12-month period allows better ascertainment of prevalent comorbid conditions that would otherwise not be obtained for patients not enrolled in Medicare before developing kidney failure. We excluded patients with a catheter with limited life expectancy, defined by 1 or more of these conditions in the past 12 months: under hospice care in the current reporting month, metastatic cancer, end-stage liver disease, or coma or anoxic brain injury. These patients were excluded because they would be unlikely to be referred for an AVF.

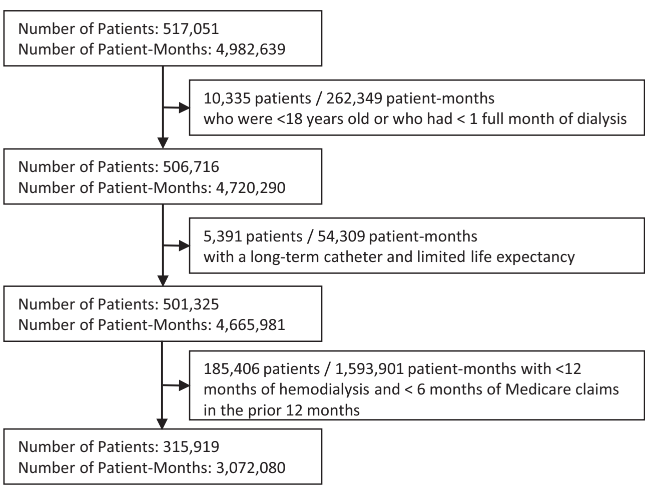

Figure 1. Derivation of study cohort.

Data

Clinical data are from CROWNWeb from September 2014 to August 2015 for monthly vascular access type: AVF, central venous catheter, and AVG. We determined vascular access type, patient age, and dialysis vintage (in years) for each month during the study period. Patient characteristics (age, sex, race, ethnicity, body mass index at incidence, primary cause of kidney failure, dialysis vintage, and whether the patient received nephrology care before dialysis initiation) are from CMS form 2728 and other CMS administrative data at the start of the study period. Nursing home status in the prior calendar year is based on the CMS nursing home Minimum Data Set.

We obtained patient-level comorbid conditions at dialysis incidence from CMS form 2728 and prevalent comorbid conditions from the prior 12 months of either in- or outpatient Medicare claims relative to each of the reporting months. We considered the condition present if reported in either CMS form 2728 or Medicare claims. Ten comorbid conditions are included as risk factors for AVF use: diabetes (either as primary cause of kidney failure or prevalent condition), heart failure, other heart diseases, peripheral vascular disease, cerebrovascular disease, chronic obstructive pulmonary disease, anemia (unrelated to chronic kidney disease), non–vascular access-related infections (including pneumonia, hepatitis, human immunodeficiency virus [HIV] infection, and tuberculosis), inability to ambulate/transfer, and drug dependence. The selection of comorbid conditions was based on input from the 2015 Vascular Access Technical Expert Panel, factors that empirical analyses indicated were predictive of AVF use and have been used in other studies.[13-15]

This study is based on work performed for CMS under contract to support quality measure development and quality improvement programs and is therefore institutional review board exempt and waived from Health Insurance Portability and Accountability Act (HIPAA) requirements for informed consent.

Definition of Facility-Level Comorbidity Burden Groups

All 5,813 dialysis facilities were initially classified into 11 groups (9 cutoff values for the deciles plus the 1st and 99th percentiles) based on the number of patient-level comorbid conditions. At each facility, incident and prevalent comorbid conditions were summed over all patient-months to calculate an average of total comorbid conditions. For the descriptive analyses, we combined percentile groupings with similar comorbidity rates to reduce the number of percentile categories from 11 to 5: the lowest comorbidity burden is below the 1st percentile (58 facilities); low comorbidity burden includes the 1st to 20th percentiles (1,104 facilities); medium comorbidity burden, the 21st to 80th percentiles (3,489 facilities); high comorbidity burden, the 81st to 99th percentiles (1,104 facilities); and highest comorbidity burden, includes facilities in the 99th to less than 100th percentiles of average number of comorbid conditions (58 facilities). The cutoff values used to define the 11 comorbidity burden groups are $p_1 = 2.3$, $p_{10} = 2.8$, $p_{20} = 3.0$, $p_{30} = 3.2$, $p_{40} = 3.3$, $p_{60} = 3.5$, $p_{70} = 3.6$, $p_{80} = 3.8$, $p_{90} = 4.1$, and $p_{99} = 4.9$, where p_q is the qth percentile. Vascular access type distributions are compared across facilities by their respective comorbidity burden.

Primary Outcomes

For the patient-level analysis, the primary outcome is AVF use as the sole vascular access at the end of each reporting month in the study period. For the facility-level analysis, the primary outcome is the monthly percentage of AVF use (the total number of AVFs in use divided by the total number of patient-months at each facility) at the end of the reporting month. An AVF was considered the sole vascular access if it was in use for the last treatment of the reporting month with 2 needles (or 1 needle with an approved single-needle device) and no catheter is present. A long-term catheter was defined as present if the catheter was in use on the last treatment of the reporting month and the prior 2 months.

Statistical Analyses

We first evaluated the association between patient-level AVF use and individual comorbid conditions and then evaluated facility-level AVF proportions to compare AVF use among 11 facility-level comorbidity burden groups. For the patient-level analysis, we use generalized estimating equations[16] with a logit link to estimate the odds of AVF versus other access type. The within-patient correlation across months is accounted for in the generalized estimating equations using an unstructured correlation matrix. We included facility indicators in the model and adjusted for patient characteristics. For the facility-level analysis, a generalized estimating equation model with the identity link was fit with the percentage AVF use of each facility (each reporting month) as the continuous outcome variable, adjusting for facility-specific percentages of patient characteristics. To account for the correlation among monthly-repeated measures, a facility-specific random intercept term was included in the model. All analyses were performed using SAS, version 9.4 (SAS Institute Inc).

Results

Patient Characteristics and Vascular Access by Comorbidity Burden Group

There were 315,919 prevalent hemodialysis patients (3,072,080 patient-months) from 5,813 facilities with at least 11 patients during the study period. Table 1 reports facility-level means of patient characteristics by the 5

Table 1. Characteristics of Study Population by Comorbidity Burden

Characteristic	Facility Comorbidity Burden, by Percentile Category: Lowest: <1st	Low: 1st-20th	Medium: 21st-80th	High: 81st-99th	Highest: >99th	Total
No. of facilities	58	1,104	3,489	1,104	58	5,813
Patient-months	339.3 (292.4)	517.6 (315.1)	555.5 (322.3)	474 (306.5)	340.3 (289.0)	528.5 (320.0)
Comorbid conditions per patient-month	2.1 (0.2)	2.7 (0.2)	3.4 (0.2)	4.1 (0.2)	5.1 (0.3)	3.4 (0.5)
Age, y	57.6 (7.7)	61.8 (3.8)	63.4 (3.8)	65.1 (4)	67.3 (5.2)	63.4 (4.1)
Age > 75 y, %	13.5 (12.7)	19.7 (10.0)	22.6 (10.5)	25.7 (11.6)	30 (15.0)	22.6 (10.9)
Female sex, %	42.2 (11.9)	44.3 (9.4)	44.7 (8.9)	45.8 (9.9)	45.9 (13.8)	44.8 (9.3)
Race, %						
Black	41.8 (36.4)	39.5 (33.7)	34.1 (29.1)	28.8 (26.8)	41.5 (29.6)	34.3 (29.9)
Nonblack	58.2 (36.4)	60.5 (33.7)	65.9 (29.1)	71.2 (26.8)	58.5 (29.6)	65.7 (29.9)
Hispanic ethnicity, %	11.8 (20.6)	13.9 (21.3)	15.4 (22.4)	14 (22.5)	9.7 (15.9)	14.7 (22.1)
Dialysis vintage, %						
1-4 y	50.1 (19.0)	55.9 (11.8)	59.6 (11.1)	64.1 (11.0)	66 (12.7)	59.7 (11.7)
5-8 y	25.6 (10.1)	24.5 (8.1)	23.7 (7.7)	22.2 (8.1)	19.9 (7.8)	23.6 (7.9)
≥9 y	24.3 (16.4)	19.6 (9.1)	16.6 (7.7)	13.7 (7.3)	14.1 (9.3)	16.7 (8.3)
BMI category[a], %						
Underweight	3.6 (4.9)	3.1 (3.1)	2.9 (2.9)	2.6 (2.9)	3.3 (3.9)	2.9 (3.0)
Normal	26.5 (10.5)	24.9 (8.3)	24.2 (8.3)	22.6 (8.5)	22.7 (9.8)	24 (8.4)
Overweight	26.2 (10.7)	27.3 (8.1)	27.5 (7.7)	27.5 (8.6)	25.6 (10.6)	27.4 (8.0)
Obese	40.9 (13.8)	42.7 (10.9)	43.9 (10.2)	46.1 (11.1)	46.7 (13.3)	44.1 (10.7)
Nursing home stay in prior y, %	3.7 (5.2)	6.6 (5.1)	9.2 (5.8)	14.5 (11.9)	38.6 (28.0)	9.9 (8.7)
Predialysis nephrologist care, %	48.9 (19.4)	52.2 (14.5)	54.3 (14.8)	54.8 (14.7)	50.3 (18.5)	53.9 (14.8)
Initiated dialysis with AVF, %	24.1 (23.7)	20 (16.2)	18 (13.8)	14.7 (13)	11.7 (12.1)	17.8 (14.4)

Note: Values shown are facility-level mean (standard deviation).
Abbreviations: AVF, arteriovenous fistula; BMI, body mass index.
[a]Underweight is BMI < 18.5 kg/m^2; normal, 18.5 to 24.9 kg/m^2; overweight, >24.9 to 29.9 kg/m^2; and obese, >29.9 kg/m^2.

comorbidity facility groupings and overall. On average, the number of comorbid conditions per patient-month was progressively greater with greater facility comorbidity burden (range, 2.1-5.1). Compared with low comorbidity burden facilities, high comorbidity burden facilities had older patients (65.1 vs 61.8 years), a higher proportion of female patients (45.8% vs 44.3%) and patients with a nursing home stay in the prior year (14.5% vs 6.6%), and lower proportions of black patients (28.8% vs 39.5%). The proportion of Hispanic patients was similar between the low and high comorbidity groups (13.9% vs 14.0%).

Diabetes and heart disease were most prevalent in each of the comorbidity groupings (Fig 2). Even in the lowest comorbidity burden facilities, 50.9% of patients had diabetes and 42.6% had cardiovascular disease, whereas in the highest comorbidity burden facilities, those comorbid conditions were present in 82.0% and 88.0% of patients, respectively. Peripheral vascular disease prevalence was 47.9% overall, ranging from 26.1% to 73.2% in the lowest and highest comorbidity burden facilities, respectively.

The standardized mortality ratio was 0.87 for the lowest comorbidity burden facilities and was progressively greater in higher comorbidity burden facilities, reaching 1.43 for the highest comorbidity burden facilities. Similarly, the standardized hospitalization ratio ranged from 0.78 to 1.14 in the lowest to highest comorbidity burden facilities, respectively. Average first-year unadjusted mortality per facility was a little more than 2.5 times greater in the highest comorbidity burden facilities than in high and medium comorbidity burden facilities.

The overall percentage of AVF use was 65.8%. It was 67.1% and 63.9% in the low and high comorbidity burden facilities, respectively (Fig 3). The highest comorbidity burden facilities (>99th percentile) had the lowest percentage of patients with an AVF (55.2%). The mean percentage of patients with a long-term catheter was lowest in low comorbidity burden facilities (9.5%) and highest (18.5%) in the highest comorbidity burden facilities; in between these 2 extremes, the pattern was greater percentage of long-term catheter use with greater comorbidity burden. AVG use was 19.3% overall and similar across comorbidity strata.

Patient-Level Results: Odds of AVF by Individual Comorbid Conditions

At the patient level, younger age, nonblack race, male sex, Hispanic ethnicity, higher body mass index, and prior nephrology care were all significantly associated with higher odds of an AVF (Table 2). Compared with patients aged 60 to 75 years, those aged 25 to 59 years had 6% higher odds of an AVF (odds ratio [OR], 1.06; 95% confidence interval [CI], 1.02-1.11). Compared with normal weight patients, those who were overweight or obese had 24% to 26% higher odds of an AVF (ORs of 1.24 [95% CI, 1.18-1.30] and 1.26 [95% CI, 1.21-1.32], respectively). Having nephrology care before starting dialysis was associated with a 22% higher odds of an AVF (OR, 1.22; 95% CI, 1.17-1.27).

Patient factors associated with lower odds of an AVF included age of 75 or more years (OR, 0.83; 95% CI, 0.79-0.87), a nursing home stay in the prior year (OR, 0.74; 95% CI, 0.70-0.78), and dialysis vintage of 5 or more years (ORs of 0.91 [95% CI, 0.87-0.95] for 5-8 years and 0.61 [95% CI, 0.58-0.64] for 9+ years). Except

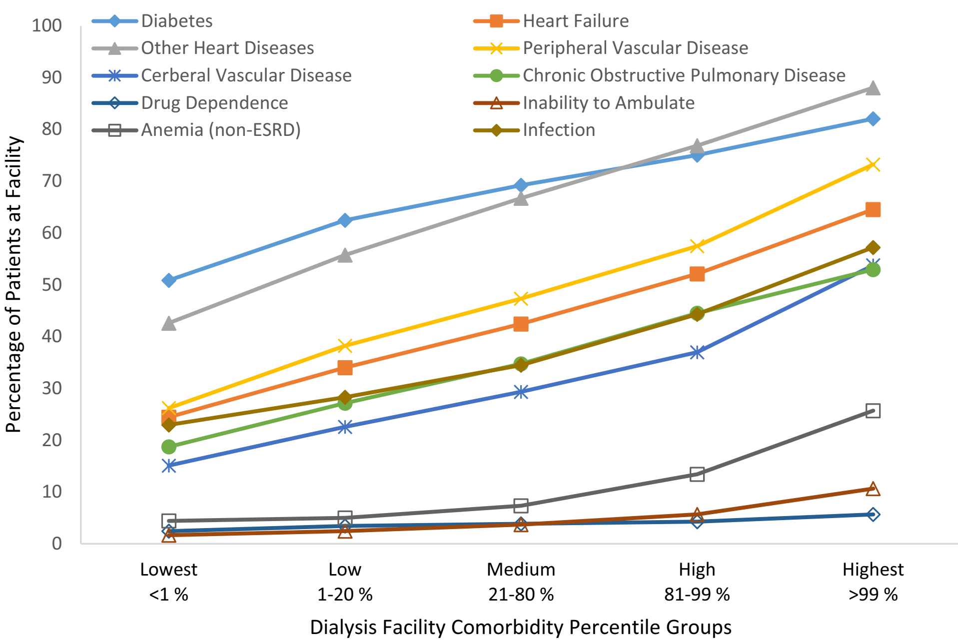

Figure 2. Mean percentage of patient comorbid conditions across dialysis facility percentile groups. The initial 11 groups were consolidated into 5 groups based on similar percentages of comorbid conditions.

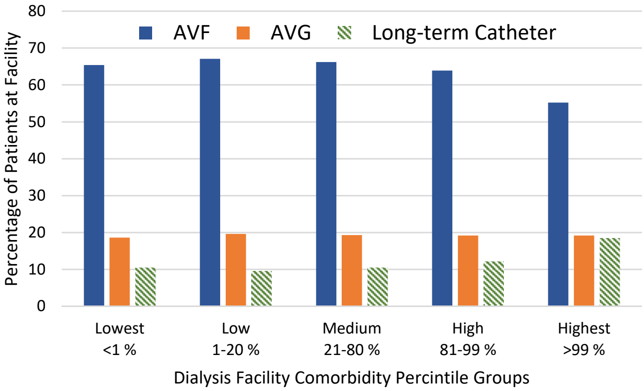

Figure 3. Vascular access distribution across dialysis facility percentile groups. Long-term catheter is defined as more than 3 months. Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft.

Table 2. Patient-Level Analysis: Odds of AVF Use and Individual Comorbid Conditions

Covariate	Odds Ratio (95% CI)	*P*
Age		
18-24 y	1.05 (0.82-1.34)	0.7
25-59 y	1.06 (1.02-1.11)	0.01
60-75 y	1.00 (reference)	
≥75 y	0.83 (0.79-0.87)	<0.001
Female sex	0.52 (0.50-0.54)	<0.001
Black race[a]	0.74 (0.70-0.77)	<0.001
Hispanic ethnicity[b]	1.28 (1.20-1.37)	<0.001
BMI[c]		
Underweight	0.98 (0.88-1.10)	0.8
Normal	1.00 (reference)	
Overweight	1.24 (1.18-1.30)	<0.001
Obese	1.26 (1.21-1.32)	<0.001
Nursing home stay in prior y	0.74 (0.70-0.78)	<0.001
Predialysis nephrologist care	1.22 (1.17-1.27)	<0.001
Dialysis vintage		
1-<5 y	1.00 (reference)	
5-<9 y	0.91 (0.87-0.95)	<0.001
≥9 y	0.61 (0.58-0.64)	<0.001
Comorbid conditions		
Diabetes[d]	0.93 (0.89-0.97)	<0.001
Heart failure	1.04 (1.00-1.08)	0.03
Other heart diseases	0.91 (0.87-0.94)	0.01
Peripheral vascular disease	0.67 (0.65-0.70)	<0.001
Cerebrovascular disease	0.93 (0.90-0.97)	<0.001
COPD	0.96 (0.93-1.00)	0.03
Drug dependence	0.85 (0.78-0.92)	<0.001
Inability to ambulate/transfer	0.72 (0.65-0.79)	<0.001
Anemia (unrelated to CKD)	0.95 (0.90-1.01)	0.1
Non–vascular access-related infections[e]	0.79 (0.76-0.81)	<0.001

Abbreviations: AVF, arteriovenous fistula; BMI, body mass index; CI, confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.
[a]Nonblack is reference group.
[b]Non-Hispanic is reference group.
[c]Underweight is BMI < 18.5 kg/m^2; normal, 18.5 to 24.9 kg/m^2; overweight, >24.9 to 29.9 kg/m^2; and obese, >29.9 kg/m^2.
[d]Diabetes: either as primary cause of end-stage kidney disease or as a comorbid condition.
[e]Including pneumonia/hepatitis/human immunodeficiency virus infection/tuberculosis.

for anemia, all but 1 of the comorbid conditions (heart failure) were significantly associated with lower odds of an AVF at the $P \leq 0.03$ or $P \leq 0.01$ levels (Table 2).

Facility-Level Results: Mean Difference in Percentage of AVFs by Low, Medium, and High Comorbidity Burden

Facility-level AVF use differences between comorbidity burden groups were adjusted for average patient characteristics within the same facility (Table 3). Adjustment factors were centered at their mean so that the intercept estimate of 65.99 indicates that AVF use of 65.99% was based on an average facility in the 41st to 60th percentile of comorbidity burden, with the following patient population at the average facility: 22.6% were 75 years or older, 44.8% female, 34.3% black, 14.7% Hispanic, 2.9% underweight, 27.4% overweight, 44.1% obese, 9.9% with a nursing home stay in the prior year, 53.9% with predialysis nephrologist care, 23.6% with dialysis vintage of 5 to 8 years, and 16.7% with dialysis vintage of 9 or more years. The association of each covariate with the facility percentage of AVFs is interpreted as the percent greater or lower for each unit increment in that covariate. For example, facility AVF use was lower by 0.13 (95% CI, −0.15 to −0.11) percentage points for each 1–percentage point greater the facility proportion of females. All but 4 adjustment factors presented in Table 3 were significant at the $P < 0.001$ or $P \leq 0.02$ levels.

Greater facility-level comorbidity burden from the 61st to 99th deciles was associated with progressively lower AVF use. Facility AVF use was nominally lower by 0.27 (95% CI, −0.54 to 0.00), 0.30 (95% CI, −0.63 to 0.04), 1.05 (95% CI, −1.48 to −0.63), and 1.74 (95% CI, −2.32 to −1.16) percentage points, respectively, moving from the 61st to 70th decile through the 91st to 99th decile. AVF use was lower by 3.47 (95% CI, −5.28 to −1.67) percentage points for facilities in the highest comorbidity burden group (>99th percentile). Facilities with lower comorbidity burden were associated with small but steadily greater AVF use, of 0.42 (95% CI, 0.18-0.67), 0.63 (95% CI, 0.33-0.94), 1.34 (95% CI, 0.95-1.72), and 1.90 (95% CI, 1.43-2.37) percentage points, moving from the 31st to 40th decile to the 1st to 10th decile, respectively. The lowest comorbidity burden (<1st percentile) was associated with 2.64 (95% CI, 1.26-4.02) percentage point greater facility-level AVF use. After adjustment for comorbid conditions, the associations of the other patient factors such as age, sex, race, and ethnicity were markedly attenuated.

Discussion

We evaluated the association between dialysis facility–level comorbidity burden and AVF use in Medicare beneficiaries

Table 3. Facility-Level Analysis: Facility Comorbidity Burden and Percentage of Patients Using an AVF

	Estimate (95% CI)	*P*
Covariate[a]		
Intercept	65.99 (65.65 to 66.32)	<0.001
% of patients aged ≥75 y	−0.03 (−0.05 to −0.01)	<0.002
% of patients who are female	−0.13 (−0.15 to −0.11)	<0.001
% of patients who are black	−0.11 (−0.13 to −0.10)	<0.001
% of patients of Hispanic ethnicity	0.01 (−0.01 to 0.03)	0.3
Dialysis vintage		
% with vintage 1-<5 y (reference)	--	
% with vintage 5-8 y	0.02 (−0.00 to 0.03)	0.07
% with vintage ≥ 9 y	−0.06 (−0.08 to −0.04)	<0.001
BMI		
% underweight	−0.06 (−0.12 to −0.01)	<0.02
% normal (reference)	--	
% overweight	0.05 (0.02 to 0.07)	<0.001
% obese	0.07 (0.05 to 0.09)	<0.001
% with nursing home stay in prior y	−0.07 (−0.10 to −0.05)	<0.001
% with predialysis nephrologist care	0.04 (0.02 to 0.05)	<0.001
Comorbidity Burden Groups[b]		
<1st percentile	2.64 (1.26 to 4.02)	<0.001
1st-10th percentiles	1.90 (1.43 to 2.37)	<0.001
11th-20th percentiles	1.34 (0.95 to 1.72)	<0.001
21st-30th percentiles	0.63 (0.33 to 0.94)	<0.001
31st-40th percentiles	0.42 (0.18 to 0.67)	<0.001
41st-60th percentiles (reference)	--	
61st-70th percentiles	−0.27 (−0.54 to 0.00)	0.05
71st-80th percentiles	−0.30 (−0.63 to 0.04)	0.09
81st-90th percentiles	−1.05 (−1.48 to −0.63)	<0.001
91st-99th percentiles	−1.74 (−2.32 to −1.16)	<0.001
>99th percentile	−3.47 (−5.28 to −1.67)	<0.001

Abbreviations: AVF, arteriovenous fistula; BMI, body mass index; CI, confidence interval.
[a]The following variables were centered at their means: 75 years or older, 22.6%; female sex, 44.8%; black, 34.3%; Hispanic, 14.7%; dialysis vintage, 5 to 8 years, 23.6%; 9 or more years, 16.7%; BMI underweight, 2.9%; BMI overweight, 27.4%; BMI obese, 44.1%; nursing home stay in prior year, 9.9%; predialysis nephrologist care, 53.9%. Estimates for these categorical groups are percentage point differences.
[b]Estimate is interpreted as the percentage point difference in facility AVF use, compared to the reference comorbidity burden group.

after the first year of dialysis. We found small differences in AVF use until very high or very low levels of comorbidity burden were reached. For 70% of dialysis facilities in the United States, variation in comorbidity levels accounts for <1% of the difference in fistula rates. For the 20% of facilities with the lowest level of comorbid conditions, AVF rates were only 1.3 to 2.6 percentage points greater than the median, suggesting that other factors may be important in successful vascular access creation beyond just the patient's overall health. Similarly, in the 58 facilities with the highest comorbidity (>99th percentile), AVF use was only 3.4 percentage points lower than the median after adjustment for other patient characteristics. These observations suggest that although individual comorbid conditions may affect the likelihood of fistula creation at the individual level, high comorbidity burden is not a sufficient reason for low facility-level AVF use.

Our study used both patient-level comorbid conditions at dialysis incidence and prevalent comorbid conditions from the prior 12 months of Medicare claims. Our patient-level results are generally consistent with several other patient-level studies in both incident and prevalent patients, which similarly found that lower AVF use was associated with several comorbid conditions, including diabetes and vascular disease, and residing in a nursing home.[2,4,17] Additionally, although Zarkowsky et al[17] found that Hispanic ethnicity was associated with a lower likelihood of having an AVF, we found that Hispanics were more likely to have an AVF in our adjusted patient-level model. This difference may be attributed to decreased access to care in incident patients from the Zarkowski et al study compared with our study, which focused on prevalent patients. Both obesity and congestive heart failure were associated with increased odds of an AVF. Our analyses did not include access location, but it is possible that upper-arm veins may be more protected in obese individuals, who may then be eligible for a transposed upper-arm AVF. The association with congestive heart failure is less clear, but of marginal clinical and statistical significance. Our facility-level results are consistent with a study from Tangri et al[5] that found that patient case-mix, as measured by comorbid conditions, did not contribute substantially to explaining overall variation in facility AVF rates. The unique contribution of our study is that we begin with patient-level analyses but use a more extensive comorbidity risk adjustment in both our patient- and facility-level analyses, along with more granular categories of comorbidity burden. Our analysis also includes the entire eligible Medicare maintenance dialysis population, resulting in greater generalizability of our findings.

One implication of these results is on the assessment of dialysis facility performance. CMS publicly reports quality measures for AVF and long-term central venous catheter use to inform the public about dialysis facility care quality.[18] High facility-level rates of AVF use suggest better performing facilities, while high long-term central venous catheter rates suggest suboptimal care quality. In recognition of the impact that comorbid conditions have on successful creation of AVFs at the patient level, dialysis facility AVF rates are adjusted for comorbid conditions in public reporting on Dialysis Facility Compare and in the End-Stage Renal Disease (ESRD) Quality Incentive Program.[19] Although these are important enhancements to the existing quality measures, our findings suggest that modifiable practice patterns may affect AVF rates even in dialysis facilities with a patient population with a higher burden of comorbidity. Therefore, some dialysis facilities with robust processes for vascular access may be able to create AVFs in sicker patients.

These changes in the vascular access quality measures come during a paradigm shift that recognizes that an AVF may not always be the best or an achievable outcome for some patients. For example, some studies have suggested the advantages of an AVF are not as pronounced for older patients, especially women with diabetes, indicating the effect of lower AVF success rates and lower life expectancy in this population.[20,21] Furthermore, recent reports indicate that the lower mortality associated with AVFs relative to AVGs has probably been overestimated. A pair of studies have provided evidence that factors affecting AVF creation, instead of the access itself, may account for two-thirds or more of the mortality benefit traditionally ascribed to AVFs.[22,23] Finally, there is growing recognition that AVFs that require additional interventions after creation to mature and remain patent, as many do, have vascular access costs that are 2 to 3 times higher than AVFs that do not require intervention.[24,25]

The attenuated benefits of AVFs for some patients, coupled with the escalating costs of AVF maintenance, have fueled the current debate in the dialysis community as to whether it is appropriate to try to place AVFs in all patients. In recognition of this controversy and the overall improvement in the national AVF rates, the "Fistula First" program was renamed "Fistula First, Catheter Last" and more recently, the ESRD Networks have shifted to tracking only long-term catheter rates as part of their quality improvement projects. Although our study demonstrates that even dialysis facilities with a relatively high patient comorbidity burden can have similar fistula rates as other facilities, the dialysis community is grappling with how to tailor vascular access strategies in a patient-centric way to achieve optimal outcomes.

An important contribution of our study is that we use a more comprehensive risk adjustment approach for measuring comorbid conditions, using both incident and prevalent comorbid conditions, in our assessment of facility AVF use. In addition, using primarily a facility-level analysis aligns with the way vascular access is publically reported and used in a federal value-based purchasing program (ESRD Quality Incentive Program). Last, using all dialysis facilities with a contemporary cohort of patients better reflects current vascular access practices compared with prior studies.

This study has several limitations. To capture more current comorbid conditions, our analysis was limited to the Medicare population on maintenance dialysis for 1 year or longer. Therefore, we do not capture the comorbidity status of non-Medicare patients, or incident patients, who could be systematically different from the Medicare prevalent dialysis population. Although the exclusion of patients in the first year of dialysis may introduce selection bias, and first-year unadjusted mortality was markedly higher in the highest comorbidity burden facilities, our analysis necessitated sufficient time to collect prevalent comorbidity information and observe vascular access creation in incident patients who started treatment with a catheter. In addition, the lower percentage of AVF use in the high comorbidity burden facilities at the initiation of dialysis suggests that these facilities were able to attain similar AVF rates as the lower comorbidity burden facilities with healthier patients and a higher proportion of incident patients with an AVF. We recognize that a measure of comorbidity burden does not directly account for severity of comorbid conditions. Although severity is a more granular indicator of health status, this information is not available in national claims data used for prevalent comorbid conditions or the incident data from the CMS form 2728. However, we found that the number of comorbid conditions was a reasonable indicator of overall health status in that progressively higher facility-level comorbidity burden was associated with higher standardized mortality ratio and standardized hospitalization ratio. We also do not account for facility characteristics (such as geographic location, size, staffing ratios, or ownership characteristics) that may influence vascular access practices and achieved AVF rates, or decision making by a surgeon whether to place an AVF in patients with more comorbid conditions. Finally, we did not adjust for patient- or area-level socioeconomic characteristics that may influence AVF rates.

In summary, we demonstrate that there is little variation in dialysis facility AVF use across a spectrum of comorbidity burden, suggesting that other factors such as facility practice patterns likely play an important role in determining rates of AVF use.

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