Provision of Kidney Disease Education Service Is Associated with Improved Vascular Access Outcomes among US Incident Hemodialysis Patients

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Key Points
- Provision of pre-ESKD Kidney Disease Education is associated with substantially improved vascular access outcomes.
- The benefits of pre-ESKD Kidney Disease Education on vascular access outcomes is independent of, and in addition to, ongoing renal care.
- Despite substantially improved vascular access outcomes and home dialysis utilization, KDE services appear to be highly underutilized in the United States.

Abstract
Background Pre-ESKD Kidney Disease Education (KDE) has been shown to improve multiple CKD outcomes, but its effect on vascular access outcomes is not well studied. In 2010, Medicare launched KDE reimbursements policy for patients with advanced CKD.

Methods In this retrospective USRDS analysis, we identified all adult patients on incident hemodialysis with ≥6 months of pre-ESKD Medicare coverage during the first 5 years of CMS-KDE policy and divided them into CMS-KDE services recipients (KDE cohort) and nonrecipients (non-KDE cohort). The primary outcome was incident arteriovenous fistula (AVF) and the composite of incident AVF or arteriovenous graft (AVG) utilization. Secondary outcomes were central venous catheter (CVC) with maturing AVF/AVG and pure CVC utilizations. Step-wise multivariate analyses were performed in four progressive models (model 1, KDE alone; model 2, multivariate model encompassing model 1 with sociodemographics; model 3, model 2 with comorbidity and functional status; and model 4, model 3 with pre-ESKD nephrology care).

Results Of the 211,990 qualifying patients on incident hemodialysis during the study period, 2887 (1%) received KDE services before dialysis initiation. The rates of incident AVF and composite AVF/AVG were more than double (30% and 35%, respectively, compared with 14% and 17%), and pure catheter use about a third lower (40% compared with 65%) in the KDE cohort compared with the non-KDE cohort. The maximally adjusted odds ratios in model 4 for study outcomes were incident AVF use, 1.78, 99% confidence interval, 1.55 to 2.05; incident AVF/AVG use, 1.78, 99% confidence interval, 1.56 to 2.03; incident CVC with maturing AVF/AVG, 1.69, 99% confidence interval, 1.44 to 1.97; and pure CVC without any AVF/AVG, 0.51, 99% confidence interval, 0.45 to 0.58. The benefits of the KDE service were maintained even after accounting for the presence, duration, and facility of ESKD care.

Conclusion The occurrence of pre-ESRD KDE service is associated with significantly improved incident vascular access outcomes. Targeted studies are needed to examine the effect of KDE on patient engagement and self-efficacy as a cause for improvement in vascular access outcomes.

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Introduction Initiating hemodialysis with an arteriovenous fistula (AVF), that is, incident AVF, is associated with improved outcomes, including a reduction in infectious complications, hospitalizations, health care costs, and, above all, improved vascular access and patient survival (1). In 2003, the Centers for Medicare and Medicaid Services (CMS) and ESKD Network National Coordinating Center jointly launched the Fistula-First Breakthrough Initiatives to improve the incident AVF rates to >50% from the then prevailing rates of about 12% (2). Limited success in the early
phase prompted a modification of this initiative to Fistula First, Catheter Last initiative to allow for appropriate use of arteriovenous grafts (AVG) and avoidance of central venous catheters (CVC) (3). These efforts have resulted in a substantial improvement in the prevalent vascular access rates over the last two decades (2,4). However, to date, improvements in the incident vascular access rates have been modest, with rates rising from 12% in 2005 to 19% in 2018 (4). Over 80% of patients with incident ESKD, even today, initiate their hemodialysis therapy with a CVC (4). Compared with the United States, many industrialized countries across Europe and Asia have managed to achieve much higher incident AVF/AVG rates, about 50%–84% (5).

Although several sociodemographic and comorbidity-related factors influence incident vascular access rates, the presence and duration of pre-ESKD nephrology care is among the strongest predictor of the incident vascular access outcomes (6–8). Nevertheless, 65%–77% of those with >6 months of pre-ESKD nephrology care still initiate hemodialysis therapies with a CVC. Prior studies have also shown that providing patients with pre-ESKD Kidney Disease Education (KDE) can improve awareness of CKD and its management options, and positively influence several CKD and ESKD outcomes, a major one being home dialysis utilization (9–14). As a result, in routine clinical situations, many view KDE primarily as a tool to improve home dialysis utilization, and the provision of KDE is preferentially skewed toward those with a greater likelihood to use home dialysis (15). Few studies have assessed the effect of KDE on vascular access outcomes. Beginning January 1, 2010, the CMS implemented KDE as a Medicare reimbursable service. In addition to the modality options, CMS recommends KDE to provide education regarding hemodialysis vascular access (16). We conducted this analysis to ascertain the associations between the CMS-KDE service and the incident vascular access outcomes.

Materials and Methods
This retrospective study was approved by the University of Florida Institutional Review Board. Using the standard files from the 2016 United States Renal Data System (USRDS) as a primary source, we identified all adult (aged ≥18 years old) Medicare recipients who were diagnosed with ESKD and initiated first-ever dialysis therapy in any form of hemodialysis on or after January 1, 2010 (CMS-KDE policy implementation date) to December 31, 2014 (the last date for available data in the USRDS 2016 report). On the basis of the prior studies showing a significant influence of medical insurance and that in the USRDS database, 6 months was the average time for the majority of patients on hemodialysis to have functioning vascular access (4,17), we ascertained the study cohort as patients who had active Medicare Part-A and/or Part-B for ≥6 months before the start of dialysis (Supplemental Table 1). We then used the ESKD and the pre-ESKD Institutional and Physician/Supplier claims data to identify those who had the Healthcare Common Procedure Coding System (HCPCS) codes of G0420 or G0421 for KDE (KDE cohort) and patients without the HCPCS codes for KDE (non-KDE cohort). Finally, we used the CMS Medical Evidence Report form (CMS-2728) and the core USRDS data set to retrieve information on patient demographics, primary disease causing ESKD, date of the first dialysis, first dialysis modality type, the type of vascular access used on first output patient dialysis (i.e., AVF, AVG, or CVC), the presence of AVF or AVG maturing, body mass index (BMI), comorbidities (i.e., diabetes mellitus, hypertension, congestive heart failure, chronic obstructive pulmonary disease, peripheral vascular disease, stroke, and coronary heart disease), need for assistance with daily activities, inability to ambulate, being institutionalized, and laboratory data, including eGFR and serum albumin.

Outcome Measures
On the basis of two national initiatives, the two primary outcomes of the study were: (1) the rates of incident AVF use and (2) rates of the composite of AVF/AVG use determined by the presence and use of existing AVF or AVG for the first dialysis compared with the CVC rates. Recognizing that some individuals may have an AVF or AVG placed, but it may not mature enough for use at the time of their first dialysis, we also studied the following secondary outcomes: (1) composite rates of AVF or AVG maturing in situ where the initial dialysis was provided by the CVC and (2) the rates of pure CVC use where no AVF or AVG was present.

Statistical Analysis
Demographic, clinical, and socioeconomic characteristics were compared between the KDE cohort and the non-KDE cohort using t test or Wilcoxon rank-sum test for normally and non-normally distributed continuous variables and chi-squared test for categorical variables. We used univariate and multivariate logistic regression models to determine the association between KDE and our primary and secondary outcomes of interest. We sequentially entered demographics, comorbidities, functional status, prior nephrology care, and duration in the multivariate regression models to adjust for potentially confounding variables. For each outcome, we constructed four regression models. Model 1 was the unadjusted model using KDE as the only predictor. Model 2 was adjusted for age, sex, race, and ethnicity. Model 3 was adjusted further for BMI, eGFR, and medical comorbidities, including congestive heart failure, diabetes mellitus, cardiovascular disease, serum albumin level, and functional status. For these multivariate analyses, cardiovascular disease was defined as a composite of coronary heart disease, stroke, or peripheral vascular disease, and functional limitations were defined as a need for assistance for activities of daily living, inability to ambulate, or being institutionalized. Model 4 was adjusted further for prior nephrology care and duration. We performed stratified analysis assessing the interaction between KDE and pre-ESKD nephrology care and duration using multivariate logistic regression models. Finally, to avoid indirect associations between the model of practice and vascular access, that is, practices that bill for KDE service may also be proactive in vascular access creation, subgroup analyses were performed restricting study population only to the incident ESKD patients affiliated with the facilities that admitted any patient on pre-ESKD KDE service recipient-incident
hemodialysis. To account for multiple hypothesis testing, we set alpha at 0.01 and reported odds ratios with 99% confidence intervals. All significance tests were two sided, with $P<0.01$ considered statistically significant. Statistical analyses were performed using Statistical Analysis Software, version 9.4 (SAS Institute Inc., Cary, North Carolina).

**Results**

Figure 1 shows the selection of the patients for the study. We identified a total of 369,938 eligible patients who initiated their first-ever dialysis during the study period. After excluding the patients whose dialysis modalities were listed as “peritoneal dialysis” and “others,” a final incident hemodialysis cohort of 308,804 patients was identified with their first-ever dialysis occurring during the study period. Of these, we identified the analytic cohort of 211,990 patients who had an active Medicare Part-A and/or Part-B for 6 months before the incident ESKD date. Among these, 2887 patients had ≥1 HCPCS KDE code before their first date of dialysis (henceforth referred to as KDE cohort), and 209,103 patients did not have any HCPCS KDE service codes (non-KDE cohort).

Table 1 shows the comparison with the baseline characteristics at the time of the initiation of hemodialysis between the KDE and the non-KDE cohorts. Overall, patients in the KDE cohort were older, retired, and had a higher comorbidity burden, with higher rates for diabetes, hypertension, and pre-existing cardiovascular disease. These patients also had higher albumin levels and a lower need for physical assistance as identified by various “need for assistance” parameters recorded in the CMS-2728 form.

Finally, the prevalence of pre-ESKD nephrology care of ≥6 months was significantly higher in the KDE cohort than in the non-KDE cohort (46% versus 27%, $P<0.0001$).

Figure 2 shows the rates of vascular access outcomes among the KDE and non-KDE cohorts. The crude rates of incident AVF and incident AVF or AVG in the KDE cohort were 30% and 35%, respectively, more than twice that of the non-KDE cohort (14% and 17%). To ensure this difference represents a real increase in the AVF/AVG creation, and not just an increase in the probability of having mature vascular access alone, we then compared the rates of maturing AVF or AVG in situ, excluding those with either AVF or AVG in use at the time of first dialysis. These were also significantly higher in the KDE cohort (25%) compared with those in the non-KDE cohort (18%). Finally, at a composite level, the rates of pure CVC use, that is, CVC without any coexistent maturing or in-use AVF/AVG, were significantly lower in the KDE than the non-KDE cohort (40% versus 65%, $P<0.0001$).

Table 2 shows the multivariate analysis examining the association between the pre-ESKD KDE delivery and the vascular access outcomes in progressively restrictive models, with model 1 being the univariate analysis, and progressive models 2, 3, and 4 showing successive adjustments for sociodemographics, comorbidity status, and functional limitations, and presence and duration of prior nephrology care. Adjustments in sociodemographics (model 2) and medical comorbidity and functional limitations (model 3) had limited attenuating effects on the strength of association between KDE service and vascular access outcomes. Even after adjusting for the presence and duration of nephrology care, we found patients with incident ESKD in

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**Figure 1.** Study flow chart. USRDS, United States Renal Data System; CMS, Centers for Medicare and Medicaid Services; HCPCS, Healthcare Common Procedure Coding System; KDE, Kidney Disease Education. CMS‐2728 report, CMS Medical Evidence report 2728.
the KDE cohort had a 69%–78% greater likelihood of incident vascular access outcome, and the odds of pure CVC use were halved compared with the non-KDE cohort.

The forest plot in Figure 3 shows the multivariate analysis affecting vascular access outcomes in the most comprehensive, model 4 (the data for AVF and maturing AVF/AVG is not shown but was congruent to the findings for AVF/AVG use). Female sex, cardiac disease, including congestive heart failure, and need for assistance were significant negative predictors of the vascular access outcomes. Pre-ESKD nephrology care was among the strongest positive predictors of vascular access outcomes. Considering such strong positive associations between the pre-ESKD nephrology care and vascular access outcomes, we specifically performed a stratified multivariate analysis of KDE on vascular access outcomes among different strata of prior nephrology care (Table 3). We found that the presence and duration of pre-ESKD nephrology care had

### Table 1. Demographics and baseline variables at the initiation of dialysis

| Cohort Variables                  | Non-KIDNEY Disease Education Cohort (n=209,103) | Kidney Disease Education Cohort (n=2887) | P Value |
|-----------------------------------|------------------------------------------------|----------------------------------------|---------|
| **Age, yr**                       | 72.1±11.2                                      | 73.4±10.8                              | 0.001   |
| 18–44                             | 4802 (2.3)                                     | 46 (1.6)                               | <0.0001 |
| 45–64                             | 39,996 (19.1)                                  | 451 (15.6)                             |         |
| >65                               | 164,305 (78.6)                                 | 2390 (82.8)                            |         |
| **Sex, male, n (%)**              |                                                |                                        |         |
|                                   | 118,616 (57)                                   | 1625 (56)                              | 0.01    |
| **BMI, kg/m²**                    | 28.9±7.9                                       | 28.8±7.6                               | <0.0001 |
| **Smoking**                       | 11,249 (5.4)                                   | 142 (4.9)                              | 0.001   |
| **Drug dependence**               | 1277 (0.6)                                     | 10 (0.4)                               | 0.01    |
| **Alcohol dependence**            | 2567 (1.2)                                     | 16 (0.6)                               | 0.0001  |
| **Race, n (%)**                   |                                                |                                        |         |
| Black                             | 47,420 (23)                                    | 646 (22)                               | <0.0001 |
| White                             | 152,898 (73)                                   | 2120 (73)                              |         |
| Other                             | 8785 (4)                                       | 121 (4)                                |         |
| **Hispanic ethnicity, n (%)**     |                                                |                                        | <0.0001 |
| **Employment status**             |                                                |                                        |         |
| Employed                          | 6261 (3)                                       | 60 (2.1)                               | 0.0007  |
| Retired                           | 170,704 (81.6)                                 | 2428 (84.1)                            |         |
| Unemployed                        | 32,138 (15.4)                                  | 399 (13.9)                             |         |
| **Primary kidney disease**        |                                                |                                        |         |
| Diabetes mellitus                 | 97,398 (46.6)                                  | 1430 (49.5)                            | <0.0001 |
| Hypertension                      | 67,452 (32.3)                                  | 1059 (36.7)                            |         |
| Glomerulonephritis                | 9240 (4.4)                                     | 126 (4.4)                              |         |
| Polycystic kidney disease         | 1618 (0.77)                                    | 28 (0.97)                              |         |
| **Comorbidity status**            |                                                |                                        |         |
| Diabetes mellitus<sup>a</sup>     | 131,818 (63)                                   | 1889 (65.4)                            | 0.0005  |
| Congestive heart failure          | 85,239 (40.8)                                  | 1088 (38)                              | <0.0001 |
| Hypertension                      | 180,887 (86.5)                                 | 2624 (90.9)                            | <0.0001 |
| Obstructive pulmonary disease     | 30,127 (14.4)                                  | 385 (13.3)                             | 0.005   |
| Atherosclerotic heart disease     | 51,187 (24.5)                                  | 789 (27.3)                             | <0.0001 |
| Peripheral vascular disease       | 34,581 (16.5)                                  | 491 (17)                               | 0.01    |
| Stroke                            | 24,677 (11.8)                                  | 328 (11.4)                             | 0.008   |
| Combined CVD<sup>b</sup>          | 81,349 (38.9)                                  | 1184 (41)                              | 0.01    |
| Cancer                            | 21,579 (10.3)                                  | 272 (9.4)                              | 0.007   |
| Albumin, g/dl                     | 3.1±2.43                                       | 3.3±0.6                                | <0.0001 |
| Functional limitation             | 55,511 (26.6)                                  | 589 (20.4)                             | <0.0001 |
| **Prior nephrology care**         |                                                |                                        | <0.0001 |
| None                              | 122,351 (58.5)                                 | 2388 (81.7)                            |         |
| <6 mo                             | 86,870 (41.5)                                  | 529 (18.3)                             | <0.0001 |
| 6–12 mo                           | 29,157 (13.9)                                  | 397 (13.8)                             | <0.0001 |
| >12 mo                            | 36,575 (17.5)                                  | 652 (21.7)                             |         |
| eGFR at dialysis initiation, ml/min | 56,601 (27.1)                                 | 1336 (46.2)                            | <0.0001 |

<sup>P</sup> values for comparison between the KDE and matched non-KDE control cohort, by <i>t</i> test or Wilcoxon rank-sum test for normally and non-normally distributed continuous variables, and chi-squared test for categorical variables. Functional limitation was calculated by patients with any of the following: need for assistance for activities of daily living, inability to ambulate, or institutionalized. CVD, cardiovascular disease; KDE, Kidney Disease Education.

<sup>a</sup>Diabetes as a comorbidity was decided on the basis of patients either having diabetes as a cause of ESKD or diabetes listed in other medical problems.

<sup>b</sup>Combined CVD was calculated by patients having an existing diagnosis of coronary heart disease, stroke, or peripheral vascular disease.
significant interaction with the magnitude of KDE’s association with the primary outcomes. Nevertheless, the positive association of KDE service on vascular access outcomes was maintained across all strata of the prior nephrology care, with the rising duration of nephrology care, the relative strength of these associations appeared to decrease. Finally, subgroup analysis including patients with incident ESKD only from facilities that admitted patients who received pre-ESKD KDE services showed continued significant association of KDE service to vascular access outcomes (Supplemental Table 2).

Discussion

Despite focused efforts by ESKD networks through two large system-wide initiatives, incident vascular access rates have remained <20% in the United States. In contrast, many industrialized nations have achieved much higher, approximately 50%–84%, incident vascular access rates (5). Several sociodemographic and comorbidity-related variables, such as advanced age, female sex, and presence of diabetes, etc., negatively affect vascular access outcomes (5,6,8). Unfortunately, these are nonmodifiable risk factors. Against these, the presence and duration of pre-ESKD nephrology care have long been recognized to be potentially modifiable risk factors, with a consistently strong positive influence on vascular access outcomes. Several studies have shown that pre-ESKD KDE improves many clinical and health services outcomes in CKD, independent of, and in addition to, the gains achieved by routine nephrology care (9–14). However, the effect of KDE on vascular access outcomes has not been well studied.

Our analysis demonstrates the occurrence of a formal CMS-KDE service in the pre-ESKD period is associated with a substantial increase, nearly doubling, the incident vascular access rates. We further show these increases are not limited to the mature, ready-to-use incident vascular access, but are also associated with increased rates of “created, but not ready-to-use,” in situ vascular access. Isolated prior institutional studies have examined the effect of patient education on vascular access outcomes. In a small cohort study (n=147), Lindberg et al. found that 77% of their “Healthy-start clinic cohort,” that is, those receiving multidisciplinary patient education, had

Table 2. Effect of Kidney Disease Education service on the odds for achieving the vascular access outcomes in progressive multivariate models

| Outcomes          | Model 1 Odds Ratio (99% Confidence Interval) | Model 2 Odds Ratio (99% Confidence Interval) | Model 3 Odds Ratio (99% Confidence Interval) | Model 4 Odds Ratio (99% Confidence Interval) |
|-------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
| AVF use           | 2.65 (2.38 to 2.96)                         | 2.66 (2.39 to 2.97)                         | 2.39 (2.09 to 2.73)                         | 1.78 (1.55 to 2.05)                         |
| AVF/AVG use       | 2.58 (2.33 to 2.85)                         | 2.58 (2.33 to 2.86)                         | 2.34 (2.06 to 2.66)                         | 1.78 (1.56 to 2.03)                         |
| AVF/AVG in situ   | 2.16 (1.91 to 2.44)                         | 2.19 (1.93 to 2.47)                         | 2.03 (1.74 to 2.37)                         | 1.69 (1.44 to 1.97)                         |
| Pure catheter use | 0.37 (0.34 to 0.41)                         | 0.37 (0.33 to 0.41)                         | 0.41 (0.36 to 0.46)                         | 0.51 (0.45 to 0.58)                         |

Model 1 was the unadjusted model using KDE as the only predictor. Model 2 was adjusted for age, sex, race, and ethnicity. Model 3 was adjusted further for BMI, eGFR, serum albumin level, and medical comorbidities, including congestive heart failure, diabetes mellitus, cardiovascular disease, and functional status. Cardiovascular disease in model 3 was defined as the presence of either of atherosclerotic heart disease, stroke or peripheral vascular disease. Model 4 was adjusted further for prior nephrology care and duration. AVF, arteriovenous fistula; AVG, arteriovenous graft; KDE, Kidney Disease Education; BMI, body mass index.
functioning vascular access at the initiation of dialysis, compared with only 36% receiving the usual care (18). In a similar analysis of the data obtained from a dialysis organization, Lacson et al. showed that 33% of their education recipients initiated dialysis with AVF/AVG, whereas only 17% of those not using their pre-ESKD education services initiated dialysis with vascular access (19). Our analysis validates these findings in a broader manner, with results showing near doubling of vascular access rates in the KDE cohort, with combined AVF or AVG (mature and in situ) rates of 60%, mirroring those prevalent in many European countries. Our analysis further confirms the known negative and positive associations of the sociodemographic and medical comorbidities, and the presence and duration of the nephrology care, respectively, on vascular access outcomes (5,6,8). However, even after adjusting for these variables in our progressively restrictive multivariate model, we show that the positive associations of KDE service to vascular access outcomes are independent of, and in addition to, the effects of these known predictors, with 70%–84% higher odds of desired incident vascular access outcomes. Finally, our stratified analyses confirm these independent positive associations are maintained, even for the patients under nephrology care, albeit the strength of association declines with increasing duration of nephrology care.

**Table 3. Stratified analysis clarifying the effect of Kidney Disease Education among those with differing lengths of prior nephrology care**

| Nephrology Care | Incident Arteriovenous Fistula | Incident Arteriovenous Fistula/Arteriovenous Graft | Arteriovenous Fistula/Arteriovenous Graft Maturing | Pure Central Venous Catheter |
|-----------------|--------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------|
| None            | 3.80 (2.42–5.98)               | 3.29 (2.17–4.99)                              | 1.97 (1.36–2.85)                              | 0.41 (0.30–0.55)            |
| <6 mo           | 2.05 (1.41–2.97)               | 2.14 (1.53–3.00)                              | 1.92 (1.29–2.85)                              | 0.44 (0.32–0.61)            |
| 6–12 mo         | 1.45 (1.08–1.93)               | 1.42 (1.08–1.86)                              | 1.72 (1.27–2.34)                              | 0.58 (0.45–0.75)            |
| >12 mo          | 1.71 (1.42–2.06)               | 1.70 (1.43–2.04)                              | 1.49 (1.17–1.90)                              | 0.56 (0.46–0.67)            |

The odds ratio are adjusted for all variables accounted for in the model 4 of our analysis. KDE, Kidney Disease Education.

- Statistically significant interaction term (P value for interaction <0.01).
- Statistically insignificant interaction term (P value for interaction ≥0.01).
What could be the explanation? The beneficial effects of KDE on patient awareness and home dialysis utilization have been well reported. A meta-analysis of the published, primarily cohort studies showed that the provision of pre-ESKD KDE more than triples the odds of home dialysis selection and use in patients with pre-ESKD nephrology care (14). In a recently published study, we showed the occurrence of CMS-KDE service in the pre-ESKD period is associated with a near doubling of incident home dialysis use (15). In routine clinical practice, most clinicians view KDE primarily as a tool to improve home dialysis rates. As a result, the provision of KDE is preferentially skewed toward those with a greater likelihood to use home dialysis (15). Considering the indirect association between patient education and vascular access creation, one could argue that our results merely reflect a better quality or model of pre-ESKD nephrology care. At the same time, more than half of KDE cohort initiated their hemodialysis with a CVC, highlighting the importance of multiple additional practice-related factors, including the availability of and coordination with the proficient vascular access creation team (20). Overall, at the minimum, our analyses serve to identify a unique marker for what some have described as the "optimal initiation of dialysis," with more than doubling the rates of both incident home dialysis and incident vascular access use.

However, an alternate possibility could also be operative. Behavior theory suggests patient education can improve patient awareness, enhancing motivation and self-efficacy, leading to altered health behavior affecting health outcomes (21,22). In a cross-sectional study, Cavanaugh et al. found that increased patient awareness is positively associated with incident vascular access outcomes (23). Recently, in a small cohort study, Grubbs et al. showed dialysis decision making, not the number of pre-ESKD nephrology visits, predicts incident vascular access outcomes (24). Strong concurrence of our subgroup analysis restricted to the patients with incident ESKD only from the units that admitted patients who received pre-ESKD KDE services certainly raises the possibility that providing patients with a focused KDE service may lead to improved vascular access outcomes through these alternate mechanisms. Both the low rates of home dialysis and suboptimal incident vascular access are closely linked to the quality of pre-ESKD care and patient awareness. Many European and Asian health care systems have developed practice patterns that lead to substantially higher rates of optimal initiation of ESKD therapy. Our results strongly argue for the need for targeted prospective studies within the United States to examine the effect of pre-ESKD KDE on these two, long-desired but underachieved targets for the US nephrology community.

Discounting whether these findings represent an association or causality, the very low occurrence of pre-ESKD KDE service in a nationwide sample raises significant concerns. As highlighted before, KDE has been shown to influence many CKD and ESKD outcomes positively. To our knowledge, no studies are showing negative effects of KDE on patient outcomes to date. As a result, universally, regulatory agencies and professional renal societies recommend that all patients with advanced CKD receive pre-ESKD KDE (25). Improving the care coordination and education to enable a safer transition to ESKD is one of the three explicit objectives of the Advancing American Kidney Health executive order (26). Thus, such low reporting of the KDE service at the minimum impedes our ability to assess the efficacy of this vital endeavor for patient-centered care. At the worst, it reflects substantial underutilization of universally recommended care. Overall, the results strongly urge the health care community and regulators to examine and address the barriers and facilitators to a much wider KDE service use and its documentation/coding.

Finally, we recognize the inherent limitations of a retrospective database analysis, especially concerns related to the coding. For example, lack of KDE service code should not be considered analogous to the lack of occurrence of KDE. Many health care infrastructures, including our own, have provided targeted pre-ESKD KDE for many years without billing with HCPCS codes. Similarly, successiveUSRDS annual reports have shown that a not insignificant fraction of patients with incident ESKD without pre-ESKD nephrology care (about 5%-15%) have functioning incident vascular access or use home dialysis (4). These occurrences likely reflect concern about the pre-ESKD nephrology care coding. If fully accounted for, such occurrences could further strengthen our conclusions because these missed codes, if causally related, may have a greater positive effect on the vascular access rates in the non-KDE cohort. Similarly, concurrence of our subgroup analysis with the primary findings further demonstrates the robustness of these associations. Second, CMS recommends the KDE service to include counseling on various aspects of advanced CKD care, including the management of comorbidities, avoiding uremic complications, delaying the need for dialysis, and each option for dialysis, including their access, so we cannot ascertain the true incorporation of vascular access education in the delivered KDE services across the renal community. Finally, we acknowledge the limitations of statistical analysis of a large database with limited fraction of the population receiving the intervention and having multiple outcome comparison. It is plausible there may be unmeasured bias related to these factors despite our multi-step regression and stratified analyses. To address the concerns regarding multiple outcomes comparisons, we set alpha at 0.01 and we reported odds ratios with 99% confidence intervals. We believe the strength of benefit across nearly all patient variables and strata of nephrology care provides reassuring support to our conclusions.

To conclude, US incident vascular access outcomes have been resistant to improvements over the last two decades. Our data show pre-ESKD KDE is associated with substantial improvements in incident vascular access outcomes. Targeted studies are needed to assess whether this association merely reflects an improved quality clinical care or an effective tool to improve self-efficacy and clinical outcomes. Finally, the analysis shows that pre-ESKD KDE service is very low in the community, which, whether genuinely reflective of the pre-ESKD KDE occurrence or its documentation, raises significant concerns for the care of patients with advanced CKD in the United States.

Disclosures
A.M. Shukla reports being a scientific advisor or member of the Veteran Healthcare Administration (VHA) National Peritoneal Dialysis Workgroup. M.S. Segal reports receiving research funding from clinical trials with Alexion and RegenMed. All remaining authors have nothing to disclose.
References

1. Dhingra RK, Young EW, Hulbert-Shearon TE, Leavey SF, Port FK. Type of vascular access and mortality in U.S. hemodialysis patients. Kidney Int 60: 1443–1451, 2001 https://doi.org/10.1046/j.1523-1755.2001.00947.x

2. Lee T: Fistula initiation: Historical impact on vascular access practice patterns and influence on future vascular access care. Cardiovasc Eng Technol 8: 244–254, 2017 https://doi.org/10.1007/s13239-017-0319-9

3. Lacson E Jr, Lazarus JM, Hammelar J, Izkizer TA, Hakim RM: Balancing fistula first with catheters last. Am J Kidney Dis 50: 379–395, 2007 https://doi.org/10.1053/j.ajkd.2007.06.006

4. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases: USRDS Annual data report: Epidemiology of kidney disease in the United States. Available at https://www.usrds.org. Accessed November 18, 2021

5. Pisoni RL, Zepel I, Port FK, Robinson BM: Trends in US vascular access use, patient preferences, and related practices: An update from the US DOPPS practice monitor with international comparisons. Am J Kidney Dis 65: 905–915, 2015 https://doi.org/10.1016/j.ajkd.2014.12.014

6. Smart NA, Titus TT: Outcomes of early versus late nephrology referral in chronic kidney disease: A systematic review. Am J Med 124: 1073–80.e2, 2011 https://doi.org/10.1016/j.amjmed.2011.04.026

7. Lorenzo V, Martín M, Rufino M, Hernández D, Torres A, Ayus JC: Predialysis nephrologic care and a functioning arteriovenous fistula at entry are associated with better survival in incident hemodialysis patients: An observational cohort study. Am J Kidney Dis 43: 999–1007, 2004 https://doi.org/10.1016/j.ajkd.2004.02.012

8. Hod T, Desilva RN, Pathandla BK, Yin Y, Brown RS, Goldfarb-Rumyantsev AS: Factors predicting failure of AV “fistula first” policy in the elderly. Hemodial Int 18: 507–515, 2014 https://doi.org/10.1111/hdi.12106

9. Ghafari A, Sepehrvand N, Hatami S, Ahmadnejad E, Ayubian B, Maghsudi R, Kargar C: Effect of an educational program on awareness about peritoneal dialysis among patients on hemodi-alysis. Saudi J Kidney Dis Transpl 21: 636–640, 2010

10. Yen M, Huang JJ, Teng HL: Education for patients with chronic kidney disease in Taiwan: A prospective repeated measures study. J Clin Nurs 17: 2927–2934, 2008 https://doi.org/10.1111/j.1365-2702.2008.02348.x

11. Mason J, Khunti K, Stone M, Farooqi A, Carr S: Educational interventions in kidney disease care. A systematic review of randomized trials. J Kidney Dis 51: 933–951, 2008 https://doi.org/10.1053/j.jkd.2008.01.024

12. Goldstein M, Yassa T, Dacouris N, McFarlane P: Multidisciplinary predialysis care and morbidity and mortality of patients on dialysis. Am J Kidney Dis 44: 706–714, 2004 https://doi.org/10.1016/S0227-6686(04)00940-0

13. Wei S-Y, Chang Y-Y, Ma L-W, Lin M-Y, Chi H-C, Tsai JC, Huang C-J, Chen H-C, Hwang S-J: Chronic kidney disease care program improves quality of pre-end-stage renal disease care and reduces medical costs. Nephrol 15: 108–115, 2010 https://doi.org/10.1111/j.1440-1797.2009.01154.x

14. Devins GM, Mendelsohn DC, Barré PE, Taub K, Binik YM: Predialysis psychoeducational intervention extends survival in CKD: A 20-year follow-up. Am J Kidney Dis 46: 1088–1098, 2005 https://doi.org/10.1053/j.ajkd.2005.08.017

15. Shukla AM, Bozorgmehri S, Ruchi R, Mohandas R, Hale-Gallardo JL, Ozrazat-Baslanti T., Orozco T, Segal MS, Jia H: Utilization of CMS pre-ESRD Kidney Disease Education services and its associations with the home dialysis therapies. Perit Dial Int 41: 453–462, 2020 https://doi.org/10.1177/ 0896745720957586

16. Young HN, Chan MR, Yevzlin AS, Becker BN: The rationale, implementation, and effect of the Medicare CKD education benefit. Am J Kidney Dis 57: 381–386, 2011 https://doi.org/10.1053/j.ajkd.2010.10.056

17. Lin E, Mell MW, Winkelmayr WC, Erickson KK: Health insurance in the first 3 months of hemodialysis and early vascular access. Clin J Am Soc Nephrol 13: 1866–1875, 2018 https://doi.org/10.2215/CJN.06600518

18. Lindberg JS, Hussein FE, Ross JL, Jackson D, Scarlata D, Nussbaum J, Cohen A, Elzein H: Impact of multidisciplinary, early renal education on vascular access placement. Nephrol News Iss 19: 35–36, 41–33, 2005

19. Lacson E Jr, Wang W, DeVries C, Leste K, Hakim RM, Lazarus P, Pulliam J: Effects of a nationwide predialysis educational program on modality choice, vascular access, and patient outcomes. Am J Kidney Dis 58: 235–242, 2011 https://doi.org/10.1053/j.ajkd.2011.04.015

20. Lee S-YD, Xiang J, Khirisagar AV, Steffick D, Saran R, Wang V: Supply and distribution of vascular access physicians in the United States: A cross-sectional study. Kidney360 1: 763–771, 2020 https://doi.org/10.34067/KID.0002722020

21. Bandura A: Self-efficacy: Toward a unifying theory of behavioral change. Psychol Rev 84: 191–215, 1977 https://doi.org/10.1037/0033-295X.B4.2.191

22. Bandura A: Health promotion by social cognitive means. Health Educ Behav 31: 143–164, 2004 https://doi.org/10.1177/1090198104236660

23. Cavanaugh KL, Wingard RL, Hakim RM, Elasy TA, Izkizer TA: Patient dialysis knowledge is associated with permanent arteriovenous access use in chronic hemodialysis. Clin J Am Soc Nephrol 4: 950–956, 2009 https://doi.org/10.2215/CJN.04809008

24. Grubbs V, Jaar BG, Cavanaugh KL, Ephraim PL, Ameling JM, Cook C, Greer RC, Boulware LE: Impact of predialysis nephrology care engagement and decision-making on provider and patient action toward permanent vascular access. BMC Nephrol 22: 60, 2021 https://doi.org/10.1186/s11359-021-02264-7

25. Moss AH: Revised dialysis clinical practice guideline promotes more informed decision-making. Clin J Am Soc Nephrol 5: 2380–2383, 2010 https://doi.org/10.2215/CJN.07170810

26. House TW: Executive Office of the President. Advancing America’s kidney health. Available at: https://www.federalregister.gov/documents/2019/10/07/2019-15159/advancing-american-kidney-health. Accessed August 23, 2019

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