

# Evolution of Vascular Access Use among Incident Patients during the First Year on Hemodialysis: A National Cohort Study

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## Abstract

**Background** Although the arteriovenous fistula (AVF) confers superior benefits over central venous catheters (CVCs), utilization rates remain low among prevalent patients on hemodialysis (HD). The goal of this study was to determine the evolution of vascular access type in the first year of dialysis and identify factors associated with conversion from CVC to a functioning AVF.

**Methods** We studied adult patients ( $n=610$ ) who began HD between the January 1, 2015 and December 31, 2016 and were treated for at least 90 days, using data from the National Kidney Disease Clinical Patient Management System in the Irish health system. Prevalence of vascular access type was determined at days 90 and 360 after dialysis initiation and at 30-day intervals. Multivariable logistic regression explored factors associated with CVC at day 90, and Cox regression evaluated predictors of conversion from CVC to AVF on day 360.

**Results** CVC use was present in 77% of incident patients at day 90, with significant variation across HD centers (from 63% to 91%,  $P<0.001$ ), which persisted after case-mix adjustment. From day 90 to day 360, AVF use increased modestly from 23% to 41%. Conversion from CVC to AVF increased over time, but the likelihood was lower for older patients (for age  $>77$  years versus referent, adjusted hazard ratio [HR], 0.43; 95% CI, 0.19 to 0.96), for patients with a lower BMI (per unit decrease in BMI, HR, 0.95; 95% CI, 0.93 to 0.98), and varied significantly across HD centers (from an HR of 0.25 [95% CI, 0.08 to 0.74] to 2.09 [95% CI, 1.04 to 4.18]).

**Conclusion** CVCs are the predominant type of vascular access observed during the first year of dialysis, with low conversion rates from CVC to AVF. There is substantial center variation in the Irish health system that is not explained by patient-related factors alone.

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## Introduction

Central venous catheters (CVCs) contribute substantially to adverse clinical outcomes—including bloodstream infection, infection-related hospitalization, mortality, and healthcare costs—among patients undergoing hemodialysis (HD) (1–3). Evidence from international studies has confirmed that CVCs are inferior to arteriovenous fistulas (AVFs) with regard to major outcomes (1,3). A recent, systematic review of 62 cohort studies, comprising 586,337 patients, revealed that patients dialyzing with a CVC experienced a 25% higher risk of cardiovascular events, a 50% higher risk of mortality, and double the risk for fatal infections, compared with those with an AVF (2). In contrast, patients dialyzing with a functioning AVF have demonstrated substantially lower risks for such

negative outcomes (2). Consequently, international guidelines and professional societies advocate for AVF over CVC as the preferred vascular access type for all patients who require treatment with HD (4).

Although clinical guidelines recommend AVF as the preferred access option for most patients who require HD, the reality is that a substantial number of patients who develop ESKD and require HD begin treatment with a CVC (5). Barriers to AVF creation have hampered efforts at achieving high rates of usable AVF across countries. These barriers include increasingly complex patient phenotypes, high burden of frailty, late referral, insufficient patient education, and lack of standardized care processes, which inevitably lead to lower rates of AVF use and higher dependency on catheters (6). Increasing the rates of

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AVF use is a key objective for most national programs. The development of highly coordinated policies, underpinned by strong implementation strategies, has yielded benefits for many countries. An excellent example is the Fistula First policy in the United States, where AVF rates have increased steadily from 33% in 2003 to 63% in 2015 among prevalent patients on HD (7–8). However, despite these efforts, the prevalence of functioning AVFs at dialysis initiation remain low for many countries and suggests the appropriate planning, patient engagement, and education process before dialysis onset fall short of expectations (8–12). It remains unclear to what extent patient-level factors contribute to the high dependency on CVCs. It is also uncertain whether rates of AVF placement increase rapidly in the first year of dialysis, at a time when patients are primarily under the supervision of a nephrologist.

To increase our understanding of vascular access provision both before and after the initiation of HD, we established an inception cohort of incident patients beginning HD and tracked their progress in the first year of HD in the Irish health system. The primary aim was to describe the patterns of vascular access use during the first year of dialysis among incident patients, and determine the extent to which patient- and center-related factors influenced access provision. A secondary objective was to evaluate conversion rates from CVC to a functioning AVF among those who had started HD with a tunneled dialysis catheter.

## Methods

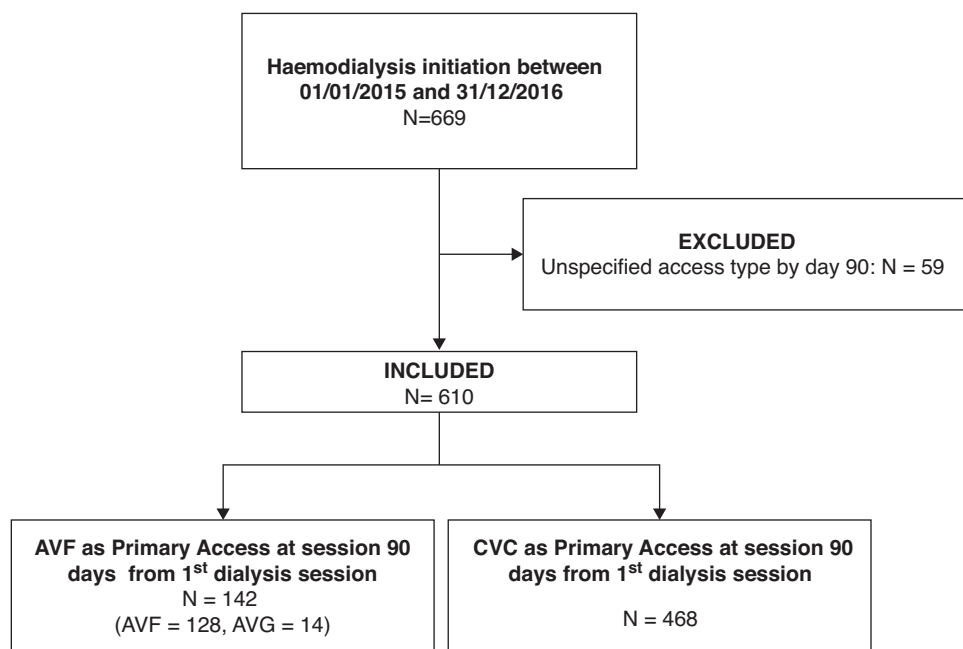
### Data Source

We used the Kidney Disease Clinical Patient Management System (KDCPMS) as the primary data source to examine vascular access use in the Irish health system (12). The KDCPMS is a kidney-specific national information

system that tracks patients from late-stage CKD across the transition to ESKD in all dialysis centers in Ireland. The system interfaces directly with local hospital information systems to capture real-time data on demographics, laboratory results, and core indicators of care for patients with kidney disorders. RRTs within the Republic of Ireland are provided through primary kidney centers, organized into six hospital groups. Under the supervision of these primary centers, HD for adult patients is arranged and supervised across 20 dialysis units. Every patient on HD has a “center of primary medical supervision” at which their care is managed, including arrangements for the provision of vascular access placement. Data—such as the primary cause of ESKD, comorbid conditions, and ancillary notes on clinical care delivery—are manually entered by users at the site of care. Each renal center has a local KDCPMS supervisor to support data reporting and data management. Over the last several years, renal centers in the Republic of Ireland were incrementally added onto the KDCPMS. In 2017, all units were included in the system.

### Study Design

We established an observational cohort of adult patients who began HD between January 1, 2015 and the December 31, 2016 and continued to receive RRT for at least 90 days postinitiation of HD. We excluded patients who had missing data on vascular access recorded at day 90 (Figure 1). Data were captured on demographic characteristics, comorbid conditions, primary cause of ESKD, vascular access type, the location of medical supervision, and a comprehensive list of laboratory values for all patients 90 days after HD initiation. For each patient, the type of vascular access in use at day 90 of dialysis, and at monthly intervals thereafter, was recorded. Vascular access assignment was



**Figure 1.** | Central venous catheters were the main type of vascular access among patients at day 90 of dialysis. Study flow diagram. AVF, arteriovenous fistula; CVC, central venous catheter; KDCPMS, Kidney Disease Clinical Patient Management System.

determined on the basis of the last recorded access in use from the real-time dialysis record. If two access types coexisted, the access type used for the HD treatment was assigned as the primary access. For this study, patients who were treated with an arteriovenous graft ( $n=14$ ) were grouped with those who had an AVF.

The primary cause of kidney disease and comorbid diagnoses were collapsed into categories and classified as per the United States Renal Data System (10). A patient was considered to have hypertension or diabetes if these conditions were listed among the comorbid conditions, or if diabetes or hypertension was among the causes of kidney disease. Laboratory variables were recorded at day 90, or the nearest session within 7 days of day 90. The time-weighted median value for each test type was determined and included in the final dataset. Patient assignment to a specific dialysis center was based on the last “location of primary medical supervision” on day 90 after dialysis initiation. Ethical approval was not sought because this study formed part of a national quality improvement initiative and satisfied the ethical and information governance for analysis of secondary health data for improvement in population health in Ireland (13).

## Outcomes

The evolution of vascular access was assessed at monthly intervals from day 90 to day 360 of dialysis, and the conversion rate from CVC to AVF was determined.

## Statistical Analyses

Baseline characteristics, by access type and by HD center, were described for the whole population at day 90. The number of patients in each center was suppressed to maintain center anonymity. Continuous variables are presented as mean $\pm$ SD or median and interquartile range, as appropriate, whereas categorical variables are expressed as percentages. Group comparisons for continuous variables were performed using the Kruskal–Wallis test, and group comparisons were performed using the chi-squared test.

Multivariable logistic regression was used to explore factors associated with CVC use versus AVF at day 90 after initiation. Explanatory variables were classified as demographic, the primary cause of ESKD, comorbid medical conditions, laboratory indicators of health, and dialysis center. Body mass index (BMI) was modeled as a categorical variable because it was not linearly related to the log odds in a continuous form. Model building progressed manually on the basis of univariate associations, clinical reasoning, and previously published literature. A final model was constructed to explore the relative contribution of all explanatory factors with catheter use at day 90. The associations of explanatory factors with catheter presence were represented by adjusted odds ratios (AORs) and 95% CIs. For each model, the c-statistic was calculated to assess the model performance.

Cox proportional hazards regression was used to evaluate the rate of conversion from CVC use at day 90 to AVF use at day 360. Unadjusted and sequentially adjusted models were constructed to identify factors associated with conversion to AVF, expressed as hazard ratios (HRs)

and 95% 95% CIs. HRs were first adjusted for demographic variables, then for cause of ESKD, and finally for clinical variables (comorbidities and laboratory variables). The proportional hazard assumption was assessed by plotting scaled Schoenfeld residuals versus rank time. We used two-sided significance tests, and  $P$  values  $<0.05$  were considered significant. A sensitivity analysis was conducted to further explore center variation. Effect/deviation coding was used for center-based comparisons in the logistic and cox regression models. Effect coding provides estimates that are deviations from a grand mean or, in this case, a national average (referent). All analyses were performed using R statistical software (13,14).

## Results

### Baseline Characteristics

Table 1 summarizes patient characteristics on day 90 after dialysis initiation, according to the vascular access type. Overall, 610 participants met the inclusion criteria and were included in the final analysis. The mean age of patients was 59.7 years in the CVC group and 63.7 years in the AVF group. Male participants represented 65% of the total cohort (62% in the CVC group and 74% in the AVF group). Diabetic nephropathy and GN were the leading causes of ESKD. In general, baseline characteristics were similar between access groups, although patients with a CVC were, on average, 4 kg heavier, and had significantly higher baseline values for serum albumin, urea, and serum creatinine concentrations compared with the AVF group. The study cohort was distributed across six hospital groups, with ten centers of primary medical supervision. The distribution of patients by center of primary medical supervision, and by vascular access type, is shown in Table 2. CVC was the predominant access type at day 90 of ESKD, and use varied significantly, from 63% in center 8 to 91% in center 6. Center 1 had the largest proportion of patients overall and was, therefore, chosen as a referent for center-based comparisons.

### Patient and Facility-Level Characteristics Associated with CVC Use at Day 90

By day 90 of dialysis treatment, the proportion of patients that used a CVC as primary vascular access was substantial (77%), as illustrated in Figure 2. Factors associated with CVC use at day 90 are shown in Table 3. With adjustment for demographics and clinical factors, patients dialyzed with a CVC at day 90 were more often women (AOR, 1.73; 95% CI, 1.01 to 3.12). Patients with congestive heart failure were less likely to dialyze with a catheter (AOR, 0.50; 95% CI, 0.26 to 0.97). Similarly, higher serum albumin concentrations were significantly associated with lower odds of CVC use (per 1 g/L increase, AOR, 0.88; 95% CI, 0.82 to 0.95). We observed significant variation in CVC use across different centers of primary medical supervision, with use ranging from 63% to 91%,  $P<0.001$  (Figure 3). Patients undergoing dialysis at centers 3 and 9 were significantly less likely to use a CVC than AVF as their primary access (for center 3, AOR, 0.41; 95% CI, 0.17 to 0.96; for center 9, AOR, 0.25; 95% CI, 0.09 to 0.67). This variation persisted when the national average (grand mean) was

**Table 1. Patient characteristics by vascular access type at 90 days after hemodialysis initiation**

Variable	N	CVC	AVF	P Value
Total, n (%)	610	468 (77)	142 (23)	
<b>Sex, n (%)</b>				
Female	397	292 (74)	105 (26)	
Male	213	176 (83)	37 (17)	0.01
Age (yr), mean±SD	610	59.7±16	63.7±15	0.008
<b>Age group, n (%)</b>				
<60 yr	232	169 (73)	63 (27)	
60–77 yr	260	200 (77)	60 (23)	
≥78 yr	118	99 (84)	19 (16)	0.07
<b>Primary cause of ESKD, n (%)</b>				
Polycystic kidney disease	40	22 (55)	18 (45)	
Diabetic nephropathy	111	80 (72)	31 (28)	
GN	112	81 (72)	31 (28)	
Hypertension	33	26 (79)	7 (21)	
Other cause	56	48 (86)	8 (14)	
Other urologic	38	25 (66)	13 (34)	
Unknown/missing	220	186 (85)	34 (16)	<0.001
<b>Comorbidities, n (%)</b>				
Atherosclerotic heart disease	97	75 (77)	22 (23)	0.90
Cerebrovascular disease	28	24 (86)	4 (14)	0.27
Congestive heart failure	98	71 (72)	27 (28)	0.30
Other cardiac disease	98	71 (72)	27 (28)	0.30
Peripheral vascular disease	25	19 (76)	6 (24)	>0.99
Diabetes	209	162 (78)	47 (23)	0.75
Hypertension	339	250 (74)	89 (26)	0.06
<b>Physical measurements (mm Hg), mean±SD</b>				
Predialysis systolic BP	610	141.9±19.1	144.7±21.8	0.24
Predialysis diastolic BP	610	73.5±13.6	76.6±14.0	0.02
Postdialysis systolic BP	610	138.1±19.2	140.5±19.2	0.18
Postdialysis diastolic BP	610	74.9±12.3	76.5±12.3	0.13
<b>Anthropometric measures, mean±SD</b>				
Predialysis weight (kg)	609	81.9±18.2	77.6±18.9	0.008
BMI (kg/m <sup>2</sup> )	510	28.1±6.5	27.3±6.5	0.18
<b>BMI (kg/m<sup>2</sup>) category, n (%)</b>				
18.5–25.0	178	142 (80)	36 (20)	
<18.5	20	17 (85)	3 (15)	
25.0–30.0	165	125 (76)	40 (24)	
>30.0	147	106 (72)	41 (28)	0.33
<b>Laboratory measures, mean±SD</b>				
Albumin (g/L)	569	37.1±4.4	34.9±5.6	<0.001
Calcium (mmol/L)	569	2.3±0.1	2.2±0.2	<0.001
Phosphate mmol/L)	475	1.5±0.3	1.5±0.4	0.66
Hemoglobin (g/dl)	570	10.5±1.2	10.3±1.2	0.11
Ferritin (ng/L)	443	346.0±313.2	415.0±449.5	0.06
PTH (pg/ml)	468	220.5±220.6	224.3±291.7	0.91
Predialysis creatinine (μmol/L)	500	602.9±202.2	547.9±210.0	0.004
Predialysis urea (mmol/L)	486	21.6±5.6	19.8±5.7	0.007
Predialysis potassium (mmol/L)	477	4.5±0.5	4.5±0.5	0.57
Predialysis bicarbonate (mmol/L)	452	22.5±2.2	23.8±2.3	<0.001
Postdialysis creatinine (μmol/L)	430	257.6±102.5	243.9±109.0	0.12
Postdialysis urea (mmol/L)	486	21.6±5.6	19.8±5.7	0.007
Postdialysis potassium (mmol/L)	424	3.6±0.4	3.6±0.4	0.71
Postdialysis bicarbonate (mmol/L)	180	27.7±2.6	27.7±2.6	0.60

CVC, central venous catheter; AVF, arteriovenous fistula; BMI, body mass index; PTH, parathyroid hormone.

used as the referent group. In this analysis, patients from center 9 were significantly less likely to use a CVC than an AVF (AOR, 0.37; 95% CI, 0.17 to 0.79), whereas patients

from center 4 had significantly greater utilization of CVCs than AVFs compared with the national average (AOR, 2.76; 95% CI, 1.29 to 6.59) (Supplemental Table 1).

**Table 2. Patient distribution by access type at 90 days from hemodialysis initiation for each center of primary medical supervision**

Variable	N	%		P Value
		CVC	AVF	
Total	610	77	23	
<b>Primary center of supervision</b>				
Center 1	120	83	18	
Center 2	27	74	26	
Center 3	106	64	36	
Center 4	73	86	14	
Center 5	45	84	16	
Center 6	44	91	9	
Center 7	39	80	21	
Center 8	49	63	37	
Center 9	50	68	32	
Center 10	57	77	23	0.001

CVC, central venous catheter; AVF, arteriovenous fistula.

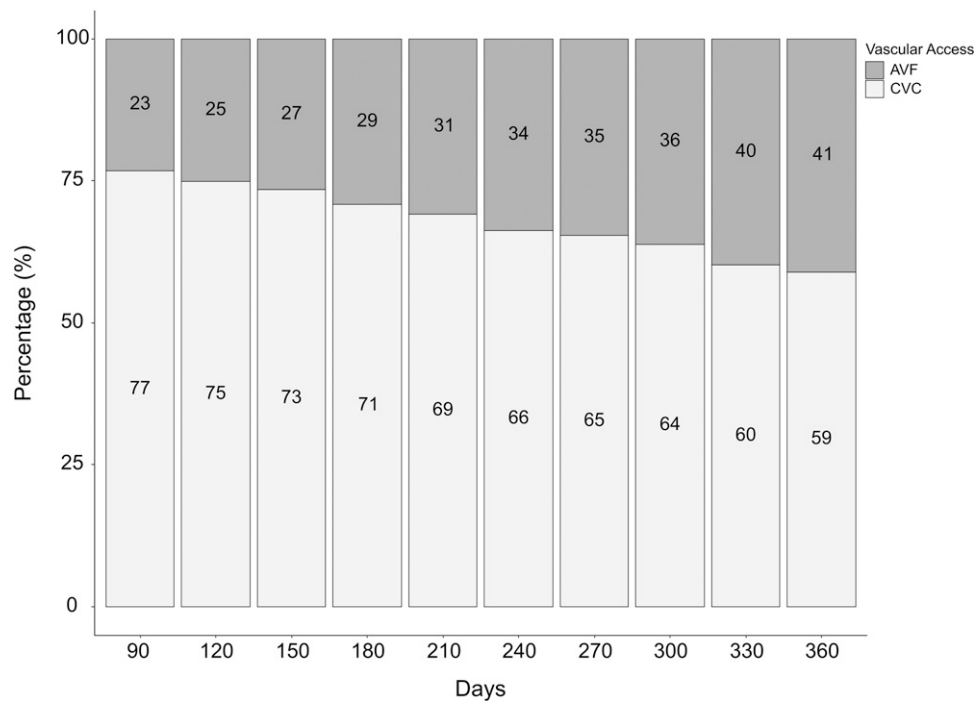
**Factors Associated with Conversion of CVC to AVF**

The evolution of permanent vascular access in the first year of HD is shown in Figures 2 and 3. The overall percentage of patients with a CVC decreased significantly from 77% at day 90 to 59% by day 360, with a corresponding rise in AVF use from 23% to 41%. After adjustment for patient and facility-level characteristics, significant inter-center variation was observed at the end of follow-up. Compared with the reference group (center 1), patients from center 3 were more than two-fold more likely to

convert to an AVF, whereas patients in center 4 were 75% less likely to use an AVF at the end of the first year of dialysis (center 3, HR, 2.09; 95% CI, 1.04 to 4.18; center 4, HR, 0.25; 95% CI, 0.08 to 0.74), as shown in Figure 4 and Table 4. This center variation persisted when the national average (grand mean) was used as referent (Supplemental Table 2). The assumption of constant relative risk over time was assessed by Schoenfeld residual analysis. The sex term was found to violate the proportional hazard assumption ( $P < 0.001$ ). Consequently, the Cox model was refit, stratified by the sex term. The same intercenter variation was confirmed and the factors associated with conversion to AVF remained unchanged. The cumulative incidence of vascular access conversion in the overall sample, stratified by sex, is described in Figure 5. From this analysis, it was apparent that conversion rates from CVC to AVF increased over time for both men and women. However, conversion rates were higher for women than men before day 240, whereas thereafter the rates of conversion were higher for men than for women. In our analysis, older patients were less likely to convert from CVC to AVF during follow-up (for age  $>77$  versus  $<60$  years [referent], HR, 0.43; 95% CI, 0.19 to 0.96). Additionally, the rates of conversion were significantly higher in patients with an elevated BMI who had a CVC after adjustment (per 1 kg/m<sup>2</sup> higher BMI, HR, 1.05; 95% CI, 1.02 to 1.08).

**Discussion**

In this nationally representative study, we observed high rates of CVC utilization (77%), and correspondingly low rates of AVF use (33%), among new patients treated with HD in the Irish health system. Furthermore, we revealed



**Figure 2.** | Among incident patients on hemodialysis in the Irish health system, there was modest rate of conversion from central venous catheter to arteriovenous fistula use during the first year of dialysis. Data is extracted from the KDCPMS for incident patients from 2015 and 2016. AVF, Arteriovenous fistula; CVC, Central venous catheter.

**Table 3. Patient and center characteristics associated CVC use (versus AVF) access at 90 days after hemodialysis initiation**

Variable	AOR (95% CI) <sup>a</sup>	P Value
<b>Sex</b>		
Male (reference)	1.00	
Female	1.76 (1.01 to 3.12)	0.05
Age per 1 year increase	1.01 (0.99 to 1.02)	0.44
<b>Primary cause of ESKD</b>		
Diabetic nephropathy (reference)	1.00	
Polycystic kidney disease	0.62 (0.20 to 1.94)	0.40
GN	1.08 (0.39 to 3.06)	0.88
Hypertension	3.21 (0.77 to 15.75)	0.12
Urologic	0.52 (0.15 to 1.78)	0.29
Other	2.96 (0.93 to 10.63)	0.08
Unknown/missing	2.00 (0.80 to 5.22)	0.15
<b>Comorbidities</b>		
Hypertension	0.83 (0.49 to 1.39)	0.48
Diabetes	1.68 (0.77 to 3.88)	0.20
Cerebrovascular disease	2.8 (0.83 to 13.21)	0.13
Congestive heart failure	0.5 (0.26 to 0.97)	0.04
Peripheral vascular disease	1.69 (0.49 to 7.94)	0.45
Atherosclerotic heart disease	0.92 (0.45 to 1.92)	0.82
<b>BMI (kg/m<sup>2</sup>) category</b>		
<18.5	0.90 (0.23 to 4.70)	0.89
18.5–25.0 (reference)	1.00	
25.0–30.0	0.85 (0.46 to 1.54)	0.59
>30.0	0.64 (0.34 to 1.19)	0.16
<b>Laboratory measures</b>		
Albumin per 1 g/L increase	0.88 (0.82 to 0.95)	0.001
Hemoglobin per 1 g/dl increase	0.36 (0.07 to 1.89)	0.23
Calcium per 1 mmol/L increase	0.97 (0.78 to 1.21)	0.80
<b>Center of supervision</b>		
Center 1 (reference)	1.00	
Center 2	0.55 (0.19 to 1.70)	0.28
Center 3	0.41 (0.17 to 0.96)	0.04
Center 4	1.88 (0.69 to 5.46)	0.23
Center 5	0.86 (0.31 to 2.63)	0.79
Center 6	1.46 (0.33 to 10.35)	0.65
Center 7	0.43 (0.13 to 1.47)	0.16
Center 8	0.46 (0.19 to 1.11)	0.08
Center 9	0.25 (0.09 to 0.67)	0.006
Center 10	0.79 (0.31 to 2.07)	0.62

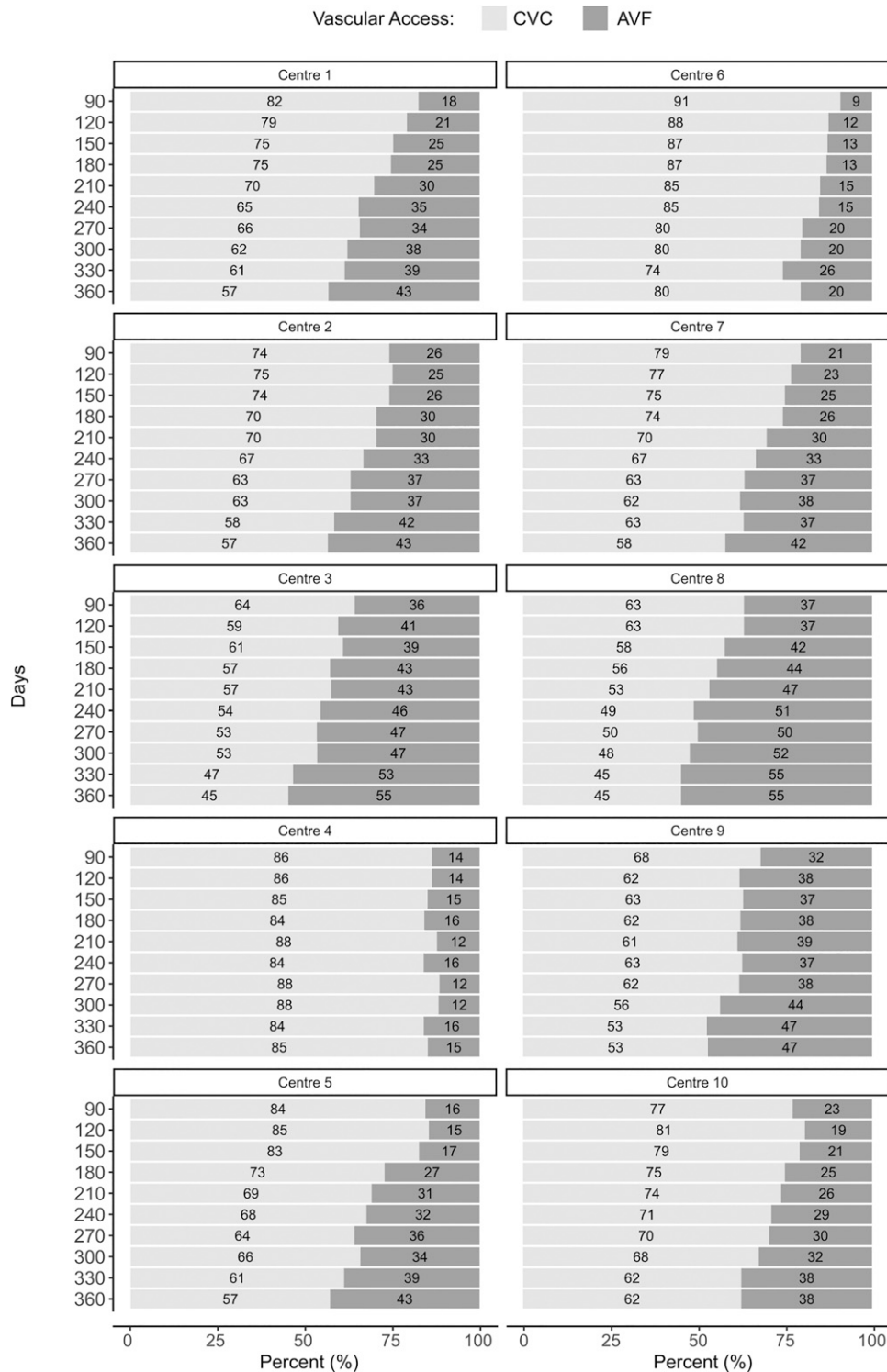
CVC, central venous catheter; AVF, arteriovenous fistula; AOR, adjusted odds ratio; BMI, body mass index.

aAdjusted odds ratio from logistic regression model adjusted for dialysis center, demographic and lifestyle characteristics (sex, age, and BMI group), comorbid conditions, primary cause of kidney disease, and laboratory indicators. Area under the curve=0.77.

relatively low conversion rates from CVC to AVF, with only 41% of all patients achieving a functioning AVF at the end of the first year of dialysis. Our analysis also uncovered considerable variation in CVC use across centers (from 63% to 91% at day 90) and in the subsequent rates of CVC conversion to AVF during the follow-up period, which was not explained by measured patient-related characteristics. Collectively, these findings indicate that factors operating outside the patient domain (*i.e.*, facility-level characteristics and organizational factors) may be responsible for the low rates of AVF in the first year and also account for the substantial differences existing across centers in the Irish health system. These results highlight that Ireland lags behind international best practice in achievement of recommended AVF rates, findings that have important implications for strategic planning and actionable initiatives.

The most striking finding from this national study is the high prevalence of CVC use within 3 months of dialysis initiation, and its relative persistence throughout the first year of dialysis. Optimum predialysis care involves aligning the right vascular access, with the right patient, at the right moment in time, and in the right circumstance (15). Such alignment is challenging, and may be hindered by a complex interplay of individual patient characteristics and center-based practices (16). Historically, it has been argued that delayed patient referral to nephrologists is the major contributor to increased catheter use due to inadequate predialysis preparation time (16–20). More recent evidence, however, suggests more complex reasons, given that programs with early referral pathways continue to have high rates of CVC use (21).

We highlight substantial variation in AVF use across dialysis facilities in the Irish health system, which was not



**Figure 3.** | Evolution of vascular access in the Irish healthcare system during the first year of dialysis among incident patients varied by center of primary medical supervision. Data for incident patients from 2015-2016 from KDCPMS.

explained by patient-level factors. The percentage rates for AVF use at day 90 after HD initiation were remarkably low, and varied from 9% to 37%, suggesting factors operating in the predialysis period were accountable. Although our research did not specifically examine patient-specific

factors, such as preference or expected survival, that may influence the type of vascular access, our results are broadly consistent with published data highlighting the substantial role of facility-related factors in driving practice patterns (22–25). Although there are international

**Table 4. Patient and center characteristics associated with conversion from a CVC in place at 90 days to a functional AVF at 360 days after hemodialysis initiation**

Characteristics	HR (95% CI) <sup>a</sup>	P Value
<b>Primary center of supervision</b>		
Center 1 (reference)	1.00	
Center 2	0.27 (0.06 to 1.18)	0.08
Center 3	2.09 (1.04 to 4.18)	0.04
Center 4	0.25 (0.08 to 0.74)	0.01
Center 5	0.96 (0.4 to 2.28)	0.92
Center 6	0.49 (0.14 to 1.76)	0.28
Center 7	1.08 (0.38 to 3.06)	0.89
Center 8	0.91 (0.36 to 2.29)	0.84
Center 9	1.22 (0.5 to 2.94)	0.67
Center 10	0.73 (0.3 to 1.74)	0.47
<b>Age (yr) group</b>		
<60 (reference)	1.00	
60–77	0.78 (0.49 to 1.26)	0.31
>77	0.43 (0.19 to 0.96)	0.04
<b>Primary cause of ESKD</b>		
Diabetic nephropathy (reference)	1.00	
Polycystic kidney disease	2.11 (0.77 to 5.77)	0.15
GN	0.97 (0.38 to 2.43)	0.94
Hypertension	0.27 (0.05 to 1.38)	0.12
Other	0.53 (0.17 to 1.59)	0.25
Urologic	1.16 (0.32 to 4.15)	0.82
Unknown/missing	0.67 (0.3 to 1.48)	0.32
<b>Comorbidities</b>		
Hypertension	1.31 (0.79 to 2.16)	0.29
Diabetes mellitus	1.21 (0.61 to 2.39)	0.59
Cerebrovascular disease	0.79 (0.3 to 2.07)	0.63
Congestive cardiac failure	1.01 (0.5 to 2.02)	0.98
Peripheral vascular disease	0.55 (0.16 to 1.88)	0.34
Atherosclerotic cardiac disease	0.73 (0.37 to 1.44)	0.36
<b>Anthropometric measures</b>		
BMI per 1 kg/m <sup>2</sup> increase	1.05 (1.02 to 1.08)	0.002
<b>Laboratory measures</b>		
Albumin per 1 g/L increase	1.04 (0.98 to 1.1)	0.23
Hemoglobin per 1 g/dl increase	1.16 (0.96 to 1.39)	0.13
Calcium per 1 mmol/L increase	1.17 (0.3 to 4.54)	0.82

CVC, central venous catheter; AVF, arteriovenous fistula; HR, hazard ratio; BMI, body mass index.

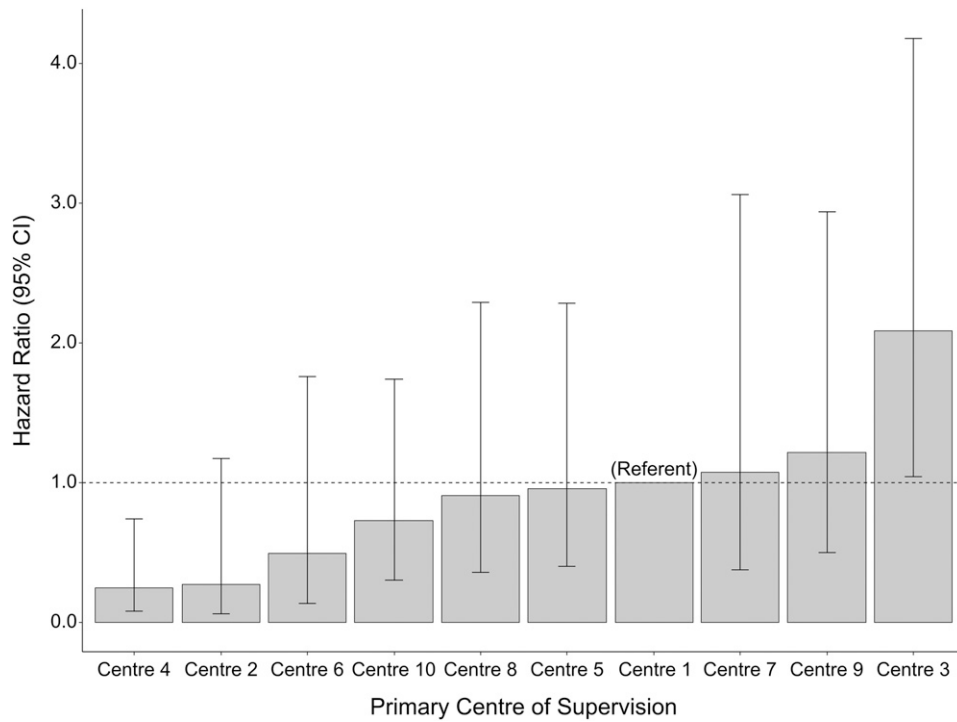
<sup>a</sup>Hazard ratio from sex-stratified Cox model, adjustments were made for dialysis center, demographic and lifestyle characteristics (age group and BMI), comorbid conditions, primary cause of kidney disease, and laboratory indicators. BMI was modeled as a linear variable, there was no evidence of conversion from CVC to AVF in this cohort for underweight participants.

differences with regard to vascular access practices; our observations suggest that care delivery in Ireland lags behind that of other industrialized countries. Data from the international Dialysis Outcomes and Practice Patterns Study found that AVF use at day 60 postdialysis initiation was 56% in Germany and 53% in the United Kingdom, which is substantially higher than the 23% rate in our Irish study (25). It is our view that such international comparisons serve to support changes in national policy and in strategic planning to promote a coordinated vascular access program. An excellent example of such landmark initiatives aiming to tackle facility-related hindrances is the “Fistula First Breakthrough Initiative” implemented in the United States in 2003. This highly effective and goal-directed quality improvement project resulted in doubling the prevalence of AVF use, from 33% to 63%, in a decade (7,8,26). Similarly, to improve vascular access practice, focused strategic policies and effective predialysis care is

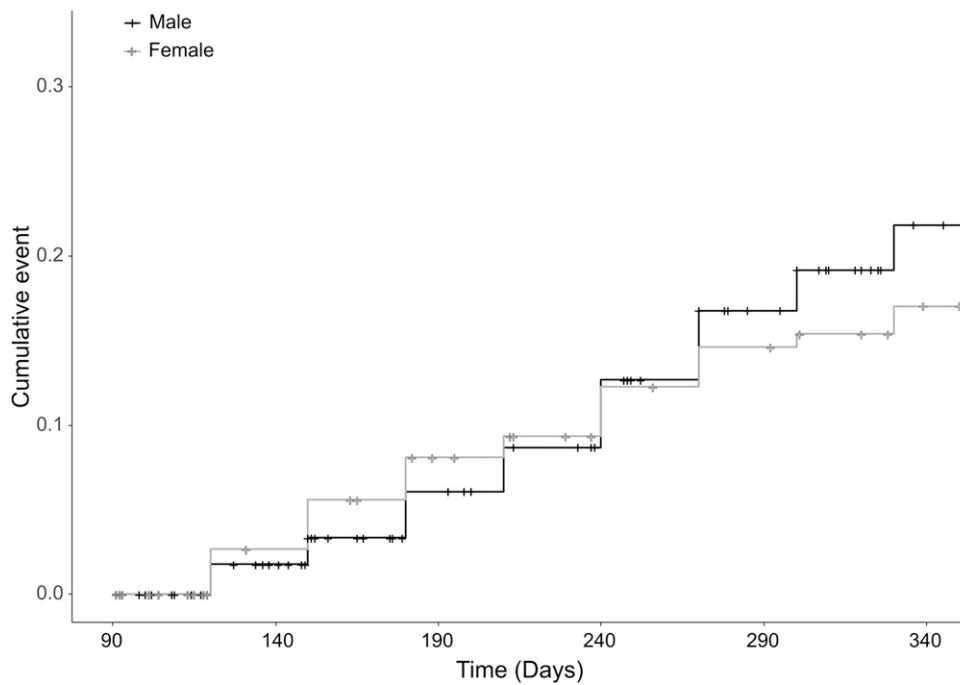
an essential requirement needed to address healthcare provider processes in the Irish healthcare system.

The adverse influence of age was again evident from this analysis, with older patients less likely to convert from a CVC at day 90 to a functioning AVF at the end of the first year. High prevalence of multimorbidity, shortened life expectancies, and high rates of nonfunctioning AVF, as compared with younger patients, may have influenced clinical practice in an Irish context. Equally noteworthy was the finding of higher rates of conversion from CVC to AVF with increasing BMI values. Although higher BMI is associated with fistula failure, the conversion rate from CVC at day 90 to an AVF at day 360 AVF was significantly higher for patients with larger, rather than smaller, body size. Our findings further support the observations of Alencar de Pinho *et al.* from the Ramipril Efficacy In Nephropathy registry (27), where patients with a higher BMI were more likely to convert to a functional arteriovenous access.





**Figure 4.** | Significant variation was observed between centers in the likelihood of conversion from central venous catheter at day 90 to a functional arteriovenous fistula. Data for incident patients on hemodialysis in 2015 and 2016 from the KDCPMS, adjusted for patient and facility-level characteristics.



**Figure 5.** | Conversion rates from central venous catheter at day 90 to a functional arteriovenous fistula were higher for women before day 240, and higher for men thereafter - Cumulative event function stratified by sex. Adjustments include age, primary kidney disease, comorbidities, laboratory variables, and center of medical supervision.

Our research has some limitations worth mentioning. Given the retrospective nature of the study, we accept that unmeasured and residual confounding is an inherent

shortcoming. We also acknowledge that other important factors, such as patient preference and AVF failure rates, were not available in our dataset and, consequently, were

not included in the final analysis. We did observe missing data on selected demographic and comorbid indicators but, in general, the rates were low (<10%), and our observed rates for primary causes of ESKD and comorbid conditions were similar to those from other European countries (28,29). Despite these shortcomings, our study had several important strengths. First, the study was nationally representative and provided the first detailed description of vascular access practices among incident patients on HD in the Irish health system. Second, the availability of longitudinal data within the first year of dialysis provided new insights into the evolution of vascular access and its determinants. Third, our analysis captured a comprehensive set of patient-level characteristics, including comorbid conditions and laboratory indicators of health, and allowed us to adjust for several potential confounders. Fourth, there was virtually complete follow-up on all patients, with very few lost to follow-up. As a consequence, our results are broadly generalizable and highlight the substantial variability in vascular access provision in the Irish health system.

We conclude that CVCs are the predominant type of vascular access in the Irish dialysis population, and are highly prevalent in the first year of dialysis. There is substantial center variation that was not explained by patient-related factors alone. The potential reasons for this variation include access to nephrology care, poor vascular access planning, patient motivation for access placement, variation in surgical expertise, and difficulty with AVF maturation in high-risk groups. Rigorous evaluation of these potential factors is key to inform national policy and guide implementation strategies so that we can improve patient outcomes.

#### Disclosures

W. D. Plant reports receiving honoraria from AstraZeneca, MSD, Novartis, NovoNordisk, and Servier. A. G. Stack reports having consultancy agreements with Astellas, AstraZeneca, and Vifor Pharma; receiving honoraria from AstraZeneca, Menarini, and Vifor; serving on the editorial board for *BMC Nephrology*; receiving research funding from Vifor Pharma (educational grant); and serving on a speakers bureau for Vifor. All remaining authors have nothing to disclose.

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#### Authors Contributions

G. Ahmed, L. D. Browne, W. F. Hussein, and A. G. Stack were responsible for data curation; G. Ahmed, W. F. Hussein, and A. G. Stack wrote the original draft; L. D. Browne and W. F. Hussein were responsible for validation and visualization; L. D. Browne and W. F. Hussein were responsible for formal analysis; L. D. Browne, W. F. Hussein, and A. G. Stack were responsible for methodology; L. D. Browne, W. D. Plant, and A. G. Stack reviewed and edited the manuscript; L. D. Browne and A. G. Stack were responsible for funding acquisition; W. F. Hussein conceptualized the study; W. F. Hussein and W. D. Plant were responsible for investigation; W. D. Plant and A. G. Stack provided supervision; A. G. Stack was responsible for project administration and resources; and all authors contributed to the development of the manuscript, and approved the final version.

#### Supplemental Material

This article contains the following supplemental material online at <http://kidney360.asnjournals.org/lookup/suppl/doi:10.34067/KID.0006842020/-/DCSupplemental>.

Supplemental Table 1. Patient and centre characteristics associated CVC use (versus AVF) access at 90 days following haemodialysis initiation.

Supplemental Table 2. Patient and centre characteristics associated with conversion from a CVC in place at 90 days to a functional AVF at 360 days following haemodialysis initiation.

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