

Supplemental Material

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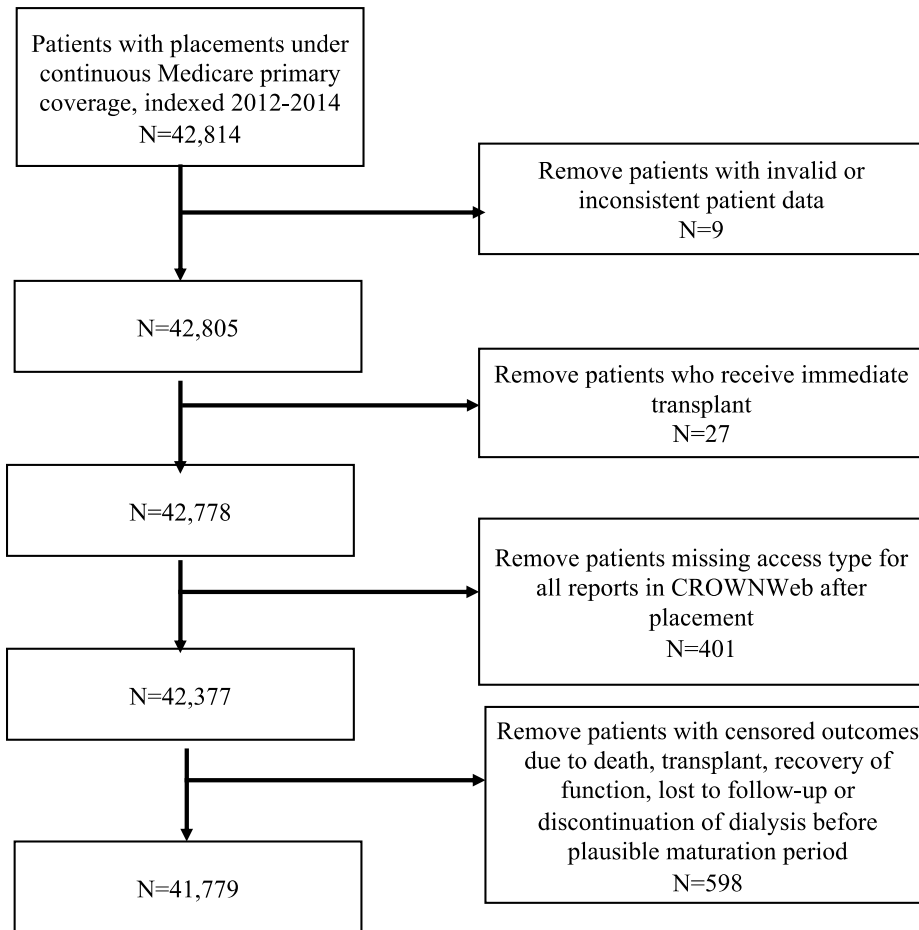
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Supplemental Figure 1. Patient Selection Diagram



Source: USRDS Data release 2016

Supplemental Table S1. Diagnosis and procedure codes defining vascular-access related services

Care Setting	Code Type	Category	Codes
Inpatient Admissions	ICD-9 Diagnosis Codes	Catheter infection	999.31, 991.32, 999.33,
		Device or vascular access infection	996.6, 996.62, 996.1, 996.73, 996.74
	ICD-9 Procedure Codes	Arteriovenostomy or revision/removal of arteriovenous shunt	39.27, 39.42, 39.43
Physician Services	HCPCS Codes	Access creation	36818, 36819, 36820, 36821, 36825, 36830
		Access revision	36832, 36833
		Catheter placement	36011, 36556, 36558, 36800, 36810, 76937
		Angioplasty	35460, 35475, 35476, 75978, G0392, G0393
		Declotting	36593, 36831, 36870, 37201
		Revision	35900, 35903, 36575, 36596, 36597, 36815, 36833, 36838, 37607
		Stents	37205, 37206, 37207, 37208, 37236, 37237, 37238, 37239, 75960
		Catheter replacement	36581, 77001
		Other	G0365, 93990, 36147, 36148, 75791, 36589
Outpatient Visits*	ICD-9 Diagnosis Codes	Catheter infection	999.31, 991.32, 999.33
		Device or vascular access infection	996.6, 996.62, 996.1, 996.73, 996.74
Other Settings (Hospice, Skilled Nursing Facility, Home Health)	ICD-9 Diagnosis Codes	Catheter infection	999.31, 991.32, 999.33
		Device or vascular access infection	996.6, 996.62, 996.1, 996.73, 996.74

*Outpatient claims are not definitively tied to a physician services claim. Therefore, a 5 day window around the physician services claim date was allowed when an outpatient facility claim could not be matched by diagnosis code or exact date.

Supplemental Table S2. Drugs included in ESRD Prospective Payment System (PPS) Consolidated Billing 2012-2014^a

ESRD PPS Drug Class	Sub-group reporting for	HCPCS Code	Name	Years In PPS
Access Management	Plasminogen Activators (PAs)	J2997	Alteplase recombinant	2012-2014
		J2993	Reteplase injection	
		J3364	Urokinase 5000IU injection	
		J3365	Urokinase 250000IU injection	
	Other access management Drugs	J1642	Inj heparin sodium per 10U	2012-2014
		J1644	Inj heparin sodium per 1000U	
		J1945	Lepirudin	
		C9121	Injection argatroban	2014
Anti-infectives		J0878	Daptomycin	2012-2014
		J3370	Vancomycin HCL injection	
Anemia Management	ESAs	J0882	Darbepoetin	2012-2014
		Q4081	EPO	2013-2014
		J0886	EPO	
	Other anemia management	J1756	Iron sucrose injection	2012-2014
		J2916	NA Ferric gluconate complex	
		J3420	Vitamin B12 injection	
		J0890	Peginesatide	
		J1750	Iron Dextran	2013-2014
		Q0139	Ferumoxytol	
		Q2047	Peginesatide	

^ahttps://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/ESRDpayment/Consolidated_Billing.html

Note: The Cellular Management class (levocarnitine only) is not included in this analysis. Two additional classes (Bone and Mineral Metabolism and Composite Rate Drugs and Biologicals) were introduced in 2013 and are not included in this analysis.

Supplemental Table S3. Utilization of Selected Drugs in the ESRD PPS for arteriovenous fistula (AVF) and arteriovenous graft (AVG) placements 2012-2014

		AVF (n=38,035)	AVG (n=12,789)	Sig.
Access Management	Plasminogen Activators (PAs)			
	Percent cohort ≥1 administration, 2012-2014 (N)	7.3% (2,782)	11.0% (1,411)	<0.001
	Mean administrations per dialysis-month (SD)	0.03 (0.37)	0.04 (0.27)	
	Median administrations per dialysis-month [Range]	0 [0-32.4]	0 [0-10.1]	<0.001
	Other access management*			
	Percent cohort ≥1 administration, 2012-2014 (N)	61.4% (23,333)	60.7% (7,762)	0.190
	Mean administrations per dialysis-month	0.39 (1.96)	0.38 (1.51)	
	Median administrations per dialysis-month [Range]	0.08 [0-106]	0.09 [0-44]	<0.001
Anti-Infectives	Daptomycin, Vancomycin†			
	Percent cohort ≥1 administration, 2012-2014 (N)	35.7% (13,595)	37.8% (4,837)	<0.001
	Mean administrations per dialysis-month	0.23 (0.64)	0.28 (0.76)	
	Median administrations per dialysis-month [Range]	0 [0-12.3]	0 [0-12.3]	<0.001
Anemia Management	Erythropoiesis Stimulating Agents (ESAs)			
	Percent cohort ≥1 administration, 2012-2014 (N)	91.4% (34,778)	88.6% (11,327)	<0.001
	Mean administrations per dialysis-month	8.78 (6.42)	8.44 (6.39)	
	Median administrations per dialysis-month [Range]	8.0 [0-45]	7.67 [0-45.9]	<0.001
	Other anemia management††			
	Percent cohort ≥1 administration, 2012-2014 (N)	91.2% (34,683)	85.8% (10,973)	<0.001
	Mean administrations per dialysis-month	2.99 (1.83)	2.72 (1.90)	
	Median administrations per dialysis-month [Range]	3.01 [0-19.1]	2.78 [0-14]	<0.001

^aDrug codes for each category are given in Supplemental Table S2.

* Includes heparin, lepirudin (all years) and argatroban (2014 only)

†Daptomycin and vancomycin are the only bundled anti-infectives over the study period

† † Includes iron supplements and vitamin B12 (all years), ferumoxytol and peginesatide in 2013-2014

Supplemental Table S4. Catheter use for dialysis post-placement in patients with arteriovenous fistula (AVF) or arteriovenous graft (AVG) placements (2012-2014).

	AVF	AVG	Sig.
Percent of cohort reporting catheter use ≥ 1 month in CROWNWeb	72.1%	23.3%	<0.001
Mean CROWNWeb monthly reports of CVC use per access life* (SD)	4.78 (3.65)	3.66 (3.89)	
Median CROWNWeb monthly reports of CVC use per access life* [Range]	4.0 [0-32]	3.0 [0-32]	<0.001
Mean percent of access life on catheter** (SD)	58.3% (36.8)	49.6% (38.7)	
Median percent of access life on catheter [Range]	53.8% [0-100]	36.4% [0-100]	<0.001

* From placement to abandonment (for post-ESRD placement only).

** CROWNWeb monthly report data represent a snapshot in time, and do not capture the entire inventory of placements used for HD in the month.

Supplemental Text 1. Comparison of results and methods to other published studies

USRDS 2010 Annual Data Report [6]

The methodology used in the 2010 ADR created patient cohorts identified by the access type (fistula, graft or catheter) in place during the last quarter of a calendar year with costs for each cohort accumulated over the following calendar year or until death, change in modality or transplant. This intent-to-treat approach may obscure the very dynamic nature of the actual vascular access type used in clinical practice. Moreover, by including period prevalent patients based on an access placed one quarter or more prior to the cost accumulation period, costs related to the placement and the early initiation phase were excluded.

ADR all-cause cost estimates are comparable to our findings: adjusting to a common 2017 dollars, the ADR estimated outpatient costs for all period prevalent HD patients to be \$2,473 per month and inpatient costs to be \$2,949 per month. However, despite similar code sets defining access-related events, the ADR access-related costs were only 6-12% of the total all-cause costs, while our estimates for an incident population are 21-30%. Much of this is likely due to our explicit capture of placement costs and the high-cost phase immediately after placement (see Figures 1-2). Furthermore, the ADR method for identifying access-related events underestimates costs in that only “pure” date and diagnosis/procedure code matches for inpatient, outpatient claims and physician/ supplier claims are included.

Thamer et al. Medicare Costs Associated With Arteriovenous Fistulas Among US Hemodialysis Patients [8]

Using the USRDS, Thamer et al. also performed an intent-to-treat analysis of 10,135 AVF patients initiating hemodialysis over a one-year period from 2010-2011. Three patient cohorts were defined by access status at hemodialysis initiation – 1) patients initiating HD with a mature AVF; 2) patients initiating HD with a maturing AVF; and 3) patients initiating HD with a CVC, having an AVF placed within 9 months of initiation. Annualized cost outcomes for up to 2.5 years of follow-up were reported by cohort and clinical outcome (maintain primary patency, primary patency loss, secondary patency loss and AVF nonuse), making direct comparisons to our findings difficult.

Code sets for physician services were largely similar, with the largest differences in the definition of access related inpatient admissions. In the Thamer study, access related admissions were defined by a set of DRG codes combined with specific diagnosis codes, while our study required only an access-related infection code. As a sensitivity analysis, we implemented the Thamer method using our access cohort and found similar cost results (Supplemental Table S3).

Supplemental Table S5. Sensitivity Analysis comparing Current Study Definition of Access-Related Inpatient Admissions to the Thamer Method.

	Access-Related Costs Using Current Study Method ¹		Access Related Costs Using Thamer Method [8]	
	AVF (n=38,035)	AVG (n=12,789)	AVF (n=38,035)	AVG (n=12,789)
Percent of cohort with ≥1 admission, 2012-2014 (N)	19.9% (7,582)	27.7% (3,581)	21.8% (8,293)	27.5% (3,512)
Mean number of admissions per dialysis-month (SD)	0.03 (0.11)	0.06 (0.15)	0.04 (0.13)	0.07 (0.18)
Median number of admissions per dialysis-month [Range]	0 [0-3]	0 [0-2]	0 [0-2.6]	0 [0-2]
Mean length of stay in days (SD)	1.9 (5.5)	2.7 (6.2)	1.7 (4.6)	2.2 (5.7)
Median length of stay [Range]	0 [0-259]	0 [0-159]	0 [0-210]	0 [0-303]
Mean cost per dialysis-month ² (SD)	\$662 (2,500)	\$1,186 (3,820)	\$698 (2,655)	\$1,152 (3,764)

¹Access-related utilization defined by ICD9 and HCPCS codes listed in Supplemental Table S1. Dialysis sessions are not considered access-related; all dialysis costs are reported in the all-cause outpatient category.

²Costs adjusted to 2017 USD.