Original Research

Increased Clinical and Economic Burden Associated With Peripheral Intravenous Catheter–Related Complications: Analysis of a US Hospital Discharge Database

Sangtaeck Lim, MPH[1], Gaurav Gangoli, PharmD[2], Erica Adams, BS[1], Robert Hyde, MBA[1], Michael S. Broder, MD, MSHS[3], Eunice Chang, PhD[3], Sheila R. Reddy, PhD, RPh[3], Marian H. Tarbox, MPP[3] [iD], Tanya Bentley, PhD[3], Liza Ovington, PhD[1], and Walt Danker III, PhD[1]

Abstract
The burden of complications associated with peripheral intravenous use is underevaluated, in part, due to the broad use, inconsistent coding, and lack of mandatory reporting of these devices. This study aimed to analyze the clinical and economic impact of peripheral intravenous–related complications on hospitalized patients. This analysis of Premier Perspective® Database US hospital discharge records included admissions occurring between July 1, 2013 and June 30, 2015 for pneumonia, chronic obstructive pulmonary disease, myocardial infarction, congestive heart failure, chronic kidney disease, diabetes with complications, and major trauma (hip, spinal, cranial fractures). Admissions were assumed to include a peripheral intravenous. Admissions involving surgery, dialysis, or central venous lines were excluded. Multivariable analyses compared inpatient length of stay, cost, admission to intensive care unit, and discharge status of patients with versus without peripheral intravenous–related complications (bloodstream infection, cellulitis, thrombophlebitis, other infection, or extravasation). Models were conducted separately for congestive heart failure, chronic obstructive pulmonary disease, diabetes with complications, and overall (all 7 diagnoses) and adjusted for demographics, comorbidities, and hospital characteristics. We identified 588 375 qualifying admissions: mean (SD), age 66.1 (20.6) years; 52.4% female; and 95.2% urgent/emergent admissions. Overall, 1.76% of patients (n = 10 354) had peripheral intravenous–related complications. In adjusted analyses between patients with versus without peripheral intravenous complications, the mean (95% confidence interval) inpatient length of stay was 5.9 (5.8-6.0) days versus 3.9 (3.9-3.9) days; mean hospitalization cost was $10 895 ($10 738-$11 052) versus $7009 ($6988-$7031). Patients with complications were less likely to be discharged home versus those without (62.4% [58.6%-66.1%] vs 77.6% [74.6%-80.5%]) and were more likely to have died (3.6% [2.9%-4.2%] vs 0.7% [0.6%-0.9%]). Models restricted to single admitting diagnosis were consistent with overall results. Patients with peripheral intravenous–related complications have longer length of stay, higher costs, and greater risk of death than patients without such complications; this is true across diagnosis groups of interest. Future research should focus on reducing these complications to improve clinical and economic outcomes.

Keywords
peripheral intravenous catheter, bloodstream infection, clinical and economic burden, length of stay, discharge status, retrospective studies, cross-sectional analysis

---

What do we already know about this topic?
Nearly 200 million peripheral intravenous (PIV) catheters are used annually in the United States, but PIV-associated complications such as bloodstream infection are currently underevaluated, which may be due, in part, to the challenge of identifying PIV-associated complications in real-world data because of the broad use, inconsistent coding, and voluntary reporting of PIV devices.

How does your research contribute to the field?
Contributes to limited research regarding evidence on PIV-associated complications and subsequent outcomes, which is warranted to improve safety procedures for using PIV catheters in hospital settings.
What are your research's implications toward theory, practice, or policy?
Patients with PIV-associated complications have longer hospital stays, higher inpatient costs, and greater risk of death than patients without such complications; by implementing policies focused on quality improvement and making procedures for using PIV catheters more safe, PIV-associated complications may be reduced and clinical and economic outcomes may be improved

Introduction

Intravenous catheters of all types are ubiquitous in health care settings in the United States. Over 5 million central venous catheters,[1] or central lines, and nearly 200 million peripheral intravenous (PIV) catheters[2-4] are used annually in the United States. The widespread use of intravascular devices has raised concerns about the risk of infection and other adverse outcomes occurring from their use.[2,5,6]

It is well established through prior research that central lines can increase the risk of complications, such as bloodstream infections (BSI), and lead to intensive health care resource utilization.[7] Central-line–associated bloodstream infections (CLABSI) occur in about 3% to 5% of catheterizations.[5,8] According to a recent Healthcare-associated Infections (HAI) Progress Report, an estimated 21 000 CLABSI occurred in the United States in 2014.[9] The Centers for Disease Control and Prevention (CDC) reported an adjusted inpatient hospital cost of nearly $30 000 per patient and a total annual cost of $0.67 to $2.68 billion due to infections associated solely with central-line use.[10] Catheter-related bloodstream infections (CRBSI), which include infections from any catheter type (eg, central lines and PIVs), are also associated with increased hospital length of stay (LOS) and health care costs.[11-13]

Despite the common use of PIVs, research on the complications and related burden associated with PIV catheter use is limited. Existing studies have focused mainly on rates of specific complications, such as BSIs or particular causative organisms, on small populations,[14-18] or on the management of catheter-related infections.[17,19,20] In addition, prior work may underestimate rates of PIV-associated complications due to potential underreporting of PIV infections.[3,15,17,18]

Furthermore, research on the costs associated with IV catheter-related complications has focused on central lines alone or combined with PIV, but not on PIV alone.[12]

Additional evidence of PIV-associated complications and subsequent outcomes is needed to inform policies that could improve procedures for using PIV catheters in hospital settings as well as for improving patient safety.[3,15,17,18] Therefore, the aim of this study was to quantify the rates of selected PIV-associated complications and the associated health care utilization and costs among hospitalized patients.

Methods

Design and Data Source

A retrospective cross-sectional analysis of hospital discharge records in the United States was conducted to examine the prevalence of PIV-associated complications and associated clinical and cost outcomes. The Premier Healthcare Database (PHD; formerly known as the Premier Perspective® Database at the time of this study), a large comprehensive electronic health care database, was used. The PHD covers over 108 million inpatient visits and over 765 million outpatient visits and contains data from over 208 million unique patients. Data include complete clinical coding, hospital cost, patient billing data (eg, medications and devices, laboratory tests, diagnostic and therapeutic services), type of admission, discharge status, and patient demographics from more than 970 hospitals (representing the 4 geographic regions) throughout the United States.[21] All discharge data were deidentified and compliant with the Health Insurance Portability and Accountability Act (HIPAA) of 1996. Institutional review board approval was not required.

[1]Ethicon, Inc., Somerville, NJ, USA
[2]Johnson & Johnson Medical Devices Companies, Somerville, NJ, USA
[3]Partnership for Health Analytic Research, LLC, Beverly Hills, CA, USA

Corresponding Author:
Gaurav Gangoli, Johnson & Johnson Medical Devices Companies, Highway 22 West, Somerville, NJ 08876, USA.
Email: ggangol@its.jnj.com

Table 1. Peripheral Intravenous–Associated Complications Code List.

Complication	ICD-9-CM code
Bloodstream infection (eg, septicemia, sepsis, severe sepsis, septic shock, septicemic, bacteremia, disseminated fungal infection, disseminated candida infection, and disseminated fungal endocarditis)	038.x Septicemia 995.91, 995.92 Sepsis, severe sepsis 785.52 Septic shock 020.0, 790.7, 117.9, 112.5, 112.81 Septicemic, bacteremia, disseminated fungal infection, disseminated candida infection, disseminated fungal endocarditis
Upper extremity cellulitis and abscess at the following sites: upper arm and forearm; hand except fingers and thumb; and unspecified sites	682.3 Upper arm and forearm 682.4 Hand except fingers and thumb 682.9 Unspecified sites
Upper extremity superficial phlebitis and thrombophlebitis at the following sites: upper extremity superficial vein; upper extremity, unspecified; and unspecified site	451.82 Upper extremity superficial vein 451.84 Upper extremity, unspecified 451.9 Unspecified site
Infections, not elsewhere classified (NEC), including acute infection following transfusion, infusion, or injection of blood and blood products; infection following other infusion, injection, transfusion, or vaccination; infection and inflammatory reaction due to vascular device, implant, and graft (includes peripheral venous vascular catheter)	999.34 Acute infection following transfusion, infusion, or injection, of blood and blood products 999.39 Infection following other infusion, injection, transfusion, or vaccination 996.62 Infection and inflammatory reaction due to vascular device, implant, and graft (includes peripheral venous vascular catheter)
Extravasation, including extravasation (infiltration) of other vesicant chemotherapy or agent	999.81 Extravasation (infiltration) of other vesicant chemotherapy 999.82 Extravasation (infiltration) of other vesicant agent

Note. ICD-9-CM = *International Classification of Diseases*, Ninth Revision, Clinical Modification.

Patient Selection

Hospital admissions occurring between July 1, 2013 and June 30, 2015 were identified, and this included patients who had 1 of 7 admission diagnoses listed as the primary diagnosis (via *International Classification of Diseases*, Ninth Revision, Clinical Modification [ICD-9-CM] code) in at least 1 inpatient admission claim: pneumonia, chronic obstructive pulmonary disease (COPD), myocardial infarction (MI), congestive heart failure (CHF), chronic kidney disease (CKD), diabetes with complications (DM), and major trauma (hip, spinal, cranial fractures) (see Appendix Table A1 for full list of codes). These admission diagnoses were selected because it was determined, based on expert clinical input, that patients admitted with such conditions would likely not have a PIV-associated complication, defined below, prior to admission.

Admissions that included dialysis, surgery, and central-line use (see Appendix Table A2 for codes) were excluded because such services could potentially cause complications independent of PIV. Also excluded were readmissions for the same primary diagnosis. Finally, it was assumed all patients in the sample received a PIV upon admission, in line with standard hospital admitting procedures. This approach was used to avoid underreporting PIV use in our sample, as dedicated procedure codes for PIV are often not used in the hospital setting.

Within each admission diagnosis and the overall group (7 admission diagnoses combined), patients were stratified according to whether they experienced a selected PIV-associated complication during the admission (yes/no). PIV-associated complication was defined as the presence of an ICD-9-CM code in the admission record for at least one of the following complications: BSI, cellulitis, phlebitis, infection not elsewhere classified, and extravasation (Table 1).

Study Measures

The rate of PIV-associated complication in the sample was calculated by the proportion of patients with each and any selected complication. The following key outcomes were compared according to PIV-associated complication status: hospital LOS in days, cost of hospitalization (USD), admission to the intensive care unit (ICU), and discharge status. Admission to the ICU was measured as the proportion being admitted (yes/no), and discharge status was measured as the proportion of patients either being sent home (reference), being sent to another facility, or having died prior to discharge.

Other variables included patient demographics (age, gender, and race), payment source (Medicare vs other), the Chronic Condition Indicator (CCI),[22] and admitting hospital characteristics, which were reported. The CCI categorizes 5-digit ICD-9-CM codes as either chronic or not chronic, which was used to calculate the number for chronic conditions for each patient.[22] Admitting hospital characteristics included admission type (urgent/emergent or elective), hospital geographic region, bed size (over 500 beds vs 500 beds or less), and whether the admission took place in an urban location (yes/no) or teaching hospital (yes/no).

Statistical Analyses

Descriptive statistics (eg, mean, standard deviation, and frequency) were reported for the patient, payer, and admitting hospital characteristics and number and frequency were for PIV-associated complication rates among each diagnosis and the overall group. Descriptive characteristics were also compared by PIV-complication status (with versus without) to assess potential confounders.

Multivariate analyses were conducted to compare the key outcomes of LOS, cost, admission to ICU, and discharge status for patients with versus without a PIV-associated complication. All models were adjusted for patient demographics (ie, age, gender, and race), number of comorbidities, and admitting hospital characteristics (ie, region, teaching hospital, and location). Analysis of covariance (ANCOVA) was conducted to compare LOS and the cost of index hospitalization between the study groups. Logistic regression and multinomial logistic regression were used to examine the outcomes of admission to ICU and discharge status, respectively. All models were conducted separately for the CHF, COPD, DM, and overall cohorts. In the model for the overall cohort, we also included 2-way interactions between diagnosis and the individual variables above. The 3 diagnosis groups were chosen based on clinical considerations, such as likeliness to have a PIV without a central line (CHF), potential vulnerability with a PIV infection (COPD), and the inclusion of younger patients (DM), and were analyzed separately to account for potential between-group differences that might obscure the relationship between PIV complication status and the outcomes.

Sensitivity analyses were conducted to examine the impact of a small percentage (1.5%) of patients who were observed in multiple diagnosis groups. For patients with multiple hospitalizations due to different diagnoses, the first hospitalization in time was chosen and those hospitalizations that followed were dropped. All data transformations and statistical analyses were performed using SAS® version 9.4 (SAS Institute, Cary, NC).

Results

Patient, Payer, and Hospital Characteristics

A total of 588 375 qualifying admissions were identified, ranging from 15 637 trauma patients to 187 904 patients admitted with pneumonia (Figure 1). In the combined group (including all 7 admission diagnosis cohorts), the mean age was 66.1 years (range: 50.5-75.0 years). Overall, 52.4% of patients were female (range: 47.8%-56.0%), and 71.2% of patients were white (range: 52.8%-78.8%). The main payer type among admissions was Medicare (66.2% overall; range: 38.2%-77.7%). Hospital admissions were mainly nonelective (95.2%; range: 94.7%-96.1%) and were distributed across all geographic regions. Overall, 39.5% (range:

35.7%-50.9%) of admissions occurred in teaching hospitals, and the majority (83.5%; range: 80.9%-89.3%) in urban settings. Nearly one quarter (24.3%; range: 20.6%-35.7%) of admissions took place in large hospitals with over 500 beds (Table 2).

PIV-Associated Complication Rates

Overall, 1.76% of patients (n = 10 354) had at least one of the selected complications (Table 3), and rates varied by admission diagnosis cohort: pneumonia (2.67%), MI (1.98%), diabetes (1.95%), CHF (1.25%), trauma (1.03%), CKD (1.00%), and COPD (0.98%). BSI was the most common complication (1.45%, or 82.2% of all complications) and ranged from 0.67% (CKD) to 2.46% (pneumonia). Rates of cellulitis, phlebitis, other infections, and extravasation were also evident, but at lower rates than BSI, and varied according to admission diagnosis (Table 3; Figure 2).

Patient, Payer, and Hospital Characteristics by PIV Complication Status

Small differences in several characteristics were observed according to PIV complication status, including age, gender, race, payment source, and hospital region and location (Table 4). The patient group with a PIV-associated complication was slightly older (67.7 vs 66.1 years; $P < .001$), had fewer females (50.5% vs 52.4%; $P < .001$), and more white patients (73.5% vs 71.1%; $P < .001$) compared with the group without a complication. The patient group with a PIV-associated complication had a higher proportion who used Medicare as payment source (67.6% vs 66.1%; $P = .009$) and a lower proportion who went to urban hospitals (82.5% vs 83.5%; $P = .006$) versus patients without a complication. Differences in hospital region were slight albeit statistically significant ($P < .001$). Admission type, teaching hospital, and number of beds were similar by PIV-associated complication status. Within the diagnosis cohorts, similar patterns in characteristics according to complication status were found.

Adjusted Utilization and Costs

In the main cohort, the adjusted mean LOS for patients with a PIV complication was 5.9 days compared with 3.9 days for those without a complication (Table 5; $P < .001$). Adjusted costs were higher among patients with a complication compared with those without (mean $10 895 [95% confidence interval [CI], $10 738-$11 052] vs $7009 [$6988-$7031]; $P < .001$). Patients with complications were more likely to be admitted to the ICU (20.4% [19.6%-21.3%] vs 11.0% [11.0%-11.1%]; $P < .001$). They were also less likely to be discharged home than those without complications (62.4% [58.6%-66.1%] vs 77.6% [74.6%-80.5%]; $P < .001$) and were more likely to have died (3.6% [1.9%-4.2%] vs 0.7%
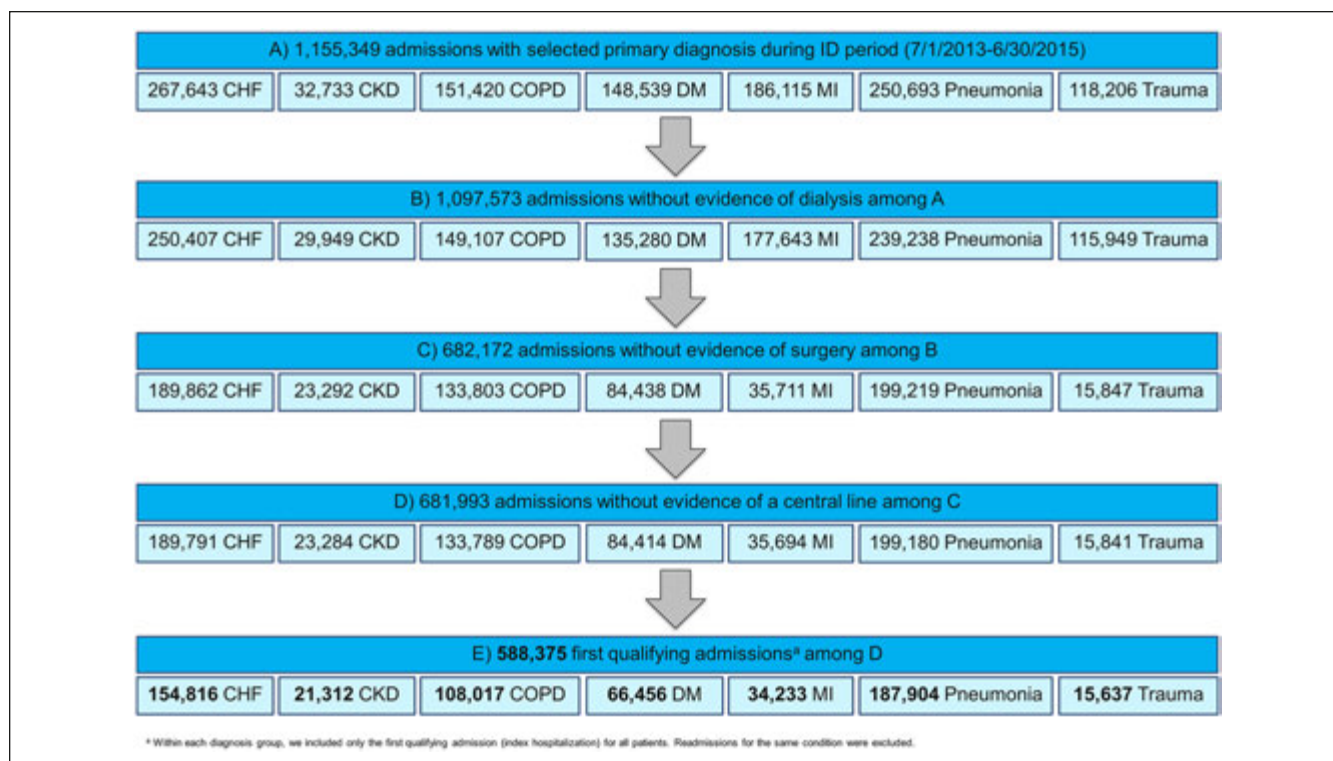
Figure 1. Patient identification.
Note. A total of 588 375 qualifying admissions were identified after applying study inclusion criteria. CHF = congestive heart failure; CKD = chronic kidney disease without dialysis; COPD = chronic obstructive pulmonary disease; DM = diabetes with complications; MI = myocardial infarction; Trauma = hip, spinal, or cranial fracture.

[0.6%-0.9%]; $P < .001$). The above differences in adjusted LOS, costs, admission to ICU, and discharge status between comparison groups were directionally similar for the 3 diagnosis groups (Table 5), yet were most pronounced in the CHF group: LOS (7.5 [7.2-7.7] days vs 4.2 [4.2-4.2] days), costs ($13 132 [$12 852-$13 411] vs $7394 [$7363-$7426]), admissions to the ICU (22.5% [20.7%-24.4%] vs 10.1% [10.0%-10.3%]), and discharge status of death (8.9% [7.6%-10.1%] vs 1.8% [1.7%-1.8%]) ($P < .001$ for all).

Sensitivity analyses that restricted patients to a single admitting diagnosis (ie, allowing only unique patients in the overall cohort) showed results that were consistent with main findings.

Discussion

This retrospective analysis of hospital discharge records revealed evidence of PIV-associated complications and associated burden. It was found that nearly 2% of patients in the sample experienced a PIV-associated complication and that most of these complications were in the form of a BSI. Patients with pneumonia, diabetes, or MI had the highest rate of PIV complications (~2%) and BSI (>1%) among any of the admission diagnosis cohorts. In addition, it was found that admitted patients with a PIV-associated complication

spent on average 2 additional days and required over $3000 more dollars while hospitalized compared with those without a complication. Patients with a PIV-associated complication were also twice as likely to be admitted to the ICU and nearly 3 times as likely to die while hospitalized than patients without a complication.

These results suggest that PIV use contributes to medical complications at a significant rate in US hospitals. Furthermore, such complications are associated with higher spending, longer and more intensive care, and higher mortality, all of which create burden for the health system and the patient.

The PIV-associated complication rates found in this study are plausible, as they are consistent with previously reported estimates.[2,23] In particular, a robust 2006 systematic review of 200 prospective studies that examined and clinically verified intravascular device–related BSIs reported pooled rates of 0.1% to 3.7% (infections per 100 devices; 0.5-9.0 infections per 1000 intravascular device days) depending on the type of PIV used (plastic, steel, venous cutdown).[2] Several other studies have reported lower rates of PIV-associated complications but have focused on specific pathogens[15,16,18,24] and on other countries,[15-17,25] and used different study designs and units[15,16,18] making results incomparable with those of our study. Moreover, reported rates may be lower than ours

Table 2. Patient Demographics, Payer Source, and Admitting Hospital Characteristics.

	CHF n = 154816	CKD n = 21312	COPD n = 108017	DM n = 66456	MI n = 34233	Pneumonia n = 187904	Trauma n = 15637	All N = 588375
Age, y, mean (SD)	73.6 (13.8)	68.7 (16.2)	68.7 (12.0)	50.5 (20.7)	75.0 (13.6)	62.2 (25.3)	63.7 (27.3)	66.1 (20.6)
Female, %	51.1	48.4	56.0	47.8	50.6	53.5	55.2	52.4
Race, %								
White	69.8	52.8	78.8	57.6	74.2	73.7	77.7	71.2
Black	16.8	32.0	10.4	25.1	10.2	11.4	6.3	14.7
Other	13.4	15.1	10.9	17.4	15.6	14.9	16.0	14.1
No. of chronic conditions, mean (SD)	0.51 (0.67)	0.43 (0.64)	0.37 (0.57)	0.27 (0.53)	0.47 (0.66)	0.39 (0.61)	0.34 (0.59)	0.41 (0.62)
Payment source, Medicare (vs other), %	77.7	68.6	71.3	38.2	76.9	61.8	60.7	66.2
Admission type, emergent (vs elective), %	95.2	95.7	95.2	96.1	95.5	94.7	96.1	95.2
Hospital region, %								
Northeast	19.3	21.2	17.3	18.2	21.7	16.7	22.4	18.3
Midwest	21.5	19.2	21.5	19.4	20.7	21.9	18.9	21.2
West	11.3	10.6	8.7	12.0	12.9	11.4	15.3	11.1
South	47.9	49.0	52.5	50.5	44.6	50.1	43.4	49.4
Teaching hospital, yes (vs no), %	41.2	46.3	35.7	43.0	39.4	37.3	50.9	39.5
Location of hospital, urban (vs rural), %	84.3	89.3	80.9	87.1	81.7	82.1	89.0	83.5
Number of beds, 501+ (vs ≤500), %	25.9	30.9	20.6	27.3	22.4	22.8	35.7	24.3

Note. CHF = congestive heart failure; CKD = chronic kidney disease without dialysis; COPD = chronic obstructive pulmonary disease; DM = diabetes with complications; MI = myocardial infarction; Trauma = hip, spinal, or cranial fracture.

Table 3. Selected Complication[a] Rates Associated With Peripheral IV.

	CHF n = 154816	CKD n = 21312	COPD n = 108017	DM n = 66456	MI n = 34233	Pneumonia n = 187904	Trauma n = 15637	All N = 588375
Patients with any complication,[a,b] n (%)	1936 (1.25)	214 (1.00)	1053 (0.98)	1293 (1.95)	677 (1.98)	5020 (2.67)	161 (1.03)	10354 (1.76)
Bloodstream infection, %	0.87	0.67	0.80	1.21	1.74	2.46	0.85	1.45
Cellulitis and abscess, %	0.29	0.23	0.15	0.67	0.17	0.13	0.14	0.24
Phlebitis and thrombophlebitis, %	0.10	0.11	0.04	0.09	0.10	0.09	0.05	0.08
Infections not elsewhere classified, %	0.02	0.01	0.01	0.01	0.02	0.01	0.03	0.01
Possible extravasation, %	<0.01	0.01	<0.01	<0.01	0.00	<0.01	0.00	<0.01

Note. IV = intravenous; CHF = congestive heart failure; CKD = chronic kidney disease without dialysis; COPD = chronic obstructive pulmonary disease; DM = diabetes with complications; MI = myocardial infarction; Trauma = hip, spinal, or cranial fracture.

[a]Complications include bloodstream infection, upper extremity cellulitis and abscess, upper extremity superficial phlebitis and thrombophlebitis, PIV-associated infections not elsewhere classified (ie, infection or inflammatory reaction following infusion, injection, transfusion, vaccination, vascular device, implant, or graft), or possible extravasation.

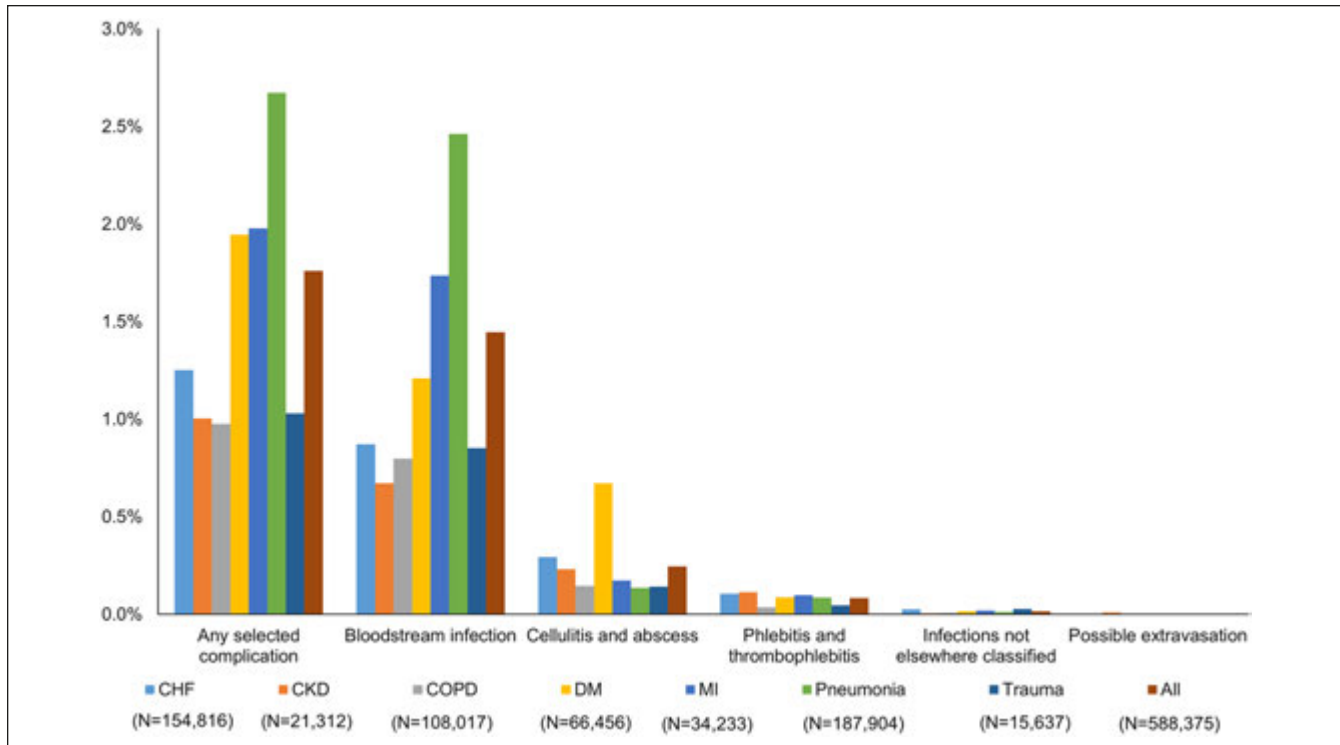[b]Patients might have more than 1 complication.

7

Figure 2. Selected complication rates associated with PIV.
Note. Bloodstream infection was the most (82.2% of all selected PIV-associated complications), overall ranging from 0.67% (CKD) to 2.46% (pneumonia). Rates of cellulitis, phlebitis, infections NEC, and extravasation were lower than BSI and varied by primary diagnosis. PIV = peripheral intravenous; CKD = chronic kidney disease; NEC = not elsewhere classified; BSI = bloodstream infections. CHF = congestive heart failure; CKD = chronic kidney disease without dialysis; COPD = chronic obstructive pulmonary disease; DM = diabetes with complications; MI = myocardial infarction; Trauma = hip, spinal, or cranial fracture.

Table 4. Patient Demographics, Payer Source, and Admitting Hospital Characteristics, by Peripheral Intravenous Complication Status.

	With complication N = 10354; 1.8%	Without complication N = 578021; 98.2%	*P* value
Age, y, mean (SD)	67.7 (18.4)	66.1 (20.6)	<.001
Female	5225 (50.5)	302957 (52.4)	<.001
Race, n (%)	7614 (73.5)	411114 (71.1)	<.001
White			
Black	1141 (11.0)	85456 (14.8)	
Other	1599 (15.4)	81451 (14.1)	
No. of chronic conditions	0.45 (0.63)	0.41 (0.62)	<.001
Payment Source, Medicare (vs other), n (%)	6998 (67.6)	382237 (66.1)	.009
Admission type, emergent (vs elective), n (%)	9856 (95.2)	550174 (95.2)	.970
Hospital region, %			<.001
Northeast	2083 (20.1)	105366 (18.2)	
Midwest	2061 (19.9)	122548 (21.2)	
West	1199 (11.6)	64183 (11.1)	
South	5011 (48.4)	285924 (49.5)	
Teaching hospital, yes (vs no), %	4054 (39.2)	228136 (39.5)	.516
Location of hospital, urban (vs rural), %	8537 (82.5)	482494 (83.5)	.006
Number of beds, 501+ (vs ≤500), %	2587 (25.0)	140554 (24.3)	.144

Table 5. Adjusted[a] Means and Rates for Length of Stay, Cost, ICU Admission, and Discharge Status Among CHF, COPD, DM, and Overall Groups.

	CHF[b]			COPD[c]			DM[d]			All[e]		
	Adjusted means/rates (95% CI)			Adjusted means/rates (95% CI)			Adjusted means/rates (95% CI)			Adjusted means/rates (95% CI)		
Dependent	With PIV complication	Without PIV complication	P value	With PIV complication	Without PIV complication	P value	With PIV complication	Without PIV complication	P value	With PIV complication	Without PIV complication	P value
Length of stay (days)	7.5	4.2	<.001	5.5	3.8	<.001	4.8	3.1	<.001	5.9	3.9	<.001
	(7.2-7.7)	(4.2-4.2)		(5.0-5.9)	(3.8-3.9)		(4.6-5.0)	(3.1-3.2)		(5.8-6.0)	(3.9-3.9)	
Cost of inpatient hospitalization	$13 132	$7394	<.001	$10 172	$6634	<.001	$8750	$5807	<.001	$10 895	$7009	<.001
	($12852-$13411)	($7363-$7426)		($9787-$10557)	($6596-$6672)		($8473-$9027)	($5768-$5846)		($10738-$11052)	($6988-$7031)	
Admission to ICU	22.5%	10.1%	<.001	15.0%	7.0%	<.001	35.6%	32.0%	.011	20.4%	11.0%	<.001
	(20.7%-24.4%)	(10.0%-10.3%)		(13.0%-17.3%)	(6.8%-7.1%)		(32.9%-38.4%)	(31.6%-32.4%)		(19.6%-21.3%)	(11.0%-11.1%)	
Discharge status												
Home	54.9%	76.7%	<.001	74.6%	87.6%	<.001	86.6%	92.9%	<.001	62.4%	77.6%	<.001
	(52.6%-57.3%)	(76.4%-76.9%)		(72.0%-77.3%)	(87.4%-87.9%)		(84.9%-88.3%)	(92.6%-93.1%)		(58.6%-66.1%)	(74.6%-80.5%)	
Other facility	36.2%	21.6%	<.001	21.9%	11.7%	<.001	12.4%	7.0%	<.001	26.8%	16.6%	<.001
	(34.0%-38.4%)	(21.4%-21.8%)		(19.4%-24.4%)	(11.5%-11.9%)		(10.7%-14.0%)	(6.8%-7.3%)		(25.9%-27.7%)	(16.5%-16.7%)	
Death	8.9%	1.8%	<.001	3.5%	0.7%	<.001	1.0%	0.1%	<.001	3.6%	0.7%	<.001
	(7.6%-10.1%)	(1.7%-1.8%)		(2.5%-4.5%)	(0.6%-0.7%)		(0.6%-1.5%)	(0.1%-0.2%)		(2.9%-4.2%)	(0.6%-0.9%)	

Note. ICU = intensive care unit; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; DM = diabetes with complications; CI = confidence interval; PIV = peripheral intravenous.
[a]Adjusted by age, gender, race, number of chronic conditions, hospital region, teaching versus nonteaching hospital, and hospital location.
[b]CHF cohort includes 154816 patients.
[c]COPD cohort includes 108017 patients.
[d]DM cohort includes 66456 patients.
[e]All diagnosis groups (N = 588375).

9

due underevaluation of such complications despite increasing use of PIV.[15-18,25,26]

Studies linking PIV-associated complications to outcomes were limited for comparison and appeared to focus on the effect of specific causative pathogens[15] rather than comparing outcomes according to the presence (vs absence) of a PIV catheter. Alternatively, other research examined predictors of PIV catheter infection, such as the clinical setting or placement location where a PIV catheter was used.[18]

In addition to the main results, this study found that PIV-associated complications were linked to worse outcomes among the 3 admission diagnosis groups. Within each subgroup of CHF, COPD, or diabetes, patients with PIV-associated complications experienced longer hospital stays, higher costs, and higher mortality compared with those without complications, adjusting for key characteristics. Interestingly, the magnitude of these differences was considerably greater for patients with CHF compared with overall and other diagnosis groups. For CHF patients with a complication, length of hospital stay and admission to ICU were about double and risk of death about 5 times that of patients without complications. This finding may reflect a modified effect of PIV-associated complications among CHF patients, potentially due to an increased vulnerability in that patient population; however, our study design precludes confirmation of this.

The findings in this study underscore the need to reduce PIV-associated complications through a multistage approach as illustrated with the case of central line catheters. The identification of central-line catheter infections as public health problem, the development and implementation of quality measures and best practices for the insertion of central lines, and the creation of federal and state prevention programs have all led to a dramatic reduction in infections rates[20,27-30] and conferred other clinical and economic benefits. Efforts such as these resulted in the reduction of 25 000 CLABSI in 2009, reflecting a 58% reduction from 2001 and corresponding to potentially 6000 lives saved and $414 million avoided in excess health care costs (ie, $1.8 billion cumulative costs) according to the CDC.[27,30] Another study reported that CDC-sponsored prevention efforts saved $5.7 to $31.5 billion in direct medical costs.[10] Through similar recognition and effort, including programs such as the Hospital-Acquired Condition Reduction Program (HACRP) under the Affordable Care Act, which creates monetary incentives for hospitals to reduce hospital-acquired

conditions, similar health and economic returns may be gained for PIV catheters.[31-33]

This study has several limitations. First, it was assumed that all patients received a PIV upon admission, which could not be verified in the data due to underuse of PIV-associated procedure codes in hospital discharge records; however, we believe this assumption was reasonable based on expert clinical input that the placement of a PIV catheter in every patient upon admission is standard practice.[34] Second, infections due specifically to PIV catheters may have been underreported in the data as there is no mandatory reporting for these devices, as required for central lines. To address this, we attributed the selected complications to PIV by ruling out other potential causes, both prior to and following admission. Nevertheless, the rate of PIV-associated complications in the sample may have been overestimated because we did not exclude other potential sources of the complications, such as sepsis related to ventilator-associated pneumonia. Third, although our findings appear consistent with previous estimates,[2] the approach we used to identify PIV-related complications was not validated pointing an area for future research. Finally, ANCOVA regression was used to estimate mean LOS and costs; as these variables often lack normal distribution, the use of ANCOVA allowed for interpretable results. However, we performed a sensitivity analysis on costs using median regression and found the results to be of a different magnitude albeit directionally similar (see Supplementary Materials) compared with ANCOVA with increased costs associated with a PIV-related complication in all groups (CHF: mean difference $5738, median difference $3712; COPD: $3538, $2008; DM: $2943, $2031; overall group: $3886, $2430).

Conclusion

This analysis of hospital records uncovered rates of PIV-associated complications that are meaningful and consistent with prior research. In addition, patients with PIV-associated complications have longer hospital stays, higher inpatient costs, and greater risk of death than patients without such complications. This relationship is present for multiple diagnosis groups. Future research should focus on expanding the current evidence base such that PIV-focused quality measures and policy interventions can be developed and implemented to reduce PIV-associated economic and disease burden.

Appendix

Table A1. Admission Diagnosis Code List.

Admission diagnosis	ICD-9-CM code
Pneumonia	480.x Viral pneumonia
	481.xx Pneumococcal pneumonia (*Streptococcus pneumoniae* pneumonia)
	482.xx Other bacterial pneumonia
	483.xx Pneumonia due to other specific organism
	484.xx Pneumonia in infectious disease classified elsewhere
	485.xx Bronchopneumonia, organism unspecified
	486.xx Pneumonia, organism unspecified
	487.xx Influenza with pneumonia
Chronic obstructive pulmonary disease	491.xx Chronic bronchitis[35]
	492.xx Emphysema[a]
	496.xx Chronic airway obstruction, not elsewhere classified[a]
Myocardial infarction	410.xx Acute myocardial infarction
Congestive heart failure	398.91 Rheumatic heart failure (congestive)[36]
	402.01, 402.11, 402.91 Hypertensive diseases with heart failure[b]
	428.xx Heart failure[b]
CKD, without dialysis	285.21 Anemia in CKD[37]
	403.00, 403.10, 403.90, 404.00, 404.01, 404.10, 404.11, 404.90, 404.91 Hypertensive CKD and hypertensive heart with CKD[c]
	588.xx, Renal osteodystrophy, nephrogenic diabetes insipidus, secondary hyperparathyroidism (renal origin), other specified/unspecified disorders from impaired renal function[c]
	585.1-585.4 CKD, Stages I-IV[c]
	585.9 CKD, unspecified[c]
	*Includes only codes without indication of kidney failure or ESRD (Stage V).
Diabetes with complications	249.1x-249.9x Secondary diabetes mellitus with ketoacidosis, hyperosmolarity, other coma, renal manifestations, ophthalmic manifestations, neurological manifestations, peripheral circulatory disorders, other specified manifestations, unspecified complications
	250.1x-250.9x Diabetes mellitus with ketoacidosis, hyperosmolarity, other coma, renal manifestations, neurological manifestations, peripheral circulatory disorders, other specified manifestations, unspecified complications
	357.2 Polyneuropathy in diabetes
Major trauma	Hip fracture
	733.14 Pathologic fracture of neck of femur
	820.xx Fracture of the neck of femur
	Spinal fracture
	733.13 Pathologic fracture of vertebrae
	806.xx Fracture of vertebral column with spinal cord injury
	Cranial fracture
	800.xx Fracture of vault of skull
	801.xx Fracture of base of skull
	803.xx Other skull fracture
	804.xx Fractures involving skull or face

Note. ICD-9-CM = *International Classification of Diseases*, Ninth Revision, Clinical Modification; CKD = chronic kidney disease; ESRD = end-stage renal disease.
[a]See Wan et al[35]
[b]See Xuan et al[36]
[c]See Vekeman et al[37]

Table A2. Potential Non-PIV Causes of Complication Code List.

Exclusion criteria	ICD-9-CM code
Dialysis	38.95 Venous catheterization for renal dialysis[38]
	39.27 Arteriovenostomy for renal dialysis[a]
	39.42 Revision of arteriovenous shunt for renal dialysis[a]
	39.43 Removal of arteriovenous shunt for renal dialysis[a]
	39.95 Hemodialysis[a]
	50.92 Extracorporeal hepatic assistance (liver dialysis)
	458.21 Hypotension of hemodialysis[a]
	996.56 Mechanical complication due to peritoneal dialysis catheter[a]
	996.68 Infection and inflammatory reaction due to peritoneal dialysis catheter
	996.73 Complications due to renal dialysis device, implant, and graft
	E879.1 Kidney dialysis as the cause of abnormal reaction of patient, or of later complication, without mention of misadventure at time of procedure
	E870.2 Accidental cut, puncture, perforation or hemorrhage during kidney dialysis or other perfusion
	E871.2 Foreign object left in body during kidney dialysis or other perfusion
	E872.2 Failure of sterile precautions during kidney dialysis or other perfusion
	E874.2 Mechanical failure of instrument or apparatus during kidney dialysis or other perfusion
	V45.11 Renal dialysis status (renal, hemodialysis, peritoneal)
	V45.12 Noncompliance with renal dialysis
	V56.xx Encounter for dialysis and dialysis catheter care
Surgery, graft, implant or non-PIV device	Procedural codes: 00-86 (includes operations, obstetrical procedures, and procedures not elsewhere classified)
	996.60 Infection and inflammatory reaction due to unspecified device, implant, and graft
	996.61 Infections and inflammatory reaction due to cardiac device, implant, and graft
	996.63 Infections and inflammatory reaction due to nervous system device, implant, and graft
	996.64 Infections and inflammatory reaction due to indwelling urinary catheter
	996.65 Infections and inflammatory reaction due to other genitourinary device, implant, and graft
	996.66 Infections and inflammatory reaction due to internal joint prosthesis
	996.67 Infections and inflammatory reaction due to other internal orthopedic device, implant, and graft
	996.69 Infections and inflammatory reaction due to other internal prosthetic device, implant, and graft
	998.5x Infected postoperative seroma and other postoperative infections[39]
	998.83 Nonhealing surgical wound[b]
Central line use	38.97 CVC placement with guidance
	89.62 Central venous pressure monitoring
	999.31 Other/unspecified infection due to CVC
	999.32 Blood stream infection due to a CVC
	999.33 Local infection due to a CVC

Note. PIV = peripheral intravenous; ICD-9-CM = *International Classification of Diseases*, Ninth Revision, Clinical Modification; CVC = central venous catheter.
[a]See Taneja et al[38]
[b]See Suaya et al[39]

ORCID iD

Marian H. Tarbox https://orcid.org/0000-0002-1138-4682

Supplemental Material

Supplemental material for this article is available online.

References

1. Kornbau C, Lee KC, Hughes GD, Firstenberg MS. Central line complications. *Int J Crit Illn Inj Sci*. 2015;5(3):170-178. doi:10.4103/2229-5151.164940.

2. Maki DG, Kluger DM, Crnich CJ. The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. *Mayo Clin Proc*. 2006;81(9):1159-1171. doi:10.4065/81.9.1159.

3. Zingg W, Pittet D. Peripheral venous catheters: an under-evaluated problem. *Int J Antimicrob Agents*. 2009;34(suppl 4):S38-S42. doi:10.1016/S0924-8579(09)70565-5.

4. Rickard CM, Webster J, Wallis MC, et al. Routine versus clinically indicated replacement of peripheral intravenous catheters: a randomised controlled equivalence trial. *Lancet*. 2012;380(9847):1066-1074. doi:10.1016/S0140-6736(12)61082-4.

5. Webster J, Osborne S, Rickard C, Hall J. Clinically-indicated replacement versus routine replacement of peripheral venous catheters. In: The Cochrane Collaboration, ed. *Cochrane Database of Systematic Reviews*. Chichester, England: John Wiley & Sons, Ltd; 2010. doi:10.1002/14651858.CD007798.pub2.

6. Sato A, Nakamura I, Fujita H, et al. Peripheral venous catheter-related bloodstream infection is associated with severe complications and potential death: a retrospective observational study. *BMC Infect Dis*. 2017;17(1):434. doi:10.1186/s12879-017-2536-0.

7. Brunelli SM, Turenne W, Sibbel S, Hunt A, Pfaffle A. Clinical and economic burden of bloodstream infections in critical care patients with central venous catheters. *J Crit Care*. 2016;35:69-74. doi:10.1016/j.jcrc.2016.04.035.

8. Bullard KM, Dunn DL. Bloodstream and intravascular catheter infections. In: Holzheimer RG, Mannick JA, eds. *Surgical Treatment: Evidence-Based and Problem-Oriented*. Munich, Germany: Zuckschwerdt; 2001. https://www.ncbi.nlm.nih.gov/books/NBK7008/

9. National and State Healthcare Associated Infections—Progress Report. Atlanta, GA: Centers for Disease Control and Prevention; March 2016:1-141.

10. R. Douglas Scott II. *The Direct Medical Costs of Healthcare-Associated Infections in U.S. Hospitals and the Benefits of Prevention*. Atlanta, GA: Centers for Disease Control and Prevention; 2009.

11. Crnich C, Maki D. Infections caused by intravascular devices: epidemiology, pathogenesis, diagnosis, prevention, and treatment. In: Grota P et al., eds. *APIC Text of Infection Control and Epidemiology*. Vol 1. 2nd ed. Washington, DC: Association for Professionals in Infection Control and Epidemiology, Inc; 2005:2421-2426.

12. Blot SI, Depuydt P, Annemans L, et al. Clinical and economic outcomes in critically ill patients with nosocomial catheter-related bloodstream infections. *Clin Infect Dis*. 2005;41(11):1591-1598. doi:10.1086/497833.

13. Pittet D, Tarara D, Wenzel RP. Nosocomial bloodstream infection in critically III patients: excess length of stay, extra costs, and attributable mortality. *JAMA*. 1994;271(20):1598-1601. doi:10.1001/jama.1994.03510440058033.

14. Danski MTR, de Oliveira GLR, Johann DA, Pedrolo E, Vayego SA. Incidence of local complications in peripheral venous catheters and associated risk factors. *Acta Paul Enferm*. 2015;28(6):517-523. doi:10.1590/1982-0194201500087.

15. Pujol M, Hornero A, Saballs M, et al. Clinical epidemiology and outcomes of peripheral venous catheter-related bloodstream infections at a university-affiliated hospital. *J Hosp Infect*. 2007;67(1):22-29. doi:10.1016/j.jhin.2007.06.017.

16. Stuart RL, Cameron DRM, Scott C, et al. Peripheral intravenous catheter-associated *Staphylococcus aureus* bacteraemia: more than 5 years of prospective data from two tertiary health services. *Med J Aust*. 2013;198(10):551-553. doi:10.5694/mja12.11699.

17. Morris AK, Russell CD. Enhanced surveillance of *Staphylococcus aureus* bacteraemia to identify targets for infection prevention. *J Hosp Infect*. 2016;93(2):169-174. doi:10.1016/j.jhin.2016.03.003.

18. Trinh TT, Chan PA, Edwards O, et al. Peripheral venous catheter-related *Staphylococcus aureus* bacteremia. *Infect Control Hosp Epidemiol*. 2011;32(6):579-583. doi:10.1086/660099.

19. Mermel LA, Farr BM, Sherertz RJ, et al. Guidelines for the management of intravascular catheter-related infections. *Clin Infect Dis off Publ Infect Dis Soc Am*. 2001;32(9):1249-1272. doi:10.1086/320001.

20. Marschall J, Mermel LA, Fakih M, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals: 2014 update. *Infect Control Hosp Epidemiol*. 2014;35(7):753-771. doi:10.1086/676533.

21. Premier Applied Sciences®. *Premier Healthcare Database: Data That Informs and Performs*. Charlotte, NC: Premier Inc.; 2018. https://learn.premierinc.com/white-papers/premier-healthcare-database-whitepaper. Accessed December 3, 2018.

22. Agency for Healthcare Research and Quality. *HCUP Chronic Condition Indicator*. Healthcare Cost and Utilization Project (HCUP). www.hcup-us.ahrq.gov/toolssoftware/chronic/chronic.jsp. Published June 2015. Accessed August 27, 2019.

23. Hadaway L. Short peripheral intravenous catheters and infections. *J Infus Nurs*. 2012;35(4):230-240. doi:10.1097/NAN.0b013e31825af099.

24. Kovacs CS, Fatica C, Butler R, Gordon SM, Fraser TG. Hospital-acquired *Staphylococcus aureus* primary bloodstream infection: a comparison of events that do and do not meet the central line–associated bloodstream infection definition. *Am J Infect Control*. 2016;44(11):1252-1255. doi:10.1016/j.ajic.2016.03.038.

25. Humphreys H, Newcombe RG, Enstone J, et al. Four country Healthcare Associated Infection Prevalence Survey 2006: risk factor analysis. *J Hosp Infect*. 2008;69(3):249-257. doi:10.1016/j.jhin.2008.04.021.

26. Coello R, Charlett A, Ward V, et al. Device-related sources of bacteraemia in English hospitals—opportunities for the prevention of hospital-acquired bacteraemia. *J Hosp Infect*. 2003;53(1):46-57. doi:10.1053/jhin.2002.1349.

27. Hu KK, Veenstra DL, Lipsky BA, Saint S. Use of maximal sterile barriers during central venous catheter insertion: clinical

and economic outcomes. *Clin Infect Dis*. 2004;39(10):1441-1445. doi:10.1086/425309.

28. Shah H, Bosch W, Thompson KM, Hellinger WC. Intravascular catheter-related bloodstream infection. *Neurohospitalist*. 2013;3(3):144-151. doi:10.1177/1941874413476043.

29. O'Grady NP, Alexander M, Burns L, et al. Guidelines for the prevention of intravascular catheter-related infections. *Clin Infect Dis*. 2011;2011:1-83.

30. Centers for Disease Control and Prevention. Vital signs: central line—associated blood stream infections—United States, 2001, 2008, and 2009. *Morb Mortal Wkly Rep*. 2011;60(8):243-248.

31. Centers for Medicare & Medicaid Services. Hospital-Acquired Condition Reduction Program Fiscal Year 2017 Fact Sheet. December 2016. https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/HAC-reduction-program.html.

32. Evans M. Half of hospitals penalized for hospital-acquired conditions are repeat offenders. *Modern Healthcare*. http://www.modernhealthcare.com/article/20151210/NEWS/151219988. Published December 10, 2015. Accessed June 30, 2017.

33. DeVries M, Valentine M. Bloodstream infections from peripheral lines: an underrated risk. *Am Nurse Today*. 2016;11(1). https://www.americannursetoday.com/piv/. Accessed August 27, 2019.

34. Johnson & Johnson. *Clinical Input on PIV BOI Study Plan Meeting*. Beverly Hills, CA: Centers for Medicare & Medicaid, 2016.

35. Wan Y, Sun S, Corman S, Huang X, Gao X, Shorr A. A longitudinal, retrospective cohort study on the impact of roflumilast on exacerbations and economic burden among chronic obstructive pulmonary disease patients in the real world. *Int J Chron Obstruct Pulmon Dis*. 2015;2127-2136. doi:10.2147/COPD.S80106.

36. Xuan J, Duong PT, Russo PA, Lacey MJ, Wong B. The economic burden of congestive heart failure in a managed care population. *Am J Manag Care*. 2009;6:693-700.

37. Vekeman F, Yameogo ND, Lefebvre P, Bailey RA, McKenzie RS, Piech CT. Healthcare costs associated with nephrology care in pre-dialysis chronic kidney disease patients. *J Med Econ*. 2010;13:673-680.

38. Taneja C, Berger A, Inglese GW, et al. Can dialysis patients be accurately identified using healthcare claims data? *Perit Dial Int*. 2014;34:643-651.

39. Suaya JA., Eisenberg DF, Fang C, Miller LG. Skin and soft tissue infections and associated complications among commercially insured patients aged 0-64 years with and without diabetes in the U.S. *PLoS One*. 2013;8:e60057.