ORIGINAL ARTICLE

Bloodstream infections and setting of onset in persons with spinal cord injury and disorder

CT Evans^{1,2,3}, RC Hershow³, A Chin¹, PR Foulis⁴, SP Burns⁵ and FM Weaver^{1,2,6}

¹Department of Veterans Affairs (VA), Spinal Cord Injury Quality Enhancement Research Initiative, Center for Management of Complex Chronic Care, Edward Hines Jr. VA Hospital, Hines, IL, USA; ²Feinberg School of Medicine, Institute for Healthcare Studies, Northwestern University, Chicago, IL, USA; ³Department of Epidemiology and Biostatistics, School of Public Health, University of Illinois at Chicago, Chicago, IL, USA; ⁴James A Haley VA Hospital, Pathology Laboratory Service, Tampa, FL, USA; ⁵University of Washington and VA Puget Sound Health Care System, Seattle, WA, USA and ⁶Department of Neurology, Northwestern University, Chicago, IL, USA

Study Design: A retrospective cohort study.

Objective: Health-care-associated (HCA) bloodstream infection (BSI) has been shown to be a distinct epidemiologic category in the general adult population, but few studies have examined specific patient populations. The objective of this study was to assess characteristics associated with BSI that occurred in the hospital (hospital-acquired, HA BSI), from health-care contact outside the hospital (HCA BSI) or in the community (community-acquired, CA BSI) in veterans with spinal cord injury and disorder (SCI&D).

Setting: Two United States Department of Veterans Affairs hospitals.

Methods: All patients with SCI&D with a positive blood culture admitted to study hospitals over a 7-year period (1 October 1997 to 30 September 2004). Demographics, medical characteristics and causative organisms were collected.

Results: Four hundred and thirteen episodes of BSI occurred in 226 patients, with a rate of 7.2 BSI episodes per 100 admissions: 267 (64.7%) were HA BSI, 110 (26.6%) were HCA BSI and 36 (8.7%) were CA BSI. Antibiotic resistance was more common in those with HA BSI (65.5%) compared with that in those with HCA (49.1%, $P=0.001$) and CA BSI (22.2%, $P<0.0001$). Methicillin resistance in *Staphylococcus aureus* was highly prevalent; HA BSI (84.5%), HCA BSI (60.6%) and CA BSI (33.3%).

Conclusion: HCA BSI comprises one-quarter of all BSIs in hospitalized patients with SCI&D. Although those with HCA and CA BSI share similarities, several differences in medical characteristics and causal microorganism are noted. Treatment and management strategies for HCA and CA infections need to vary.

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Keywords: bacteremia; spinal cord injuries; health care

Introduction

Bloodstream infections (BSIs) are a common type of infection in persons with spinal cord injury and disorder (SCI&D).^{1,2} The most common site of origin for BSI in persons with SCI&D is the urinary tract,^{3,4} and risk factors include tetraplegia, older age, use of invasive devices and chronic conditions.^{4–6} Frequently reported causative organisms of BSI are coagulase-negative staphylococci, *Staphylococcus aureus* and Gram-negative bacteria.^{2–6}

Risk factors for hospital-acquired (HA) and community-acquired (CA) BSI have been well described in the general population.^{7–9} However, little is known about the risk factors for BSI based on the epidemiologic or patient care setting. HA and CA BSIs are traditional surveillance terms used to describe BSIs. The routine care of patients with serious underlying illnesses and with invasive devices, such as persons with SCI&D, has moved from acute-care facilities to long-term care, rehabilitation centers and patients' homes.¹⁰ Infections occurring in these health-care-associated (HCA) settings have been traditionally classified as CA, but more recent evidence suggests that HCA infections are distinct and have a unique epidemiology.^{11–13} Causative microorganisms and related outcomes for these infections show more similarity to HA infections, suggesting that empirical treatment with antibiotics should be tailored to the setting where the BSI occurred.^{10,11}

Correspondence: Dr CT Evans, Department of Veterans Affairs, Center for Management of Complex Chronic Care, Spinal Cord Injury Quality Enhancement Research Initiative, EJ Hines Jr VA Hospital (151H), 5th Avenue and Roosevelt Road, PO Box 5000, Hines, IL 60141, USA.
 E-mail: Charlesnika.Evans@va.gov
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There has been no assessment of BSIs occurring in these three settings nor a comparison by category among persons with SCI&D. HCA BSI is particularly relevant to persons with SCI&D as they often have care in these HCA settings. Identifying differences between these epidemiologic categories of BSI is important in determining appropriate empiric antimicrobial treatment and management. The goal of this study was to identify and compare characteristics associated with having culture-positive BSI with onset of infection in the hospital (HA BSI), from health-care contact outside the hospital (HCA BSI) or non-HCA infections occurring in the community (CA BSI) in veterans with SCI&D.

Materials and methods

Setting/design

A retrospective review of clinical data was conducted over a 7-year period (1 October 1997 to 30 September 2004) on patients with SCI&D admitted at two Veterans Affairs (VA) tertiary care hospitals, which provide primary care and specialized services to approximately 2000 patients with SCI&D each year. An institutional review board approved this research.

Definitions for BSI

Bloodstream infection was defined as having growth from a blood microbiology culture in which isolated organisms were subjected to antibiotic susceptibility testing. Common skin contaminants (for example, diphtheroids and coagulase-negative staphylococci) were excluded. Episodes of BSI in the same patient were counted as separate BSI events if a different bacterial species was identified on different days or when >28 days separated cultures showing growth of the same organism; otherwise, the episode was counted as a recurrence and excluded from the study. BSI with more than one microorganism species was defined as polymicrobial.

Hospital-acquired BSI was defined using Centers for Disease Control and Prevention criteria: a positive blood culture identified 48 h or more after admission to the hospital.¹⁴ HCA infection was defined as a positive blood culture obtained from a patient at the time of hospital admission or within 48 h of admission plus any of the following criteria: (1) within 30 days before the BSI received intravenous therapy at home; or received any home care, including wound care or specialized nursing care through a health-care agency; (2) attended a hospital or hemodialysis clinic or received intravenous chemotherapy in the 30 days before the BSI; (3) hospitalized in an acute-care hospital for 2 or more days in the 90 days before the BSI; or (4) resided in a nursing home or other long-term care facility.¹¹ CA BSI was defined as a positive blood culture obtained at the time of hospital admission or within 48 h after hospital admission for patients who did not fit the criteria for HCA BSI.

Secondary sources of BSI were defined as a positive culture at another anatomic site within 7 days of the BSI that had the same microorganism as found in the BSI culture.⁴ If no

other site had a positive culture with the same organism, the BSI was defined as primary.

Antimicrobial-resistant BSI was defined as follows:^{15,16} (1) methicillin-resistant *S. aureus* (MRSA); (2) vancomycin-resistant Enterococcus; (3) antibiotic-resistant *Pseudomonas aeruginosa*—resistance to two or more of piperacillin, ceftazidime, imipenem/aztreonam, ciprofloxacin/levofloxacin or an aminoglycoside; (4) multidrug-resistant Gram-negative bacilli—resistance to drugs in at least two of four antibiotic classes: β -lactams, aminoglycosides, fluoroquinolones and trimethoprim/sulfamethoxazole.¹⁷

Data collected

Microbiology data were obtained from the local electronic medical record including specimen site, collection date/time, microorganism identified and antibiogram of the organism, which are categorized as susceptible, intermediate or resistant.

Veterans Affairs medical encounter databases were used to identify demographic characteristics (age, gender and race); clinical diagnoses within the previous 90 days before hospitalization and comorbid conditions (based on Charlson comorbidity index) during the hospitalization; evidence of respiratory procedures (tracheostomy, bronchoscopy and intubation) in the 30 days before BSI; and discharge status (includes if the patient died in the hospital).

The VA Spinal Cord Dysfunction Registry is a national database containing information on SCI&D characteristics. This database was used to obtain level of injury (tetraplegia versus paraplegia), etiology (traumatic vs non-traumatic causes), and age at onset and duration of injury on the sample.

Antimicrobials used in the in-patient and outpatient settings were obtained from the patient electronic medical record to determine antibiotic exposure in the previous 30 days. Validation of these data with independent data extracts from the VA Decision Support System for the last 3 years of the study period showed discrepancies in data at one of the two data-collection sites, indicating an underestimation of antibiotic use at this site. This is noted as a limitation.

Statistical analysis

Statistical analyses were performed using Stata 10 (Stata Corporation, TX, USA). As multiple episodes of BSI per patient were included in this analysis, cluster-adjusted *P*-values are shown using logistic regression for comparison of variables by study site. Associations between epidemiologic categories of infection and other variables were assessed using cluster-adjusted multinomial logistic regression including study site and year as covariates to account for differences between sites and year. A *P*-value of ≤ 0.01 was considered to be statistically significant because of the multiple comparisons.

Results

Between 1 October 1997 and 30 September 2004, 5699 admissions occurred at two VA medical centers for veterans

with SCI&D and 1251 positive blood cultures were detected during these admissions. After removing those with contaminants and recurrent BSI, there were 413 episodes of BSI in 226 patients. The incidence over 7 years was 7.2 episodes per 100 admissions. The rate of BSI differed by site (site 1: 10.7 episodes; site 2: 5.1 episodes per 100 admissions). The overall length of hospitalization for all admissions by site varied (site 1: mean = 45.9, median = 15.0 days; site 2: mean = 30.0, median = 12.0 days; $P < 0.0001$).

Hospital-acquired BSI comprised 267 (64.7%) BSI episodes; 110 (26.6%) were HCA BSI and 36 (8.7%) were CA BSI. Table 1 compares select demographic and medical characteristics by site. There were significant differences between the two sites in proportions of the three epidemiologic categories of BSI and antibiotic exposure.

HCA BSI criteria

Of those with HCA BSI ($n = 110$), 45 (40.9%) had received some type of home care that may have included wound care, specialized nursing care and intravenous therapy (criteria 1). Only three (2.7%) received dialysis or intravenous chemotherapy in the 30 days before BSI (criteria 2). However, 62 (56.4%) were hospitalized for 2 or more days in the 90 days before BSI (criteria 3), and 18 (16.4%) resided in a nursing home/long-term care facility before hospital admission (criteria 4).

Demographics, medical characteristics and factors predisposing to BSI

The average age of the cohort was 59.3 years, the majority were male (97.8%), non-Hispanic white (62.7%) and 44.1% had tetraplegia and 85.0% had a traumatic injury (caused by vehicular accidents, acts of violence, falls and sports accidents). Date of injury was missing for 17.4% of the sample, thus the category 'unknown' was created for age at onset and duration of injury. On the basis of those with complete information ($n = 341$), the average age at onset of SCI&D and duration of injury was 38.5 and 20.8 years, respectively.

The HA and HCA BSI groups were similar across all demographic characteristics except for traumatic injury status. The CA BSI group was younger at age of onset of SCI&D than both the HA and HCA BSI groups (Table 2). Having a comorbid chronic condition was common and most frequent in the HA and HCA BSI groups, and the proportion significantly differed from those in the CA group (Table 2). Pressure ulcer diagnoses were most common in the HA BSI (62.9%) and significantly differed from those in the HCA and CA BSI groups. Having any respiratory procedure conducted in the previous 30 days was seen in both HA and HCA BSI groups, but not in those with CA BSI. Antibiotic exposure in the 30 days before BSI was seen in two-thirds of patients, in which the HA group significantly differed from the HCA and CA BSI groups.

Source of BSI, causative pathogens and antibiotic resistance

A secondary source of BSI was found in 240 (58.1%) BSIs and included the urinary tract (183; 76.3%), wound/skin/bone

Table 1 Selected demographic and medical characteristics in 413 occurrences of BSI by site

Characteristics	Frequency (%)		
	Site 1 ($n = 235$)	Site 2 ($n = 178$)	P-value ^a
BSI type			
Hospital acquired	142 (60.4)	125 (70.2)	Reference
Health-care associated	78 (33.2)	32 (18.0)	0.01
Community acquired	15 (6.4)	21 (11.8)	0.25
Age (years)			
Mean (median)	60.7 (57.5)	57.4 (54.4)	0.17
Ethnicity			
White	128 (54.5)	131 (73.6)	Reference
Black	96 (40.9)	34 (19.1)	0.04
Other/unknown	11 (4.7)	13 (7.3)	0.84
Gender			
Female	8 (3.4)	1 (0.6)	Reference
Male	227 (96.6)	177 (99.4)	0.16
Level of injury			
Tetraplegia	107 (45.5)	75 (42.1)	Reference
Paraplegia	101 (43.0)	83 (46.6)	0.69
Unknown	27 (11.5)	20 (11.2)	0.92
Etiology of SCI&D			
Non-traumatic	19 (8.1)	12 (6.7)	Reference
Traumatic	193 (82.1)	158 (88.8)	0.33
Unknown	23 (9.8)	8 (4.5)	0.56
Age at onset of injury (years)			
< 25	35 (14.9)	52 (29.2)	Reference
25–49	100 (42.6)	64 (36.0)	0.07
50+	55 (23.4)	35 (19.7)	0.11
Unknown	45 (19.2)	27 (15.2)	0.11
Mean (median)	40.0 (33.4)	36.5 (32.3)	0.30
Duration of injury (years)			
< 10	41 (17.5)	46 (25.8)	Reference
10–29	110 (46.8)	60 (33.7)	0.15
30+	39 (16.6)	45 (25.3)	0.96
Unknown	45 (19.2)	27 (15.2)	0.31
Mean (median)	20.8 (20.2)	20.7 (21.7)	0.95
Medical characteristics			
Antibiotic exposure in previous 30 days	171 (72.8)	96 (53.9)	0.001
Pre-existing medical condition in 90 days before admission	108 (46.0)	93 (52.3)	0.65
Comorbid condition during hospitalization	176 (74.9)	125 (70.2)	0.47
Source of BSI			
Primary	82 (34.9)	91 (51.1)	0.06
Secondary	153 (65.1)	87 (48.9)	

Abbreviations: BSI, bloodstream infection; SCI&D, spinal cord injury and disorder.

^aLogistic regression, cluster-adjusted P-values.

(32; 13.3%) and respiratory tract (25; 10.4%). There were no significant differences between BSI type and source of infection.

There were 506 microorganisms found in the 413 BSI episodes; 71 (17.2%) of the 413 BSIs were polymicrobial.

Table 2 Demographics, medical characteristics and factors predisposing to BSI by epidemiologic type of infection

Characteristics	Frequency (%)			P-value ^a		
	Hospital-acquired BSI (n = 267)	Health-care-associated BSI (n = 110)	Community-acquired BSI (n = 36)	Health-care associated vs hospital acquired	Community acquired vs hospital acquired	Community acquired vs health-care associated
Age (years)						
< 50	71 (26.6)	20 (18.2)	15 (41.7)	Reference	Reference	Reference
50–64	95 (35.6)	55 (50.0)	14 (38.9)	0.05	0.68	0.05
65+	101 (37.8)	35 (31.8)	7 (19.4)	0.58	0.07	0.03
Mean (median)	59.7 (56.5)	59.8 (57.8)	54.4 (51.9)	0.83	0.09	0.12
Ethnicity						
White	159 (60.0)	72 (65.5)	28 (77.8)	Reference	Reference	Reference
Black	92 (34.5)	32 (29.1)	6 (16.7)	0.18	0.04	0.20
Other/unknown	16 (6.0)	6 (5.5)	2 (5.6)	0.84	0.87	1.0
Level of injury						
Tetraplegia	122 (45.7)	48 (43.6)	12 (33.3)	Reference	Reference	Reference
Paraplegia	121 (45.3)	43 (39.1)	20 (55.6)	0.76	0.28	0.20
Unknown	24 (9.0)	19 (17.3)	4 (11.1)	0.06	0.91	0.44
Etiology of SCI&D						
Non-traumatic	15 (5.6)	15 (13.6)	1 (2.8)	Reference	Reference	Reference
Traumatic	239 (89.5)	81 (73.6)	31 (86.1)	0.02	0.21	0.09
Unknown	13 (4.9)	14 (12.7)	4 (11.1)	0.84	0.24	0.24
Age at onset of injury (years)						
< 24	53 (19.9)	21 (19.1)	13 (36.1)	Reference	Reference	Reference
25–49	104 (39.0)	45 (40.9)	15 (41.7)	0.99	0.46	0.48
50+	63 (23.6)	25 (22.7)	2 (5.5)	0.83	0.03	0.03
Unknown	47 (17.6)	19 (17.3)	6 (16.7)	0.70	0.26	0.40
Mean (median)	39.4 (33.7)	38.9 (33.4)	30.2 (26.3)	0.67	0.02	0.04
Duration of injury (years)						
< 10	58 (21.7)	27 (24.5)	2 (5.5)	Reference	Reference	Reference
10–29	107 (40.1)	45 (40.9)	18 (50.0)	0.48	0.07	0.04
30+	55 (20.6)	19 (17.3)	10 (27.8)	0.46	0.08	0.04
Unknown	47 (17.6)	19 (17.3)	6 (16.7)	0.34	0.44	0.21
Mean (median)	20.5 (21.0)	20.1 (21.0)	24.7 (22.5)	0.83	0.18	0.14
Medical conditions						
Pre-existing medical condition in 90 days before admission	55 (20.6)	32 (29.1)	4 (11.1)	0.10	0.26	0.04
Comorbid condition during hospitalization	212 (79.4)	75 (68.2)	14 (38.9)	0.04	<0.0001	0.01
Type of comorbid conditions^b						
Myocardial disease	27 (10.1)	9 (8.2)	2 (5.6)	0.51	0.45	0.76
Vascular disease	10 (3.8)	2 (1.8)	1 (2.8)	0.38	0.83	0.41
Gastrointestinal ulcers	5 (1.9)	4 (3.6)	1 (2.8)	0.42	0.71	0.81
Chronic obstructive pulmonary disease	33 (12.4)	7 (6.4)	4 (11.1)	0.13	0.85	0.31
Renal disease	8 (3.0)	3 (2.7)	0	0.78	Not reported ^c	Not reported ^c
Diabetes	46 (17.2)	29 (26.4)	3 (8.3)	0.13	0.21	0.03
Pressure ulcers	168 (62.9)	40 (36.4)	10 (27.8)	<0.0001	0.001	0.41
Cancer	16 (6.0)	9 (8.2)	1 (2.8)	0.54	0.43	0.30
AIDS	11 (4.1)	0	0	Not reported ^c	Not reported ^c	Not reported ^c
Procedures/antibiotic use						
Any respiratory procedure in previous 30 days	50 (18.7)	14 (12.7)	0	0.22	Not reported ^c	Not reported ^c
Antibiotic exposure in previous 30 days	207 (77.5)	49 (44.6)	11 (30.6)	<0.0001	<0.0001	0.37

Abbreviations: AIDS, acquired immunodeficiency syndrome; BSI, bloodstream infection; SCI&D, spinal cord injury and disorder.

^aLogistic regression (controlling for site and year), cluster-adjusted P-values.

^bOnly those conditions with greater than five observations in at least one category are reported.

^cP-values not reported because of small sample size comparisons or zero cells.

The most frequent causative organisms were *S. aureus* (34.4%), followed by *Enterococcus faecium* (14.0%) and *Escherichia coli* (12.6%) (Table 3). The distribution of

polymicrobial BSI and causative organisms was similar across BSI categories, except that *E. coli* was most common in the CA BSI group.

Table 3 Causative pathogens and resistance data, by epidemiologic type of infection

Characteristics	Frequency (%)			P-value ^a		
	Hospital-acquired BSI (n = 267)	Health-care-associated BSI (n = 110)	Community-acquired BSI (n = 36)	Health-care associated vs hospital acquired	Community acquired vs hospital acquired	Community acquired vs health-care associated
<i>Specific organisms</i>						
<i>Staphylococcus aureus</i>	97 (36.3)	33 (30.0)	12 (33.3)	0.21	0.75	0.61
<i>Enterococcus faecium</i>	47 (17.6)	9 (8.2)	2 (5.6)	0.02	0.11	0.76
<i>Pseudomonas aeruginosa</i>	29 (10.9)	14 (12.7)	2 (5.6)	0.73	0.39	0.34
<i>Klebsiella pneumoniae</i>	26 (9.7)	10 (9.1)	6 (16.7)	0.87	0.27	0.39
<i>Escherichia coli</i>	24 (9.0)	19 (17.3)	9 (25.0)	0.07	0.01	0.25
Polymicrobial BSI	49 (18.4)	19 (17.3)	3 (8.3)	0.80	0.24	0.30
<i>Resistance data</i>						
Any antimicrobial resistance	175 (65.5)	54 (49.1)	8 (22.2)	0.001	<0.0001	0.06
BSI with MRSA	82 (30.7)	20 (18.2)	4 (11.1)	0.02	0.04	0.50
BSI with VRE	15 (5.6)	2 (1.8)	0	0.11	Not reported ^b	Not reported ^b
BSI with resistant <i>P. aeruginosa</i>	13 (4.9)	8 (7.3)	0	0.51	Not reported ^b	Not reported ^b
BSI with multidrug-resistant Gram-negative bacilli	86 (32.2)	36 (32.7)	4 (11.1)	0.90	0.06	0.07

Abbreviations: BSI, bloodstream infection; MRSA, methicillin-resistant *S. aureus*; SCI&D, spinal cord injury and disorder; VRE, vancomycin-resistant *Enterococcus*.

^aLogistic regression (controlling for site and year), cluster-adjusted P-values.

^bP-values not reported because of small sample size comparisons or zero cells.

At least one of the resistance patterns assessed was present in 237 (57.4%) BSI episodes, and resistance was most common in the HA BSI group compared with the HCA and CA BSI groups (Table 3). The single most common group of antibiotic-resistant microorganisms was multidrug-resistant Gram-negative bacilli (126, 30.5% of BSI episodes). MRSA was seen in 25.7% (106) of total BSI episodes and accounted for 74.6% of all *S. aureus* BSIs (106 of 142 *S. aureus* BSIs); this varied by BSI type where MRSA was 82 of 97 (84.5%) HA *S. aureus* BSIs, 20 of 33 (60.6%) HCA *S. aureus* BSIs and 4 of 12 (33.3%) CA *S. aureus* BSIs. BSI due to vancomycin-resistant *Enterococcus* or resistant *P. aeruginosa* was low, but none of the CA BSI episodes included these organisms.

In-hospital and 30-day mortality

Forty six (20.4%) of the 226 patients with BSI died in the hospital; this was 11.1% of BSI episodes. There were no significant differences in mortality between the three groups (in-hospital mortality rate for HA: 11.6%; HCA: 10.9%; and CA BSI: 8.3%). Eighteen patients (8.0%) died within 30 days of their BSI (4.4% of BSI episodes), and all deaths were in the hospital-acquired infection group (6.7% of all HA BSI episodes).

Discussion

The overall rate of BSI was high in this study sample, 7.2 episodes per 100 hospitalizations. One-quarter of the BSIs were HCA in this cohort of patients with SCI&D, two-thirds had HA BSI and less than 10% had CA BSI. These rates are not surprising, given the greater use of hospital and other health-care services in this population. Site 1 also had a higher proportion of HCA BSI than site 2 (33.2 vs 18.0%), which was likely due to site 1 having a larger proportion of patients admitted from nursing home or long-term care facilities than site 2. Site 1 also had a higher overall BSI rate

that may be explained by the longer length of hospitalization for all admissions at this site and the increased prevalence of antibiotic exposure, compared with site 2, as the length of the stay in the hospital and antibiotic exposure increases the risk of HA infection.² No other risk factors associated with development of infection, such as age or comorbidity status, differed across sites. Rates of different BSI types will vary across settings where persons with SCI receive treatment, depending on the prevalence of health-care-related risk factors in the populations served.

Health-care-associated infection comprises a significant proportion of BSIs in veterans with SCI&D, although compared with the able-bodied population,^{11,12} the HCA and CA BSI groups were similar in many ways. However, these data did show some differences between those with HCA and CA BSI. Comorbid conditions and previous use of respiratory procedures were more common in the HCA group. In addition, although the sample size was small, BSI caused by *E. coli* was more frequent in the CA BSI, and vancomycin-resistant *Enterococcus* and *P. aeruginosa* were seen in the HA and HCA BSI groups. In addition, the prevalence of methicillin resistance in *S. aureus* was high in the HA and HCA BSI groups compared with the CA BSI group. These results suggest that in the absence of immediate blood culture results, strategies to differentiate between these three groups are important in providing timely and effective treatment.

This study also provided additional data on the epidemiology of BSIs in persons with SCI&D. Chronic diseases in addition to SCI&D were highly prevalent in this population. Pressure ulcer was the most frequent comorbid condition in this population and is a risk factor for the development of infection.^{4,6,18} Development of a pressure ulcer is a frequent complication in persons with SCI&D due to loss of sensation and immobility. Pressure ulcers were most common in those with HA BSI. This is likely due to patients being admitted for

pressure ulcers, which are associated with long lengths of stay, increasing the risk of developing an HA infection.¹⁹

Antibiotic exposure in the previous 30 days was highly associated with HA. We suspect an underestimation of antibiotic use at one site based on data-validation methods. However, antibiotic exposure was still high, seen in two-thirds of BSI episodes, and can increase likelihood of antimicrobial resistance in this population.

Antimicrobial resistance was more common in those with HA and HCA BSIs, with MRSA and multidrug-resistant Gram-negative bacilli being the most common. MRSA accounted for over three-fourths of *S. aureus* HA BSI and nearly two-thirds of *S. aureus* HCA BSI. The high prevalence of MRSA suggests that empiric antibiotic coverage for MRSA should be employed for those with suspected HCA or HA infection.

The low short-term mortality rate was consistent with other SCI&D literature that has shown 30-day mortality ranging from 1.7 to 13%^{3,5,6} and could be due to urinary tract infection as a primary source of BSI, accounting for over one-third of the BSIs, and *S. aureus* being the most frequent causative organism in this population. Gram-negative bacilli are often more associated with higher mortality.²⁰

This study was retrospective and did not include a medical record review. Thus, there may be issues with the reliability of coding certain procedures and unavailability of clinical data that may have further demonstrated severity of illness such as physiologic findings, source of BSI, level of injury and time at onset for those missing data, and attributable mortality due to BSI. Coagulase-negative staphylococci species are often cited as causes of BSI in persons with SCI&D;^{3,4} however, because we were unable to confirm true infection caused by these microorganisms, they were excluded from this analysis. Finally, the small sample size limited further assessment of differences between the three epidemiologic groups.

Health-care-associated BSI comprised one-quarter of all BSIs and shared characteristics with both HA and CA BSI. Future research should focus on further evaluating HCA infections, assessing the similarities and differences between setting of onset of infection, and determine whether treatment and management strategies should vary across these types of infection.

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Conflict of interest

There are no potential conflicts of interest with any other authors. The views expressed in this paper are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs.

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