



## Hospital-Acquired Infections after Aneurysmal Subarachnoid Hemorrhage: A Nationwide Analysis

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■ **BACKGROUND:** This is the first nationwide study to evaluate the factors associated with developing hospital-acquired infections (HAIs) after aneurysmal subarachnoid hemorrhage (SAH) and analyze their impact on the efficiency of hospital care.

■ **METHODS:** Data from patients with SAH who underwent aneurysm repair were extracted from the Nationwide Inpatient Sample (2008–2011). Urinary tract infections, pneumonia, central venous catheter (CVC)-associated blood stream infection, and meningitis/ventriculitis were evaluated. Independent predictors of HAIs used in multivariable logistic regression modeling were chosen using forward selection; hierarchical multivariable linear regression assessed length of stay and charges.

■ **RESULTS:** Seven thousand five hundred sixteen admissions were included. Independent predictors in the logistic regression for developing a urinary tract infection (23.9%) included older age, female sex, noninfectious complications ( $P < 0.001$ ), intracerebral hemorrhage ( $P = 0.009$ ), and diabetes with complications ( $P = 0.04$ ). Pneumonia (23.0%) was associated with older age ( $P = 0.003$ ), congestive heart failure, severity of SAH, and noninfectious complications ( $P < 0.001$ ). Severity of SAH and noninfectious complications were predictors of meningitis/ventriculitis (4.4%;  $P \leq 0.02$ ), whereas intracerebral hemorrhage and noninfectious complications were predictors of CVC-associated infections

(1.0%;  $P \leq 0.02$ ). All HAIs were associated with significantly longer hospitalizations and higher charges. Pneumonia (odds ratio [OR], 2.85; 95% confidence interval [CI], 2.44–3.34) and CVC-associated infections (OR, 2.42; 95% CI, 1.26–4.66) were also independently associated with greater odds of poor outcome (death or institutional care).

■ **CONCLUSION:** In this nationwide analysis, urinary tract infections and pneumonia were the most common hospital-acquired infections after SAH. Although all infections were associated with significantly longer hospitalizations and greater charges, pneumonia and CVC-associated infections were also associated with increased likelihood of a poor outcome.

### INTRODUCTION

Hospital-acquired infections (HAIs) are the sixth leading cause of death in the United States,<sup>1</sup> and they levy a substantial financial burden on the healthcare system—between \$5.7 and \$6.8 billion annually.<sup>2</sup> These infectious complications have garnered particular interest as targets of quality improvement in response to research, suggesting that at least one third of HAIs may be preventable.<sup>3,4</sup> In fact, this number may be greater for some infections: an estimated 65%–70% of catheter-associated

#### Key words

- Cerebral aneurysm
- Hospital-acquired infection
- Meningitis
- Nationwide Inpatient Sample
- National Surgical Quality Improvement Program
- Pneumonia
- Subarachnoid hemorrhage
- Urinary tract infection

#### Abbreviations and Acronyms

- CI:** Confidence interval  
**CVC:** Central venous catheter  
**HAI:** Hospital-acquired infection  
**ICD-9:** International Classification of Diseases, 9th Revision, Clinical Modification  
**IQR:** Interquartile range  
**NIS:** Nationwide Inpatient Sample

**NSQIP:** National Surgical Quality Improvement Program

**OR:** Odds ratio

**SAH:** Subarachnoid hemorrhage

**UTI:** Urinary tract infection

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Citation: World Neurosurg. (2016) 88:459-474.  
<http://dx.doi.org/10.1016/j.wneu.2015.10.054>

Journal homepage: [www.WORLDNEUROSURGERY.org](http://www.WORLDNEUROSURGERY.org)

Available online: [www.sciencedirect.com](http://www.sciencedirect.com)

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**Table 1.** The Demographics of Patients from the NIS Undergoing Procedural Aneurysm Repair After Subarachnoid Hemorrhage, Stratified by Hospital-Acquired Infections

Characteristic	Total Population (n = 7516)	UTI (n = 1793)	P Value	PNA (n = 1726)	P Value	CVC (n = 77)	P Value	CNS (n = 333)	P Value
Age, years									
18–45	23.7	18.5	<b>&lt; 0.001</b>	17.9	<b>&lt; 0.001</b>	28.6	0.66	22.8	0.27
46–55	30.7	26.8		28.8		32.5		35.4	
56–65	24.2	26.4		24.1		20.8		21.3	
≥66	21.4	28.3		29.2		18.2		20.4	
Female sex	68.6	81.8	<b>&lt; 0.001</b>	63.4	<b>&lt; 0.001</b>	67.5	0.84	68.5	0.96
Insurance status									
Private	47.6	41.4	<b>&lt; 0.001</b>	42.6	<b>&lt; 0.001</b>	41.6	0.07	51.4	0.47
Medicare	23.8	29.5		30.9		16.9		23.1	
Medicaid	16.5	18.0		18.3		26.0		15.6	
Self-pay or other	12.0	11.0		8.2		15.6		9.9	
Number of comorbidities									
0	16.4	12.1	<b>&lt; 0.001</b>	11.4	<b>&lt; 0.001</b>	9.1	<b>0.04</b>	13.5	0.42
1	29.5	25.7		24.9		23.4		31.8	
2	26.8	30.7		26.5		27.3		25.8	
≥3	27.3	31.6		37.2		40.3		28.8	
NIS SAH severity scale, median (IQR)	1.2 (1–8.8)	1.3 (1–8.8)	<b>&lt; 0.001</b>	8.8 (7.0–8.8)	<b>&lt; 0.001</b>	7.6 (1.2–8.8)	<b>0.005</b>	8.8 (1.2–8.8)	<b>&lt; 0.001</b>
Intracerebral hemorrhage	9.9	11.9	<b>0.001</b>	14.4	<b>&lt; 0.001</b>	27.3	<b>&lt; 0.001</b>	11.4	0.34
Cerebral herniation	5.2	5.4	0.57	7.8	<b>&lt; 0.001</b>	5.2	0.99	8.1	0.01
Cerebral edema	12.8	13.4	0.40	18.7	<b>&lt; 0.001</b>	11.7	0.77	18.3	0.002
Microsurgical clipping	43.4	42.1	0.18	43.4	0.99	44.2	0.90	39.9	0.19
Decompressive craniectomy	1.4	1.3	0.94	3.1	<b>&lt; 0.001</b>	3.9	0.05	3.0	0.008
Noninfectious complications									
0	22.0	12.7	<b>&lt; 0.001</b>	3.6	<b>&lt; 0.001</b>	10.4	<b>&lt; 0.001</b>	8.7	<b>&lt; 0.001</b>
1	27.3	25.0		16.9		13.0		21.9	
2	24.4	28.3		28.2		28.6		29.1	
≥3	26.3	34.0		51.3		48.1		40.2	
Hospital bed size									
Small/medium	13.9	9.9	<b>&lt; 0.001</b>	14.6	0.31	14.3	0.91	12.9	0.61
Large	86.1	90.1		85.4		85.7		87.1	
Hospital teaching status									
Nonteaching	10.1	9.1	0.11	11.7	<b>0.01</b>	19.5	<b>0.006</b>	9.3	0.63
Teaching	89.9	90.9		88.3		80.5		90.7	
Hospital location									
Rural	1.1	0.8	0.16	1.3	0.56	0.0	0.34	1.2	0.92
Urban	98.9	99.2		98.7		100		98.8	
Hospital region									

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