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Outcomes and Costs Associated with Central Venous Catheter-Related *S. aureus* Bloodstream Infections in Adult Hemodialysis Patients with *S. aureus* Nares Colonization

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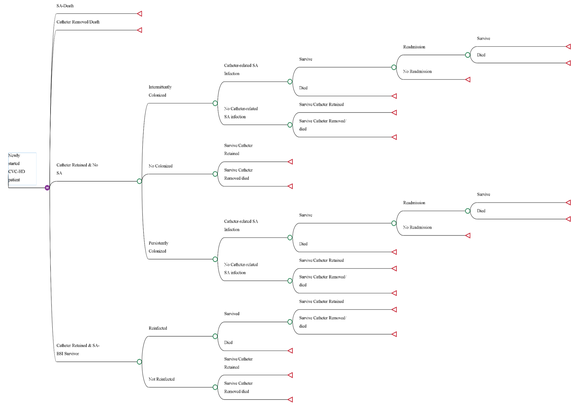
BACKGROUND AND OBJECTIVES

- Despite advances in infection control and catheter care, central venous catheter (CVC)-related *S. aureus* bloodstream infections (SA-BSI) rates in adult hemodialysis patients (pts) on using a CVC (CVC-HD) remains high, especially among CVC-HD pts with intransal *S. aureus* colonization[1-8].
- The 2014 National Healthcare Safety Network (NHSN) report indicates that there are ~4-12 access-related SA-BSIs per year per 100 CVC-HD pts[2].
- Available data indicates that most CVC-related SA-BSIs occur in adult CVC-HD pts with SA nares colonization[4-8].
- Scant data are available on the annual outcomes and costs associated with CVC-related SA-BSIs in CVC-HD pts with SA nares colonization who start in-center HD in the United States (US) each year[1-2].
- This study sought to estimate the yearly US costs associated with CVC-related SA-BSIs in adult CVC-HD patients with SA nares colonization.

STRUCTURAL MODEL



METHODS

Model Structure and Population (Figure 1)

- A model-based deterministic framework from the U.S. payer perspective was used to develop a conceptual Markov healthcare decision analytic model.
- The population comprised ~90,000 CVC-HD pts who start in-center HD in the US each year[1].

Markov Chain Model Dynamic States (Figure 2)

- The model was simulated over a one-year time horizon with events occurring in 12-week cycles.
- CVC-HD patients existed in one of the following health-related dynamic states (DS):
  1. CVC retained and no prior SA-BSI (**DS1**)
  2. CVC retained and survived previous SA-BSI (**DS2**)
  3. CVC removed/death due to non-SA causes (**DS3**)
  4. Death due to SA-BSI (**DS4)**

Nodes in Model (Figure 1)

- At model entry (cycle 0), pts were either SA nares colonized or non-colonized.
  - Colonized pts were either intermittently or persistently colonized.
- Among SA-nares colonized pts, pts were at risk for developing an SA-BSI.
  - If a pt developed a SA-BSI, they either survived and had CVC retained (**DS2**), survived and had CVC removed (**DS3**), or died due to SA-BSI (**DS4**).
  - If pts did not have a SA-BSI, pts either survived and had CVC retained (**DS1**) or had CVC removed/death due to non-SA causes (**DS3**).
- Pts in **DS2** were eligible to develop a re-infection with SA-BSI.

Model Inputs (Table 1)

- Time on CVC and transitions between dynamic states (**DS1-4**)
- SA nares colonization rates
- CVC-related SA BSI rate in intranasal SA colonized pts
- 12-Week clinical and economic outcomes for CVC-related SA-BSI
- 12-Week clinical and economic outcomes for CVC-related SA-BSI re-infection

Annualized SA-BSI Outcomes | SA Nares Colonized CVC-HD Pts (Tables 2 and 3)

- The number of SA-BSI episodes
- SA-BSI-related deaths
- SA-BSI re-infections among SA-BSI survivors
- Cost associated with SA-BSI events
  - Index hospitalization, SA-BSI-related re-admission, outpatient care, and post-acute care

Data Analysis

- Second-order, probabilistic, parameter sample sensitivity analyses were performed to assess the effect of simultaneously varying multiple input variables on cost outputs
- Inputs that were varied included SA nares colonization, SA-BSI rate, and costs associated with index hospitalization and readmissions
- Monte Carlo simulation with 5000-samples was used to estimate mean (SD), median (IQR), min/max costs
- All analyses and calculations were performed within TreeAge Pro Healthcare (Williamstown, MA)

RESULTS

Table 1. Model Inputs From Literature Review

Model Covariate	Key References	Input for Model	Range for Monte Carlo Simulation
Time on CVC and transitions between health-related dynamic states	USDRS 2020 Annual Data Report https://adr.usrds.org/2020/end-stage-renal-disease/3-vascular-access	Cycle 1 (CVC-retained): 100-68% Cycle 2 (CVC-retained): 68-46% Cycle 3 (CVC-retained): 46-28% Cycle 4 (CVC-retained): 28-17%	NA
SA-Colonization	Scheuch M et al. BMC Nephrol. 2019 May 6;20(1):153	Overall: 40% at start of each cycle 15% persistently colonized 25% intermittently colonized	30-50% (triangular distribution) 10-20% for persistent 20-30% for intermittent
SA CVC-related BSIs among SA-colonized patients	Beathard GA. Semin Dial. 2003 Sep-Oct;16(5):403-5. Beathard GA et al. Semin Dial. 2008 Nov-Dec;21(6):528-38. Price A et al. J Hosp Infect. 2015 May;90(1):22-7. 6.	7.5% of SA-colonized pts will have a CVC-related SA-BSI each cycle	5-10% (triangular distribution)
12-Week Costs for SA CVC-related BSI	Engemann JJ et al. Infect Control Hosp Epidemiol. 2005 Jun;26(6):534-9. Reed SD et al. Infect Control Hosp Epidemiol. 2005 Feb;26(2):175-83.	Weighted 12-week cost of $47,285*	Applied normal distribution with fixed lower bound of $5,000 (1 hospitalization)-$10,000 (initial hospitalization with readmission) and upper bound 2 times the mean to capture cost distribution
12-week SA CVC-related BSI reinfection	Engemann JJ et al. Infect Control Hosp Epidemiol. 2005 Jun;26(6):534-9. Choi SH et al. Clin Infect Dis. 2021 Jun 1;72(11):1891-1899.	Weighed 12-week cost of $42,352*	Applied normal distribution with fixed lower bound of $5,000 (1 hospitalization)-$10,000 (initial hospitalization with readmission) and upper bound 2 times the mean to capture cost distribution

*Inflated to 2022 USD

Figure 2. Distribution of Pts Across Markov Chain Cycles

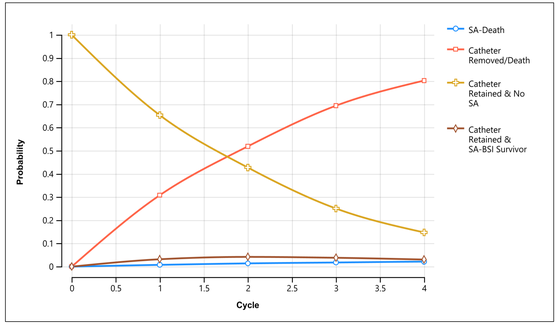


Table 2. Frequency of SA-BSIs-Related Outcomes in Each 12-Week Cycles

	CYCLE 1	CYCLE 2	CYCLE 3	CYCLE 4
CVC-related BSIs	**2,700**	**1,710**	**1,170**	**720**
SA-Deaths	**540**	**360**	**270**	**270**
Intermittently colonized				
CVC-related BSIs	1,710	1,080	720	450
SA-Deaths	360	180	90	90
Persistently Colonized				
CVC-related BSIs	990	630	450	270
SA-Deaths	180	90	90	90
Reinfection/Dead				
Re-infections	0	360	450	360
SA-Deaths	0	90	90	90

Table 3. Estimated Annual SA-BSI-Related Outcomes Attributable to Intranasal SA Colonization Among the 36,000 Incident CVC-HD Pts with SA Nares Colonization

Outcome	Estimate
SA-BSIs	**6,3000**
SA-BSI Re-infections	**1,170**
SA-BSI Deaths	**1,440**
Mean (SD) Costs (USD)*	**361.4 M ± 46 M**

*Derived from 5,000 subject second=order, probabilistic, sensitivity analysis. Cost in USD

CONCLUSIONS

- Data indicate 36,000 of the 90,000 incident CVC-HD patients who start in-center HD in the US are intranasally colonized with *S. aureus*.
- The estimated annual morbidity, mortality, and healthcare costs associated with CVC-related SA-BSIs in incident CVC-HD patients that is attributable to SA nares colonization are substantial and estimated to be ~$361M USD.
- Interventions designed at preventing CVC-related SA-BSIs in SA nares colonized CVC-HD patients are sorely needed to minimize the deleterious outcomes associated with CVC-related SA-BSIs.
- Like all studies of this nature, the findings in this analysis require validation in the clinical arena.

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