

The impact of healthcare-associated methicillin-resistant *Staphylococcus aureus* infections on post-discharge healthcare costs and utilization

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Background

- More than 440,000 adults contract a healthcare-associated infection (HAI) in the US each year at a cost of nearly \$10 billion [1].
- HAIs are classified as a "never event" by the Centers for Medicare and Medicaid Services, which stopped reimbursing US hospitals for such events in October 2008 as part of the Deficit Reduction Act of 2005 [2].
- Although recent estimates have suggested that the rate of infections due to methicillin-resistant *Staphylococcus aureus* (MRSA) has declined in the last decade, this antimicrobial-resistant pathogen remains one of the most common sources of HAI in the US [3].
- Estimates of the burden associated with HAIs can be useful in making resource allocation decisions, evaluating treatment and prevention efforts, and for comparisons with other conditions.
- A number of studies have estimated the incremental cost attributable to MRSA HAIs, but these estimates are incomplete or unreliable for several reasons.
- For example, many estimates have been limited to inpatient costs for the hospital stay when the HAI occurred [4,5].
- Without the post-discharge component of MRSA HAI costs we do not get a full picture of the resources required to treat patients with these hospital-acquired events

Objective

To estimate the post-discharge costs and healthcare utilization among patients with MRSA HAIs compared to a control group without such an infection during a one-year period following hospital discharge. We hypothesized that having an MRSA HAI would lead to greater post-discharge healthcare costs and utilization.

Data

Microbiology

- Beginning on October 1, 2007, the VA implemented a nationwide MRSA Prevention Initiative with a goal of reducing MRSA HAIs [6].
- The program called for all patients admitted to a VA acute care facility to be screened for MRSA colonization upon admission, transfer, and discharge.
- The results from these tests are entered into the VA electronic medical record.
- Our team developed a natural language processing system to extract microorganisms mentioned in these reports as well as antibiotic susceptibilities allowing us to identify positive MRSA cultures at all VA hospitals [7].

Costs and utilization

- Healthcare cost and utilization data were obtained from the VA Decision Support System (DSS), which is an activity-based accounting system.
- Physicians and managers report their activities which are then used to distribute costs from the VA payroll and general ledger.

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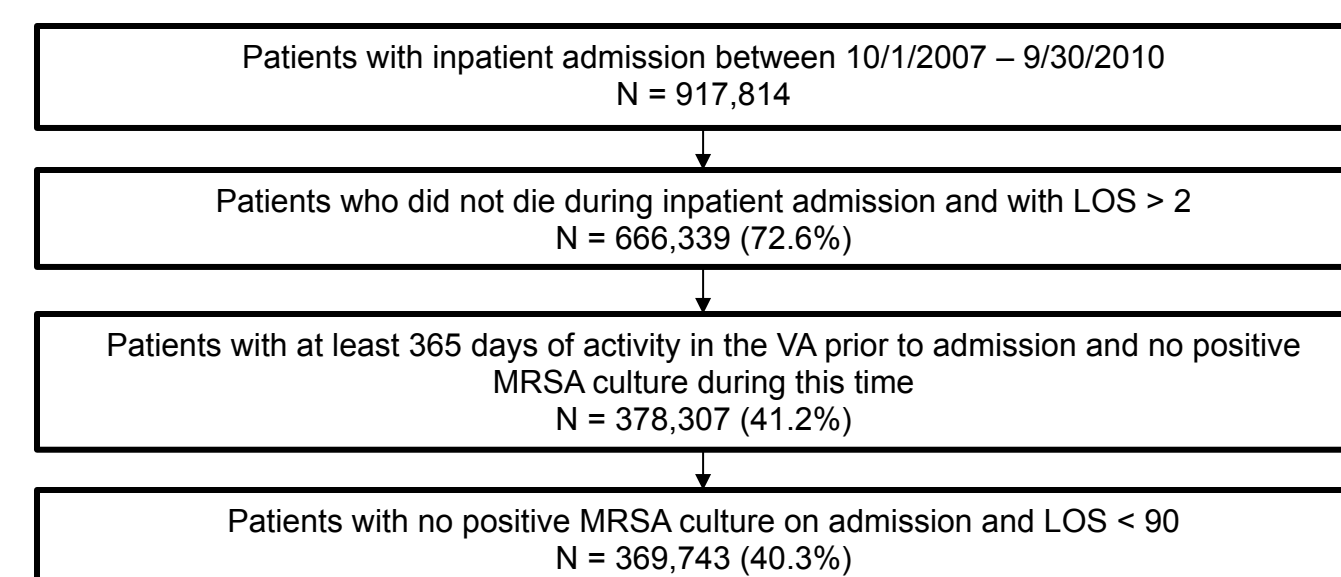


Methods

Study design and population

- We employed a historical cohort study design and used data from the VA healthcare system from October 1, 2007 and September 30, 2010.
- Patients were excluded from the cohort if they (1) died during this index hospitalization, (2) had a length of stay that exceeded 90 days, (3) were discharged from the hospital in 2 days or less, (4) had a prior positive clinical culture for MRSA or (5) did not have at least 365 days of observation in the VA prior to their index hospitalization.
- Our final sample consisted of 369,743 patients (Figure 1).

Figure 1: Patient attrition summary



Outcome variables

- Our outcome variables included outpatient, inpatient, and pharmacy costs and utilization in the VA during the 365-day period following the index hospitalization.
- Cost outcomes were converted to 2011 US dollars.
- We reported both total and variable inpatient costs.

Independent variables

- The key independent variable in our models was an indicator for a positive MRSA culture.
- We used a recently published algorithm that uses electronic data to further classify the positive MRSA cultures as healthcare-associated infections (MRSA HAIs) or not (MRSA colonization) [8].
- We also controlled for potential confounders, including demographic characteristics, VA healthcare costs in the 365 days prior to admission, length of stay at risk for MRSA infection during index hospitalization, admitting diagnosis for index hospitalization, indicator for surgery within first 48 hours of index hospitalization, and comorbidities, as measured using a risk score that combines the Charlson and Elixhauser measures [9].

Cost regressions

- We used a generalized linear model (GLM) with a log link for outpatient and pharmacy cost regressions [10] and a two-part regression model for inpatient costs [11].

Utilization regressions

- We used a negative binomial regression for outpatient encounters and prescriptions.
- We used zero-inflated negative binomial and logistic regression for inpatient days and readmission, respectively.

Propensity score matching

- We ran the regressions outlined above on a subgroup of propensity score-matched patients in order to balance observable characteristics between patients with and without a positive MRSA culture.

Results

Patient characteristics

- Characteristics of our patient cohort are shown in Table 3.
- The full cohort included 369,743 patients (3,599 of whom had an MRSA HAI), while the propensity score-matched subgroup included 3,592 patients with and without MRSA.
- Not surprisingly, the observable characteristics were much more similar in the propensity score matched subgroups than in the full cohort.

Table 1: Patient characteristics

	Full cohort		Propensity score-matched cohort	
	No MRSA	MRSA	No MRSA	MRSA
Total (n)	366,144	3,599	3,592	3,592
Age (mean)	64.3	65.9	66.0	65.9
Male (%)	94.9	96.0	96.0	96.0
Race (%)				
White	69.2	67.6	67.6	67.6
Black	19.4	21.1	20.2	21.1
Other	6.7	6.9	7.7	6.8
Unknown	4.6	4.5	4.5	4.5
CCI/Elixhauser (mean)	1.3	1.4	1.9	1.8
Outpt cost prior yr (mean)	\$9,703	\$10,711	\$16,783	\$13,483
LOS (mean)	9.3	22.4	23.2	20.1

Note: MRSA = methicillin-resistant *Staphylococcus aureus*; CCI = Charlson Comorbidity Index; LOS = length of stay.

Results

Multivariable regression

- The results of the multivariable regressions for healthcare costs are shown in Table 3.
- There was no significant difference in outpatient costs between patients with and without positive MRSA cultures.
- Pharmacy and inpatient costs were significantly higher in patients with MRSA colonization and HAI compared to those without positive cultures.

Table 3: Results - Cost outcomes

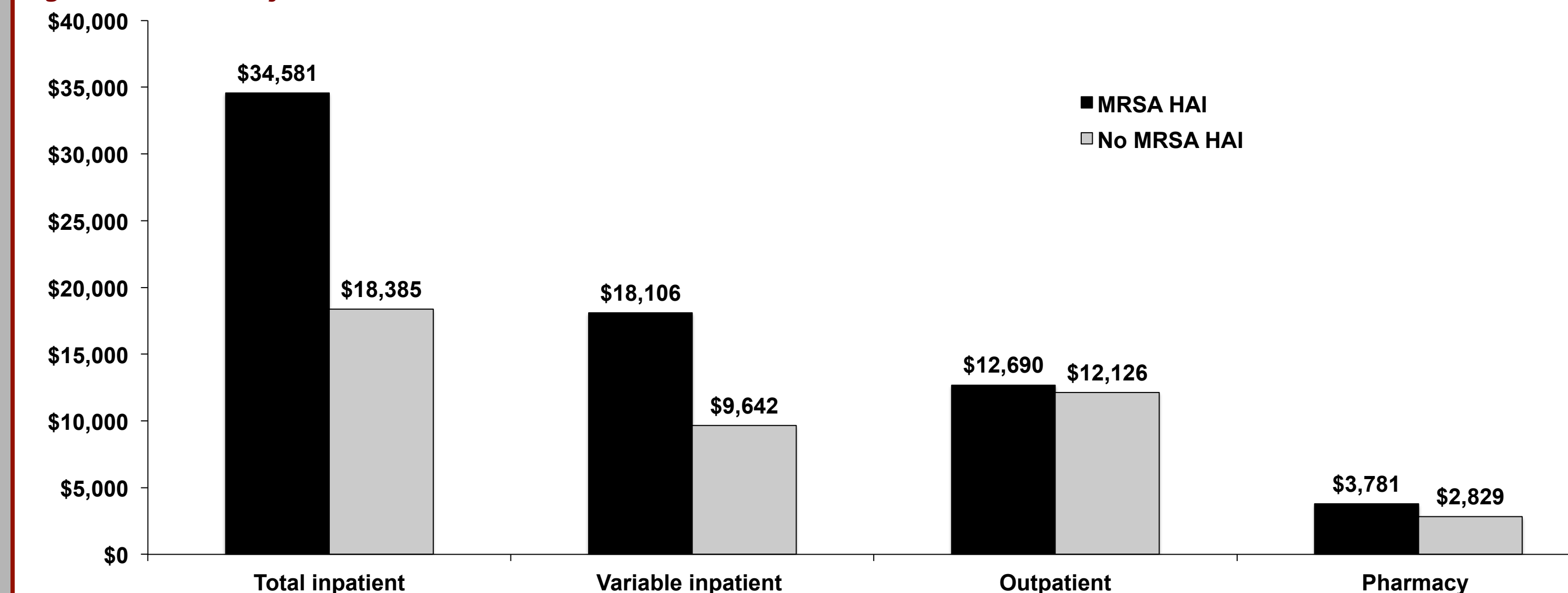
Cost category	Estimate	95% CI	
		Lower	Upper
Outpatient			
No MRSA (ref)	-	-	-
MRSA colonization	-\$272	-\$1,105	\$560
MRSA HAI	-\$1,039	-\$2,549	\$472
Pharmacy			
No MRSA (ref)	-	-	-
MRSA colonization	\$654	\$338	\$971
MRSA HAI	\$977	\$411	\$1,544
Inpatient total			
No MRSA (ref)	-	-	-
MRSA colonization	\$11,208	\$8,313	\$14,102
MRSA HAI	\$10,271	\$5,448	\$15,095
Inpatient variable			
No MRSA	-	-	-
MRSA colonization	\$5,889	\$4,363	\$7,415
MRSA HAI	\$5,537	\$3,004	\$8,069

Results

Unadjusted costs

- Unadjusted mean costs are shown in Figure 2.

Figure 2: Mean unadjusted costs



Results

Multivariable regression

- The results of the multivariable regressions for healthcare utilization are shown in Table 4.
- There was no significant difference in the number of outpatient encounters between patients with and without positive MRSA cultures.
- Pharmacy and inpatient costs were significantly higher in patients with MRSA colonization and HAI compared to those without positive cultures.

Table 4: Results - Utilization outcomes

Cost category	Estimate	95% CI	
		Lower	Upper
Outpatient			
No MRSA (ref)	-	-	-
MRSA colonization	0.945	0.901	0.991
MRSA HAI	0.918	0.843	1.001
Pharmacy			
No MRSA (ref)	-	-	-
MRSA colonization	1.144	1.090	1.200
MRSA HAI	1.106	1.014	1.207
Inpatient total			
No MRSA (ref)	-	-	-
MRSA colonization	1.392	1.258	1.541
MRSA HAI	1.416	1.179	1.700
Inpatient variable			
No MRSA	-	-	-
MRSA colonization	1.204	1.145	1.265
MRSA HAI	1.209	1.109	1.318

Summary & Conclusions

- Using electronic data from 123 VA hospitals in the US, we find that patients with MRSA HAIs incur more costs and utilize more healthcare resources relative to patients without MRSA HAIs in the 365 days after discharge.
- This is one of the first studies to examine the attributable cost of MRSA HAIs in the post-discharge period.
- These results suggest that the economic burden of MRSA HAIs may be \$481 million greater than previously thought when taking into account the post-discharge period.
- We improve upon the existing literature in several important ways:
 - First, this is one of the largest analyses of attributable costs of healthcare-associated infections ever conducted.
 - Second, the construction of such a large patient cohort was facilitated by our unique dataset of microbiology reports to identify positive MRSA cultures.
 - And third, we used propensity score matching to reduce the imbalance of observable characteristics between exposure groups.

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