

Avoiding time-dependent bias in estimating the attributable cost of healthcare-associated methicillin-resistant Staphylococcus aureus infections

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Background

- When estimating the relationship between hospital-acquired infections (HAI) and length of stay (LOS), HAIs should be treated as a time-varying exposure [1-3].
- Failure to do so leads to a phenomenon called "time-dependent bias" which can result in overestimation of the excess LOS due to HAIs.
- A similar time-dependent bias problem occurs when estimating the excess inpatient healthcare costs due to HAI.
- Because most healthcare data sets do not allow investigators to differentiate between inpatient costs that occur before an HAI from those that occur after, all estimates of the inpatient healthcare costs attributable to HAIs generated to date are too high.

Objective

To use a unique healthcare cost data set from the US Department of Veterans Affairs (VA), to overcome the time-dependent bias problem and to demonstrate the magnitude of this bias by comparing our results to those obtained using conventional methods.

Methods

- Data**
- We applied a natural language processing system to unstructured microbiology data to identify positive MRSA cultures at all VA hospitals [4].
 - Healthcare cost and utilization data were obtained from the VA Decision Support System (DSS), TRT file, which has a unique structure (see **Table 1**).

Table 1: Example structure of DSS TRT file

admitday	txspstdt	txspedt	txsp	TotCost
2009-10-29	2009-10-29	2009-10-31	63	\$57,546.72
2009-10-29	2009-10-31	2009-10-31	52	\$491.52
2009-10-29	2009-11-01	2009-11-04	52	\$3,590.69
2009-10-29	2009-11-04	2009-11-05	63	\$4,588.76
2009-10-29	2009-11-05	2009-11-12	52	\$16,875.45
2009-10-29	2009-11-12	2009-11-21	22	\$28,833.26

Note: txspstdt = treating specialty start date; txspedt = treating specialty end date; txsp = treating specialty

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) had LOS < 48 hours, (2) had MRSA positive culture on admission or in 365 days prior to admission, or (3) did not have 365 days in VA prior to admission.

Outcome variables

- Our outcome variables were total and variable inpatient costs converted to 2011 US dollars.

Independent variables

- The key independent variable in our models was an indicator for a positive MRSA culture.
- We also controlled for potential confounders, including demographic characteristics, outpatient healthcare costs in the 365 days prior to admission, admitting diagnosis for index hospitalization, indicator for surgery within first 48 hours of index hospitalization, and comorbidity index [5].

Cost regressions

- We used a generalized linear model (GLM) with a log link to estimate the attributable cost of MRSA HAIs [6].

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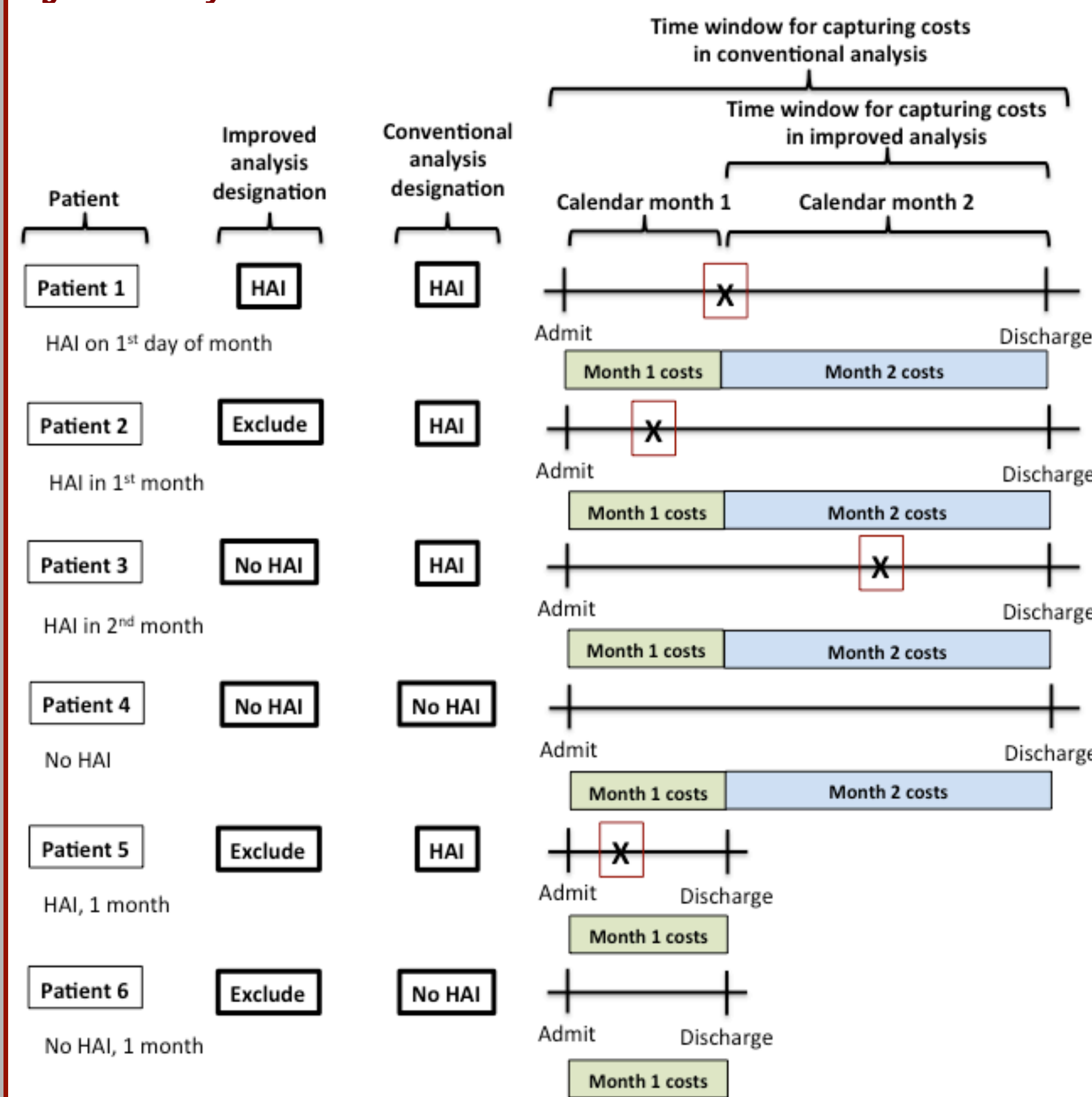
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Methods

Analyses

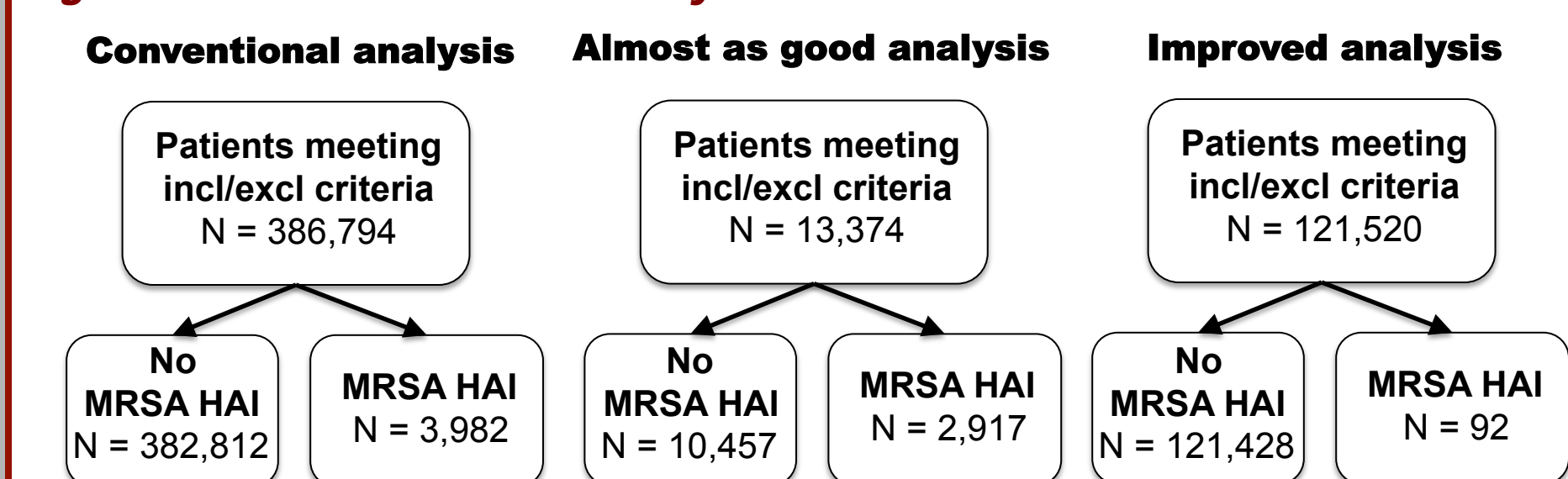
- We conducted our analysis using 3 different approaches: (1) conventional analysis, (2) improved analysis, and (3) almost as good analysis.
- Figure 1** describes how the conventional and improved analyses differed.

Figure 1: Study schematic



- Since most researchers do not have access to data that would allow for an improved analysis, we also conducted an "almost as good analysis" in which MRSA HAI patients were propensity score matched with non-MRSA HAI patients on observable characteristics and timing of HAI.
- Figure 2** describes the study population for each analysis method.

Figure 2: Patient attrition summary



Results

Patient characteristics

- Characteristics of our patient cohort are shown in **Table 2**.
- The conventional analysis included 386,794 patients (3,982 of whom had an MRSA HAI), the almost as good analysis included 13,374 patients (2,917 of whom had an MRSA HAI), and the improved analysis included 121,520 patients (92 of whom had an MRSA HAI).

Table 2: Patient characteristics

	Conventional analysis		Almost as good analysis		Improved analysis	
	No MRSA	MRSA	No MRSA	MRSA	No MRSA	MRSA
Total (n)	382,812	3,982	10,457	2,917	121,428	92
Age (mean)	64.4	65.4	64.4	65.4	64.1	65.0
Male (%)	95.0	96.1	96.2	96.4	95.4	97.8
Race (%)						
White	69.0	66.5	68.4	67.1	67.2	70.7
Black	19.5	22.7	19.9	21.2	21.7	16.3
Other	6.8	6.7	7.2	7.2	6.8	8.7
Unknown	4.7	4.2	4.6	4.6	4.4	4.3
CCI/Elixhauser (mean)	1.3	1.3	1.3	1.3	1.3	1.2
Outpt cost prior yr (mean)	\$9,703	\$10,713	\$9,730	\$10,713	\$9,748	\$8,656

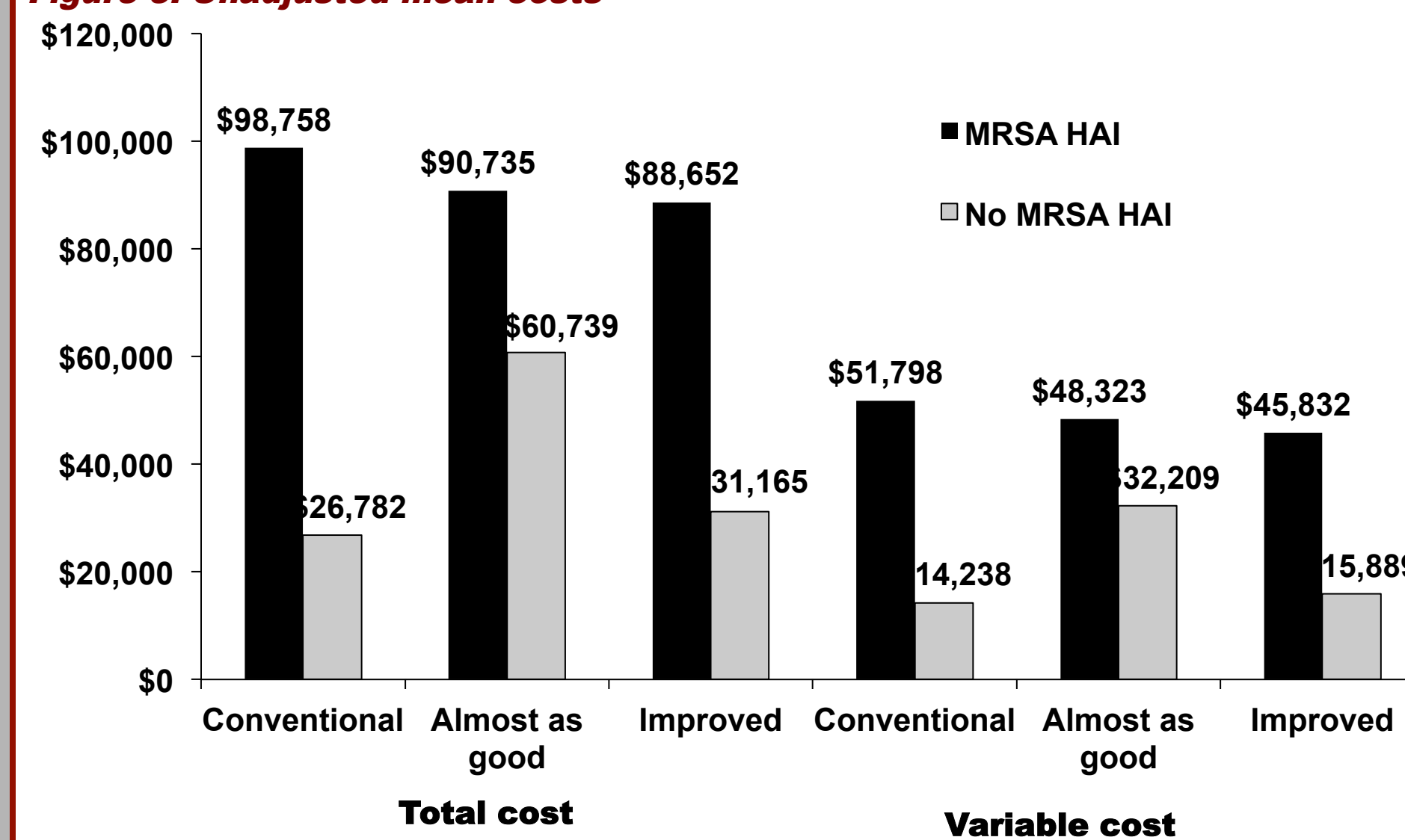
Note: MRSA = methicillin-resistant Staphylococcus aureus; CCI = Charlson Comorbidity Index; LOS = length of stay.

Results

Unadjusted costs

- Unadjusted mean costs are shown in **Figure 3**.

Figure 3: Unadjusted mean costs



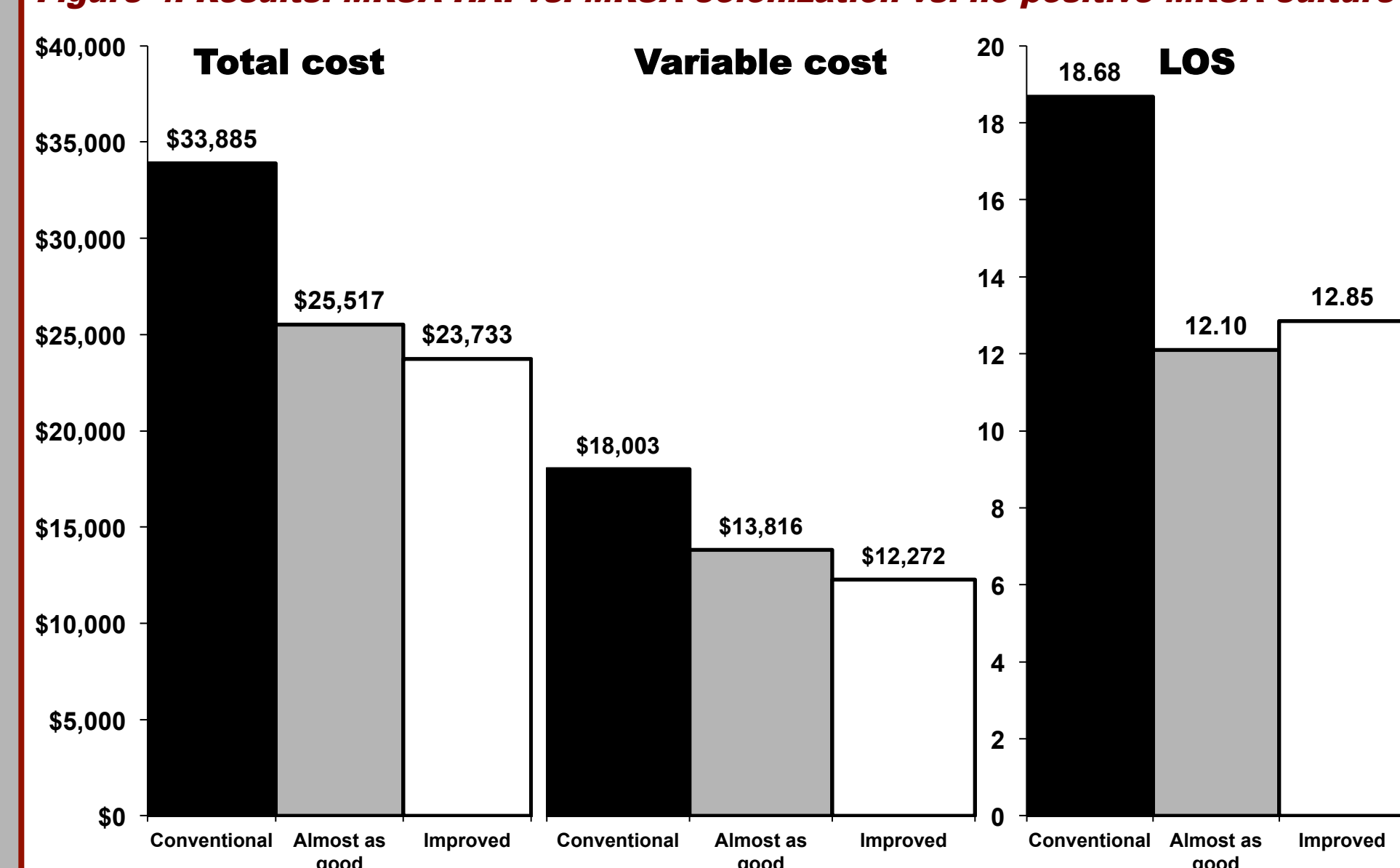
- In each case, patients with MRSA HAIs had higher mean costs than those without MRSA HAIs.
- The differences between the unadjusted costs for patients with and without MRSA HAIs were much smaller in the almost as good analysis.

Results

Multivariable regression results

- The results from the multivariable regression analyses are shown in **Figure 4** as attributable total costs, variable costs, and LOS for patients with MRSA HAI vs. no MRSA HAI.

Figure 4: Results. MRSA HAI vs. MRSA colonization vs. no positive MRSA culture



Summary & Conclusions

- Using electronic data from 123 VA hospitals in the US, our estimates of the attributable cost of MRSA HAIs were 46.7% higher (\$18,003 vs. \$12,272) using the conventional method compared to the improved method.
- Using the almost as good method, our estimates were only 4.8% higher (\$13,816 vs. \$12,272) than the improved method.
- Artificially inflated estimates of consequences of HAI can be harmful for policy makers using estimates of economic burden to prioritize scarce resources and to the medical community as a whole when expectations of the benefits of prevention efforts are overstated.
- We improve upon the existing literature in several important ways:
 - First, this is the first study of the attributable cost of HAIs to separate costs that occurred prior to an HAI from those that occurred after an HAI. Therefore, we feel that this is the most accurate estimate of attributable pre-discharge costs of HAI.
 - Second, we demonstrated that even without access to this unique healthcare cost data methods to estimate the attributable cost of HAIs that take into account the timing of the infection yield results that are much closer in magnitude than those that use conventional methods.
 - Third, the methods that we have developed here are not specific to HAIs but can be applied to other types of inpatient adverse safety events.

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