

Economic analysis of VA initiative to
prevent methicillin-resistant *Staphylococcus aureus*
infections

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Collaborators

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Lexington Kentucky VA

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Centers for Disease Control and Prevention

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Poll Question

- How familiar are you with health econometrics or cost-effectiveness analysis?
 - I have conducted cost or cost-effectiveness analyses
 - I have read papers that describe cost or cost-effectiveness analyses
 - I have lived my life up to this point by avoiding the dismal science altogether and have been happier for it

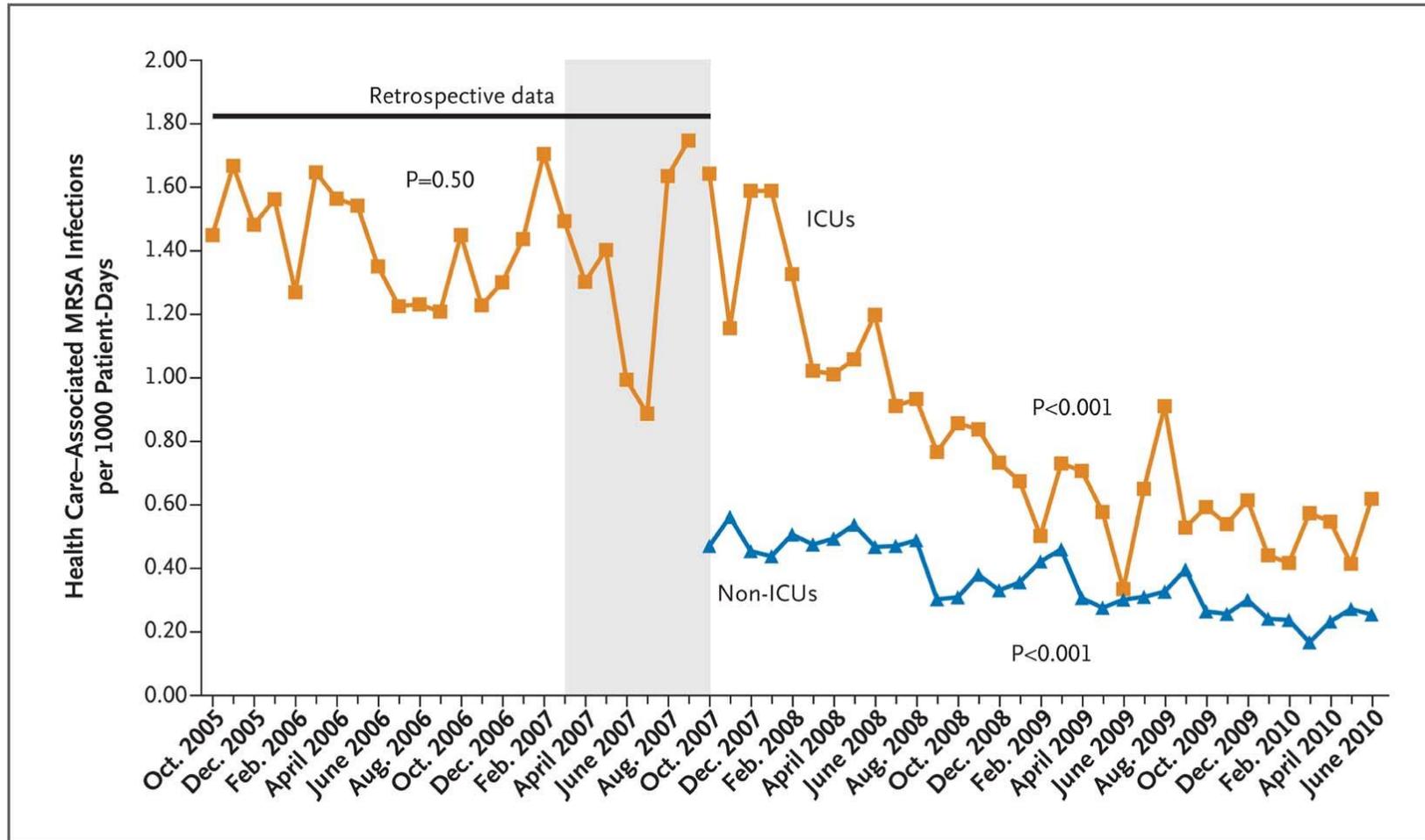
HAI and MRSA

- Healthcare-associated infections (HAI)
 - Infections that result from encounters with healthcare system
 - About 1 in 20 hospitalized patients in US
- Methicillin-resistant *Staphylococcus aureus* (MRSA)
 - Bacteria resistant to many antibiotics
 - One of the leading causes of invasive infections in healthcare settings
 - Bloodstream, pneumonia, and surgical site infections

VA MRSA Prevention Initiative

- Implemented in October 2007
- Bundle with 4 components
 1. Universal nasal surveillance for MRSA,
 2. Contact precautions for patients whose nasal test for MRSA was positive,
 3. Improved hand hygiene efforts, and
 4. Increased emphasis on infection control being the responsibility of all healthcare workers

Veterans Affairs Initiative to Prevent Methicillin-Resistant *Staphylococcus aureus* Infections



Preview

- Attributable cost of MRSA HAIs
 - Pre-discharge
 - Post-discharge
- Economic evaluation of VA initiative to prevent MRSA HAIs

Conceptual model

Admission date

HAI date

Discharge date

<p>Healthcare services attributable to HAI</p>		<ul style="list-style-type: none"> • More inpatient days • More services on each day 	<ul style="list-style-type: none"> • Number of outpatient visits • Number of prescriptions • Risk of readmission • More inpatient days on readmission
<p>Healthcare costs attributable to HAI</p>		<ul style="list-style-type: none"> • Cost per inpatient day 	<ul style="list-style-type: none"> • Cost of outpatient visit • Cost per prescription • Cost of readmission
		<p>Pre-discharge</p>	<p>Post-discharge</p>
		<p>Index hospitalization</p>	

Components of accurate cost of HAIs

1. Pre-discharge costs

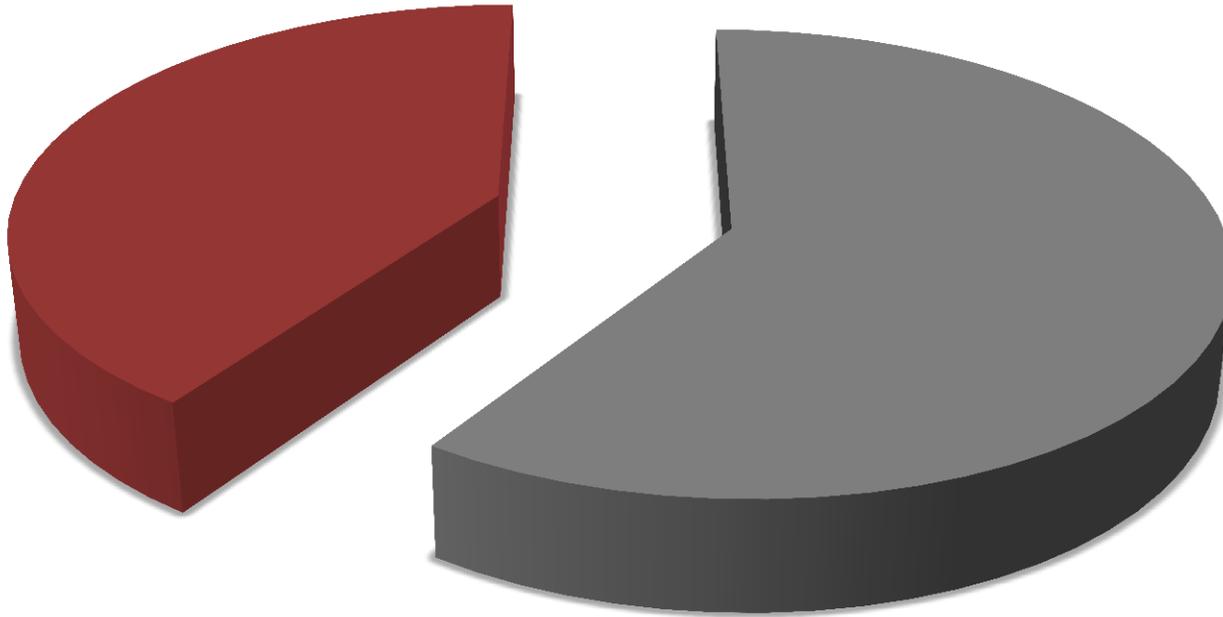
- Incorrect methods (overestimation)

2. Post-discharge costs

- Often neglected in cost of HAI estimates (underestimation)

Which Costs Can be Avoided?

Cost of HAI



- Staff
- Buildings
- Equipment

■ Fixed Cost

■ Variable Cost

- Antibiotics
- Catheters
- Other consumables

Estimating cost of MRSA HAI in VA

- Need way of identifying healthcare costs
 - VA Managerial Cost Accounting (MCA) data
 - Activity-based accounting system in VA
 - Extracts information from general ledger and VA payroll system
 - Specific job categories, supplies or equipment
 - Costs are allocated to cost centers
 - Primary care clinics
 - Intensive care units
 - Administration
 - Environmental services
 - Costs are allocated based on employee activities

Estimating cost of MRSA HAI in VA

- Need way of identifying MRSA infections
 - ICD-9 code (V09) is not good for MRSA HAIs
 - V09 = infection with drug-resistant microorganisms
 - Microbiology data
 - Unstructured

VA Microbiology Data

Jones et al. *BMC Medical Informatics and Decision Making* 2012, **12**:34
<http://www.biomedcentral.com/1472-6947/12/34>



RESEARCH ARTICLE

Open Access

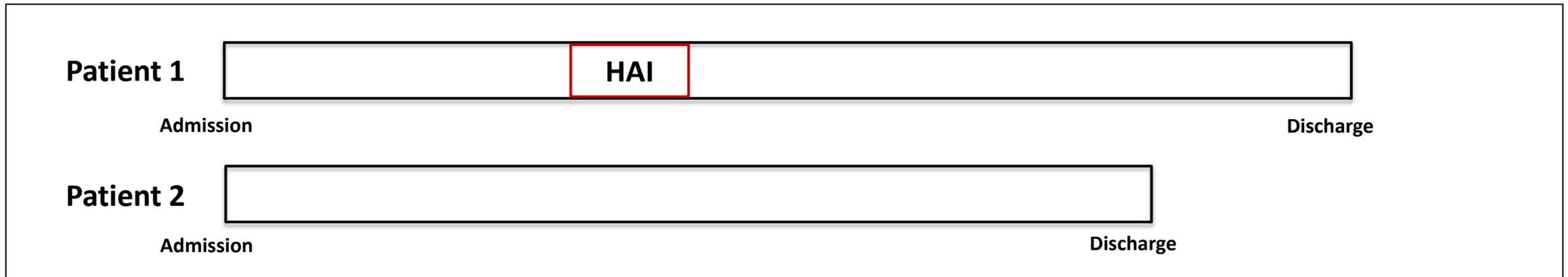
Identification of methicillin-resistant *Staphylococcus aureus* within the Nation's Veterans Affairs Medical Centers using natural language processing

Makoto Jones^{1,2*}, Scott L DuVall^{1,2*}, Joshua Spuhl¹, Matthew H Samore^{1,2}, Christopher Nielson^{3,4} and Michael Rubin^{1,2}

Impact of HAI on Pre-Discharge Costs

Aside: Impact of HAI on Excess LOS

- Important because each extra bed-day taken up by a patient with HAI represents opportunity cost for hospital
- Many studies compare total LOS between patients with HAI and those without



- But not all of the days are attributable to the HAI
- This leads to “time-dependent bias”

INFECTION CONTROL & HOSPITAL EPIDEMIOLOGY

REVIEW ARTICLE

The Magnitude of Time-Dependent Bias in the Estimation of Excess Length of Stay Attributable to Healthcare-Associated Infections

Richard E. Nelson, PhD;^{1,2} Scott D. Nelson, PharmD;^{1,3} Karim Khader, PhD;^{1,2} Eli L. Perencevich, MD, MS;^{4,5}
Marin L. Schweizer, PhD;^{4,5} Michael A. Rubin, MD, PhD;^{1,2} Nicholas Graves, PhD;⁶ Stephan Harbarth, MD, MS;⁷
Vanessa W. Stevens, PhD;^{1,3} Matthew H. Samore, MD^{1,2}

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Estimates of the Magnitude of Time-Dependent Bias

TABLE 1. Published Estimates of the Magnitude of Time-Dependent Bias: Conventional Methods vs Multistate Models

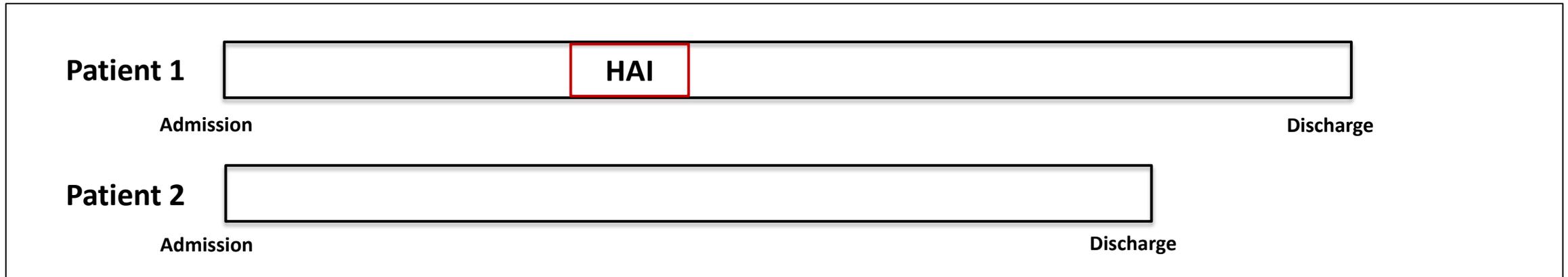
Study ^a	Country	Infection Type	Excess LOS, d (95% CI)		Absolute Difference, d	Relative Difference, %
			Conventional Methods	Multistate Model		
Schulgen (2000) Study I ¹³	Germany	Postoperative wound	16.9 (12.9–20.9)	9.8 (5.7–13.8)	7.1	72.5
Schulgen (2000) Study II ¹³	Germany	Pneumonia	12.3 (9.7–14.9)	3.4 (0.8–6.0)	8.9	261.7
Roberts (2010) ¹⁴	US	Mixed	8.1	5.9	2.2	37.3
Barnett (2011) ³	Argentina	CLABSI, CAUTI, VAP	11.2 (10.1–12.4)	1.4 (0.8–1.9)	9.9	731.9
De Angelis (2011) ¹⁵	Switzerland	Mixed	24.5 (14.5–34.5)	6.0 (0–11.9)	18.6	312.3
Macedo-Vinas (2011) ¹⁷	Switzerland	Mixed	15.3	11.5 (7.9–15.0)	3.8	33.0
Schumacher (2013) ¹⁸	Germany	Pneumonia	21.9 (17.6–26.2)	6.2 (1.3–9.1)	15.7	253.2
				Mean	9.4	238.0

TABLE 2. Published Estimates of the Magnitude of Time-Dependent Bias: Conventional Methods vs Matching on Timing of Infection

Study ^a	Country	Infection Type	Excess LOS, d (95% CI)		Absolute Difference, d	Relative Difference, %
			Conventional Methods	Matching on Timing of Infection		
Schulgen (2000) Study I ¹³	Germany	Postoperative wound	16.9 (12.9–20.9)	11.4 (7.1–15.7)	5.5	48.2
Schulgen (2000) Study II ¹³	Germany	Pneumonia	12.3 (9.7–14.9)	8.2 (5.9–10.5)	4.1	50.0
Vrijens (2010) ¹⁹	Belgium	Bloodstream	21.0	6.7	14.3	213.4
Vrijens (2012) ²⁰	Belgium	UTI, BSI, SSI, LRI, GI	38.3 (34.1–42.5)	10.0 (7.3–12.6)	28.3	283.0
Schumacher (2013) ¹⁸	Germany	Pneumonia	21.9 (17.6–26.2)	11.3 (6.8–15.7)	10.6	93.8
				Mean	12.6	139.3

Impact of HAI on Pre-Discharge Costs

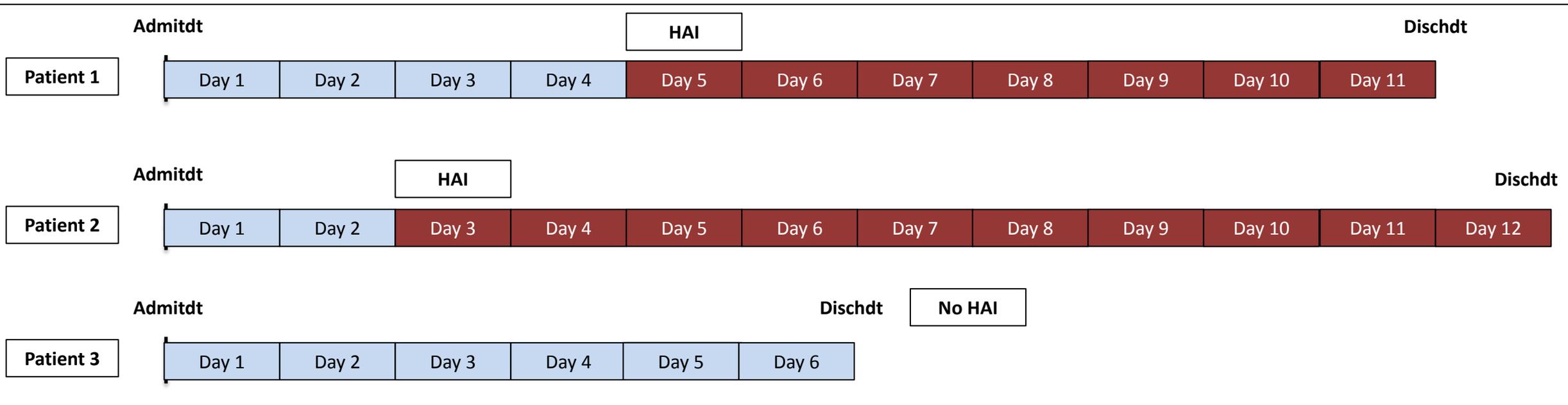
- All previous studies compare total inpatient costs between patients with HAI and those without



- But not all of the costs are attributable to the HAI
- This leads to “time-dependent bias”

Impact of HAI on Pre-Discharge Costs

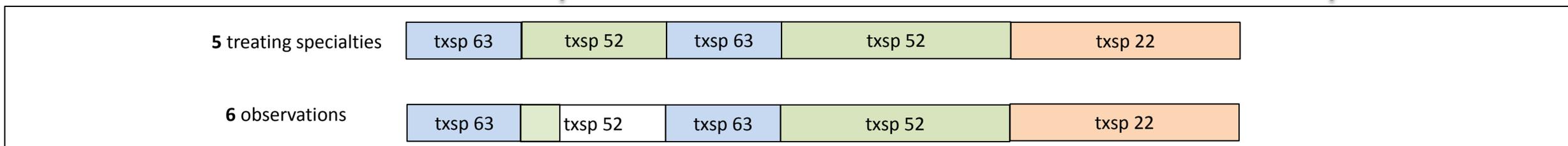
- Can we differentiate between costs that occur before and after HAI with VA data?



Impact of HAI on Pre-Discharge Costs

- Can we differentiate between costs that occur before and after HAI with VA data?
 - Separate observations for each patient-treating specialty-calendar month

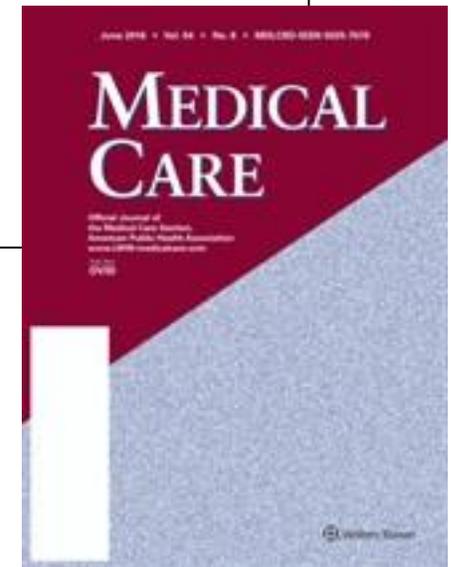
admitday	txpsdt	txspedt	txsp	fy	fp	TotCost
2009-10-29	2009-10-29	2009-10-31	63	2010	1	\$57,546.72
2009-10-29	2009-10-31	2009-10-31	52	2010	1	\$491.52
2009-10-29	2009-11-01	2009-11-04	52	2010	2	\$3590.69
2009-10-29	2009-11-04	2009-11-05	63	2010	2	\$4588.76
2009-10-29	2009-11-05	2009-11-12	52	2010	2	\$16,875.45
2009-10-29	2009-11-12	2009-11-21	22	2010	2	\$28,833.26



Reducing Time-dependent Bias in Estimates of the
Attributable Cost of Health Care–associated
Methicillin-resistant *Staphylococcus aureus* Infections
A Comparison of Three Estimation Strategies

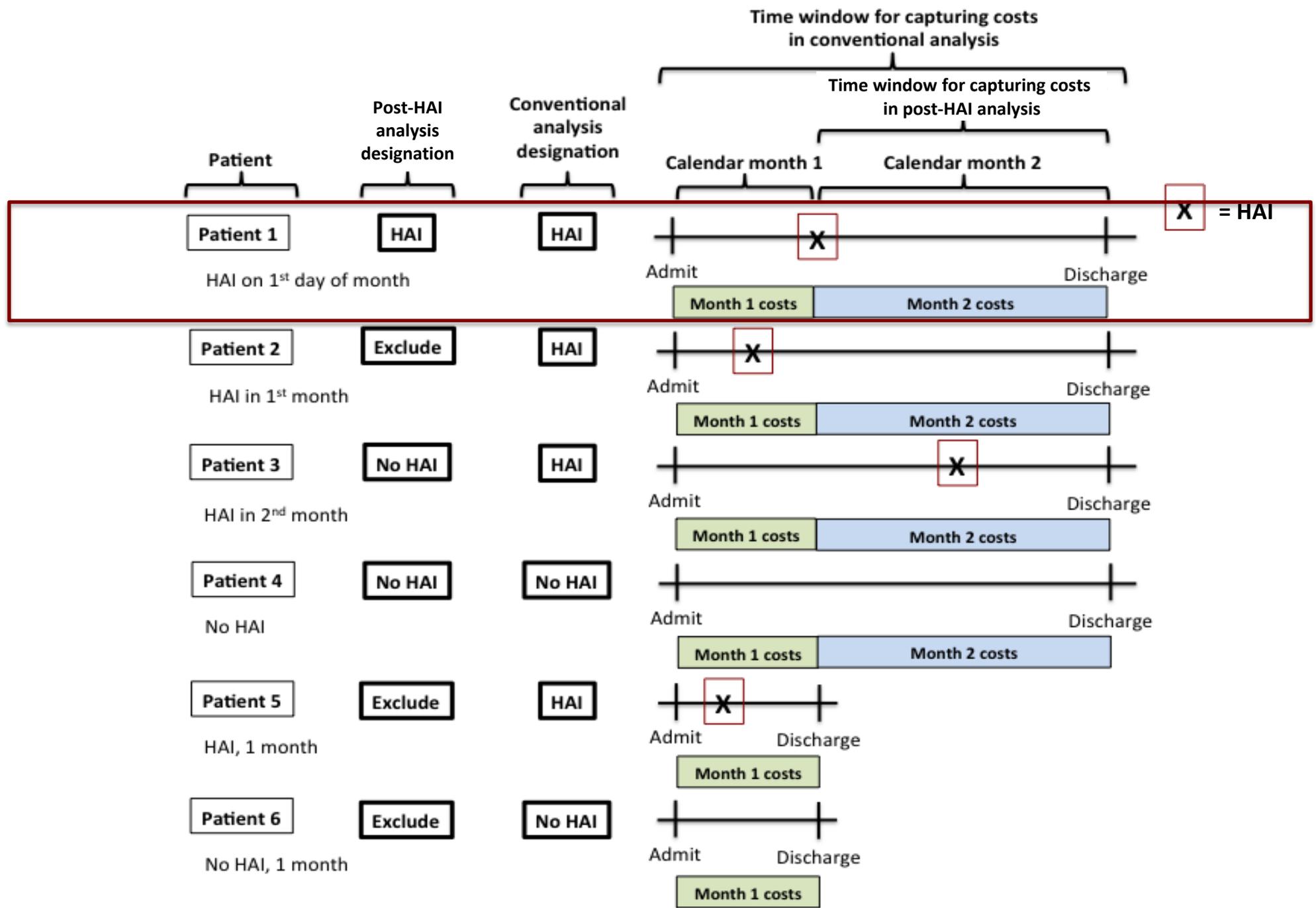
Richard E. Nelson, PhD, † Matthew H. Samore, MD,* † Makoto Jones, MD,* † Tom Greene, PhD, †
Vanessa W. Stevens, PhD,* ‡ Chuan-Fen Liu, PhD, § || Nicholas Graves, PhD, ¶
Martin F. Evans, MD, # ** and Michael A. Rubin, MD, PhD* †*

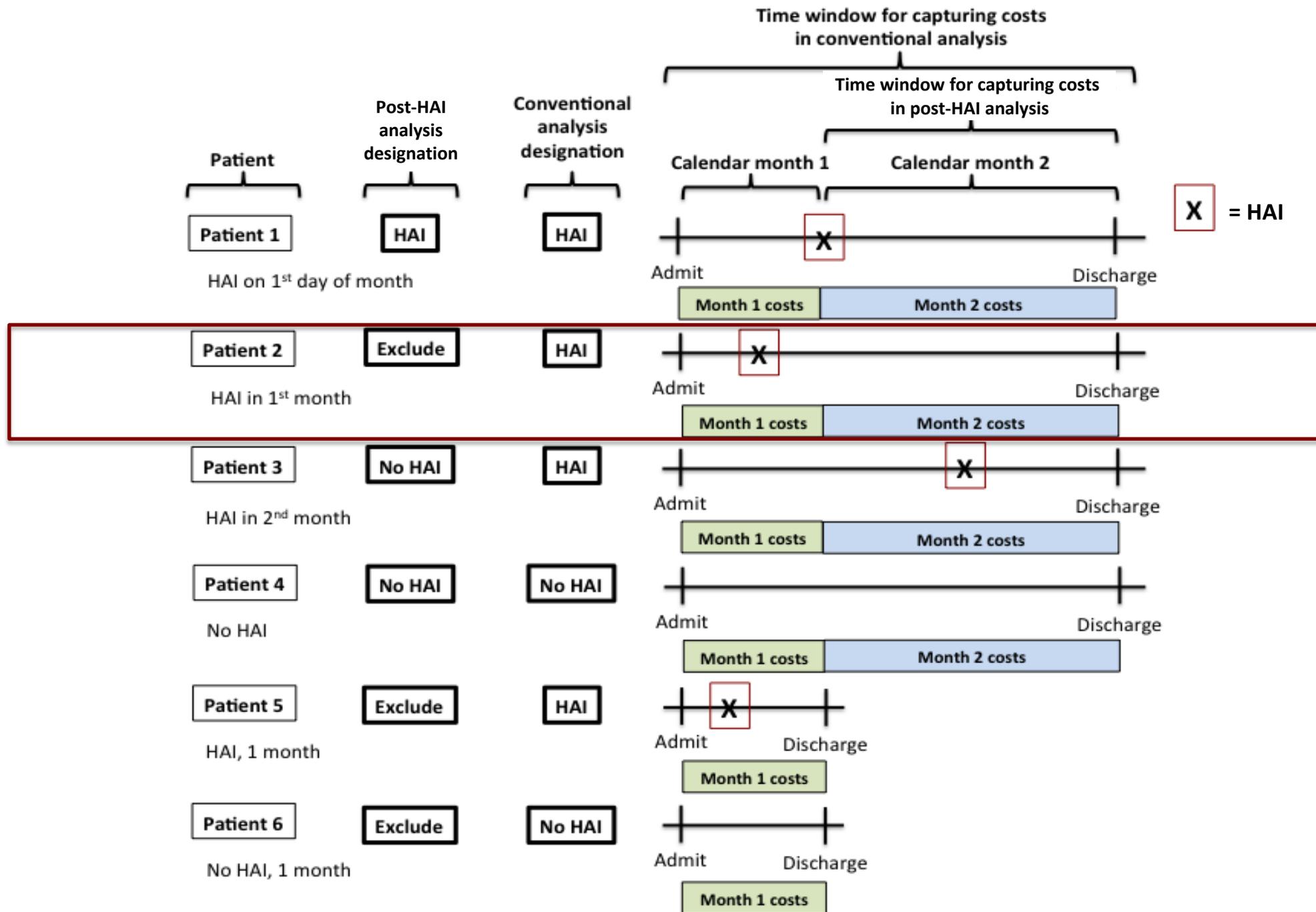
(*Med Care* 2015;53: 827–834)

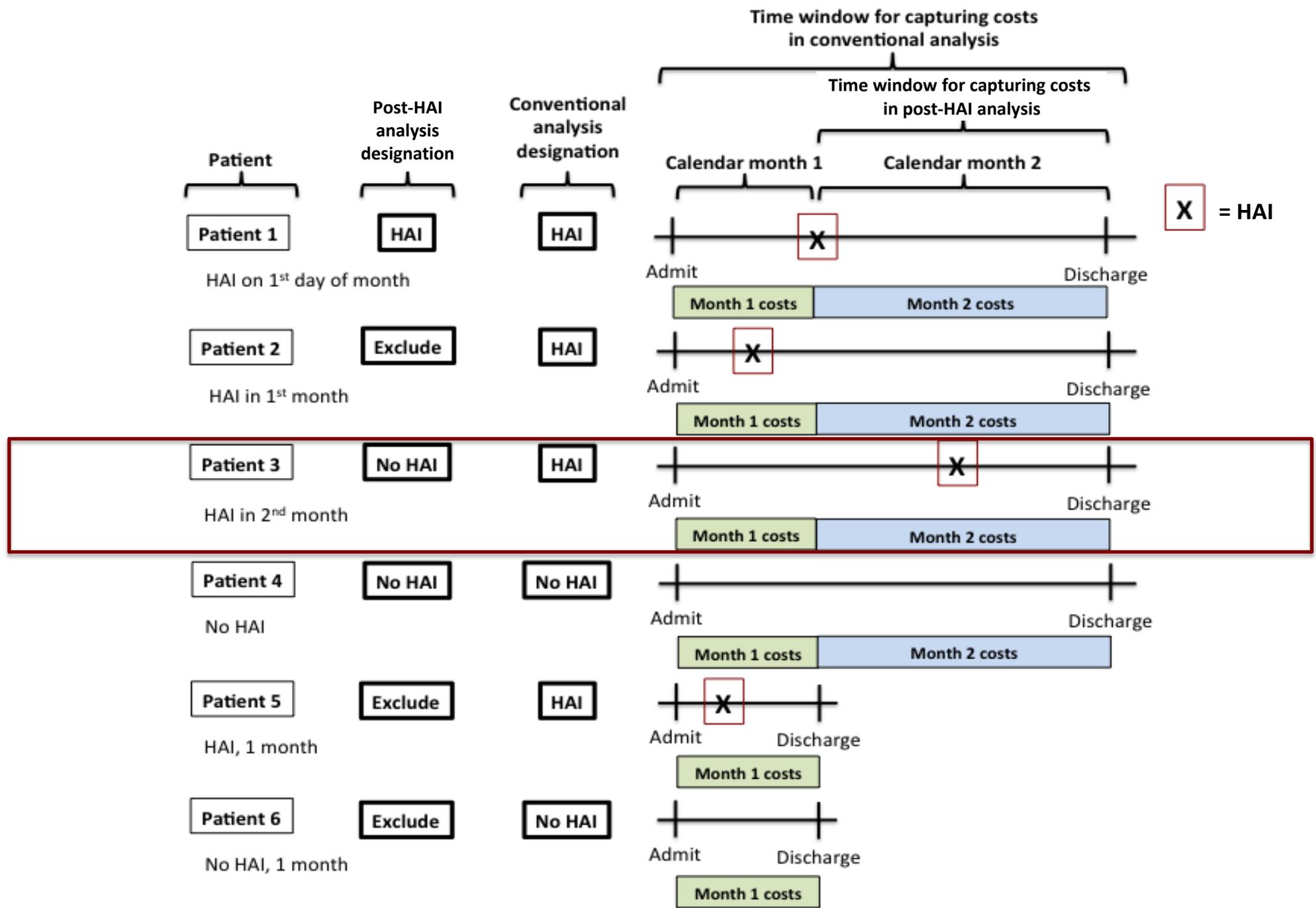


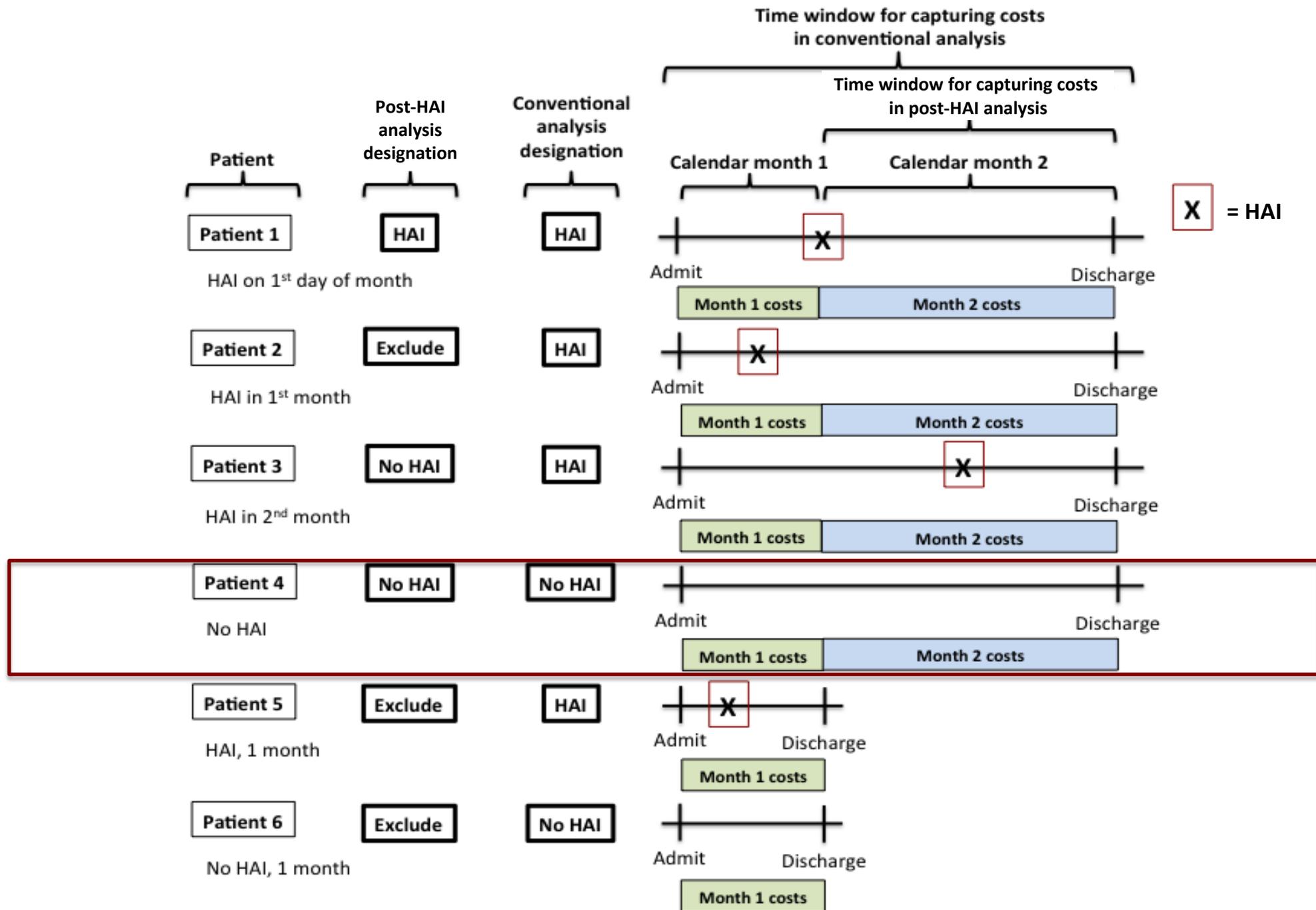
Impact of HAI on Pre-Discharge Costs

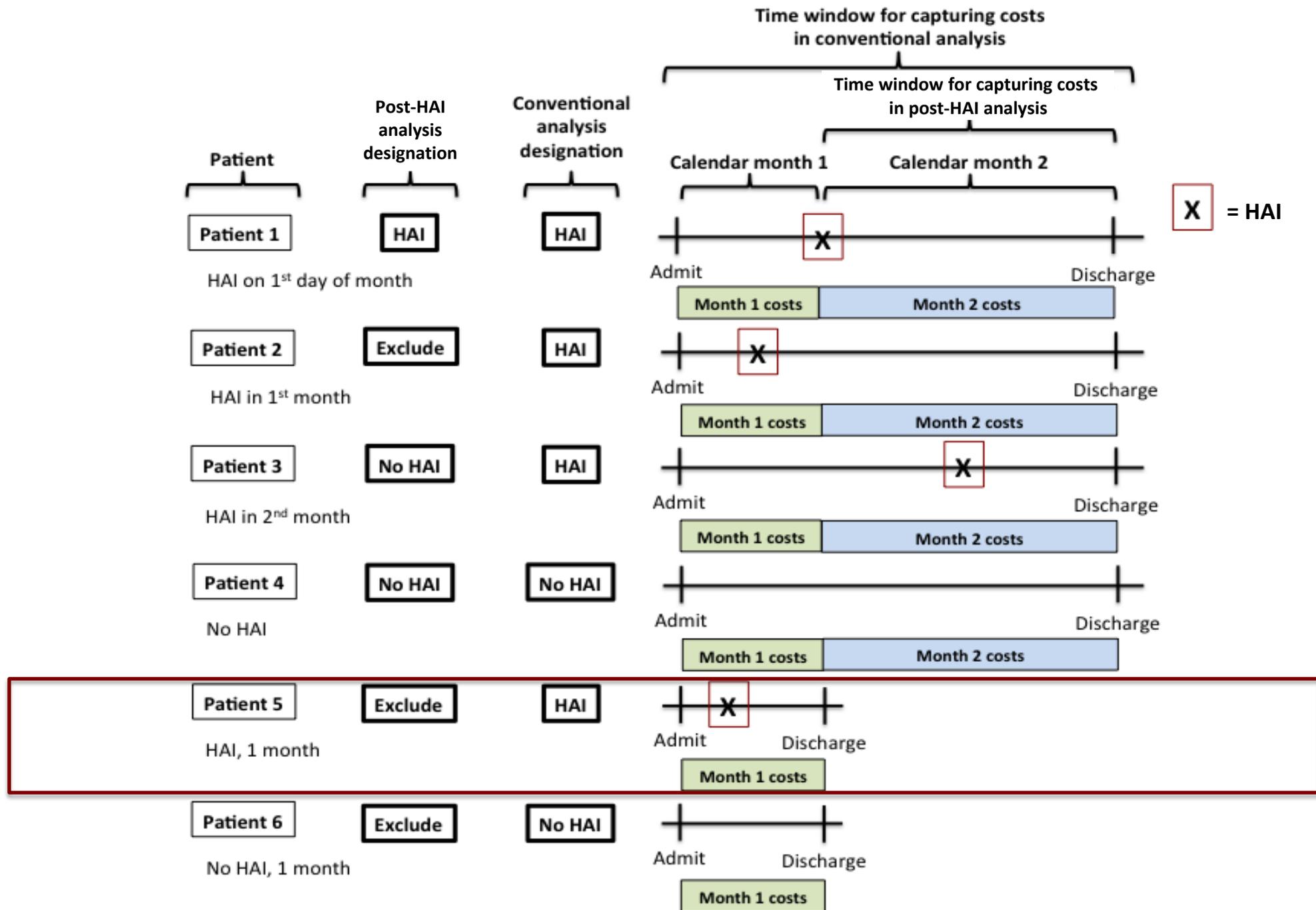
- Conventional analysis
 - Compare cost over entire LOS for patients with and without MRSA HAI
- Post-HAI analysis
 - Utilize the quirk of the MCA TRT file to identify costs occurring after MRSA HAI

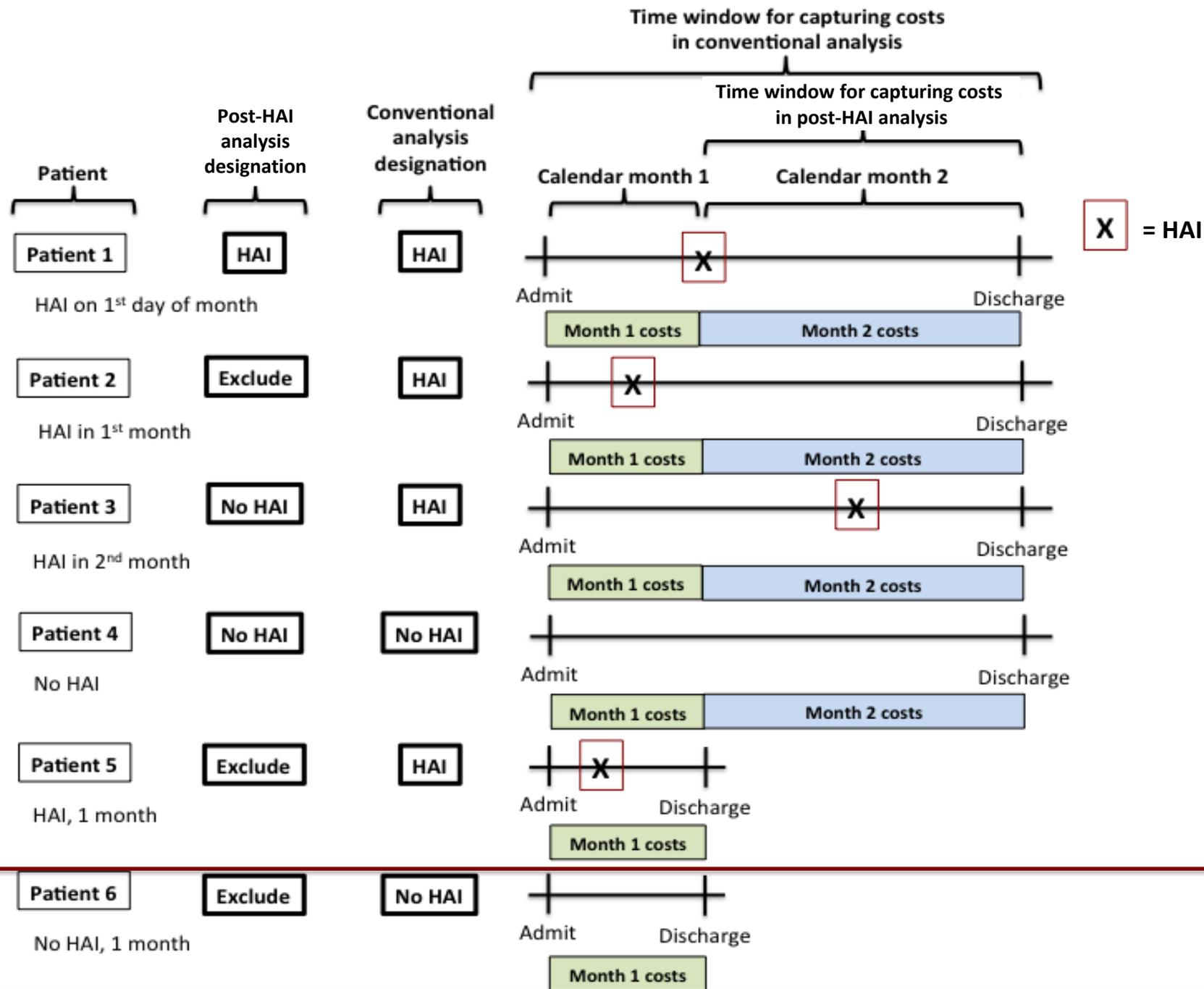












Impact of HAI on Pre-Discharge Costs

- Approximation of improved method on data more widely available
 - “Matched” method
 - If have date of HAI but not cost data that separates cost by calendar month
 - Propensity score match 4 non-MRSA HAI patients for every MRSA HAI patient
 - For each MRSA HAI patient, the potential matches were those still at risk for MRSA HAI on the day that the infected patient was infected
 - Did separate PS matching for HAIs occurring on days 3-40

Impact of HAI on Pre-Discharge Costs

- Methods
 - Dependent variables
 - Total cost
 - Variable cost
 - LOS
 - Generalized linear model (GLM)
 - Gamma distribution for costs
 - Poisson distribution for LOS

Impact of HAI on Pre-Discharge Costs

Results: Multivariable Cost Regressions

- Model = GLM, gamma/Poisson distribution, log link
- Dependent variable = inpatient cost, LOS
- Key independent variable = MRSA HAI

Variable	Post-HAI analysis ^a N=121,520			Matched analysis ^a N=12,992			Conventional analysis ^b N=386,794		
	Effect	95% CI		Effect	95% CI		Effect	95% CI	
Variable	\$12,559	\$5,903	\$19,216	\$14,393	\$12,103	\$16,684	\$16,786	\$15,999	\$17,572
Total	\$24,015	\$10,882	\$37,149	\$26,855	\$22,583	\$31,126	\$31,570	\$30,074	\$33,067
LOS	11.43	10.44	12.43	13.97	10.49	17.44	17.64	17.58	17.71

^aPost-HAI analysis regressions controlled for the following variables: demographic characteristics, comorbid conditions, surgery during 1st 48 hours, primary ICD-9 code, length of stay during 1st calendar month, and facility

^cMatched analysis regressions controlled for the following variables: demographic characteristics, comorbid conditions, surgery during 1st 48 hours, primary ICD-9 code, and facility

^cConventional method regressions controlled for the following variables: demographic characteristics, comorbid conditions, primary ICD-9 code, and facility

Impact of HAI on Pre-Discharge Costs

- Conventional analysis
 - Cost
 - 33.7% higher than post-HAI analysis
 - \$16,786 vs. \$12,559
 - LOS
 - 54.3% higher than post-HAI analysis
 - 17.64 vs. 11.43
- Matched analysis
 - Cost
 - 14.6% higher than post-HAI method
 - \$14,393 vs. \$12,559
 - LOS
 - 22.2% higher than post-HAI analysis
 - 13.97 vs. 11.43

Impact of HAI on post-discharge costs

ORIGINAL ARTICLE

**The Impact of Healthcare-Associated Methicillin-Resistant
Staphylococcus Aureus Infections on Post-Discharge Healthcare Costs
and Utilization**

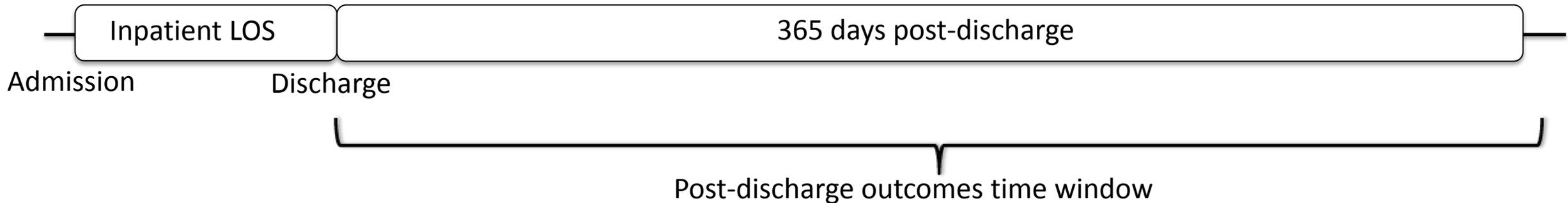
Richard E. Nelson, PhD;^{1,2} Makoto Jones, MD;^{1,2} Chuan-Fen Liu, PhD, MPH;^{3,4} Matthew H. Samore, MD;^{1,2}
Martin E. Evans, MD;^{5,6,7} Nicholas Graves, PhD;⁸ Bruce Lee, MD;⁹ Michael A. Rubin, MD, PhD^{1,2}

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Impact of HAI on post-discharge costs

- Post-discharge outcomes
 - Inpatient costs
 - Variable costs
 - Total costs
 - Outpatient costs
 - Pharmacy costs



Results – Multivariable Cost Regressions

- Model = GLM, gamma distribution, log link
- Dependent variable = cost in 365 days post-discharge
- Key independent variable = MRSA HAI

	Full cohort (N=369,743)			Propensity score matched subgroup (N=7,184)		
	Effect	95% CI		Effect	95% CI	
Outpatient	-\$487	-\$1,042	\$67	-\$435	-\$1,474	\$603
Pharmacy	\$619	\$29	\$1,209	\$1,036	\$576	\$496
Total inpatient	\$7,844	\$6,060	\$9,628	\$14,081	\$10,130	\$18,033
Variable inpatient	\$4,083	\$3,157	\$5,009	\$7,325	\$5,251	\$9,400

Note: Regression controlled for the following variables: demographic characteristics, comorbid conditions, LOS during index hospitalization, primary ICD-9 code for index hospitalization

Economic Analysis of Veterans Affairs Initiative to Prevent Methicillin-Resistant *Staphylococcus aureus* Infections

Richard E. Nelson, PhD,^{1,2} Vanessa W. Stevens, PhD,^{1,3} Karim Khader, PhD,^{1,2}
Makoto Jones, MD,^{1,2} Matthew H. Samore, MD,^{1,2} Martin E. Evans, MD,^{4,5,6}
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Eli L. Perencevich, MD,^{8,9} Michael A. Rubin, MD, PhD^{1,2}

Am J Prev Med 2016;50(5S1):S58-S65

AMERICAN JOURNAL OF
Preventive Medicine

A Journal of the American College of Preventive Medicine and Association for Prevention Teaching and Research

Objective

- The objective of this study was to conduct both a budget impact analysis and a cost-effectiveness analysis of the VA MRSA Prevention Initiative for FY2008-FY2010
 - In order to provide feedback to the VA
 - To give insight to other healthcare systems considering widespread adoption of similar infection control interventions

Background

- Cost-effectiveness analysis
 - Common analytic tool used to evaluate the economic costs and clinical benefits of two or more strategies
 - Examine the trade-off between costs and benefits a per-patient level
- $$ICER = \frac{Cost_A - Cost_B}{Effectiveness_A - Effectiveness_B}$$
- Budget impact analysis
 - Complementary to but slightly different from CEAs
 - Designed to examine the expected expenditures a healthcare system might face after implementation of a new intervention

Methods

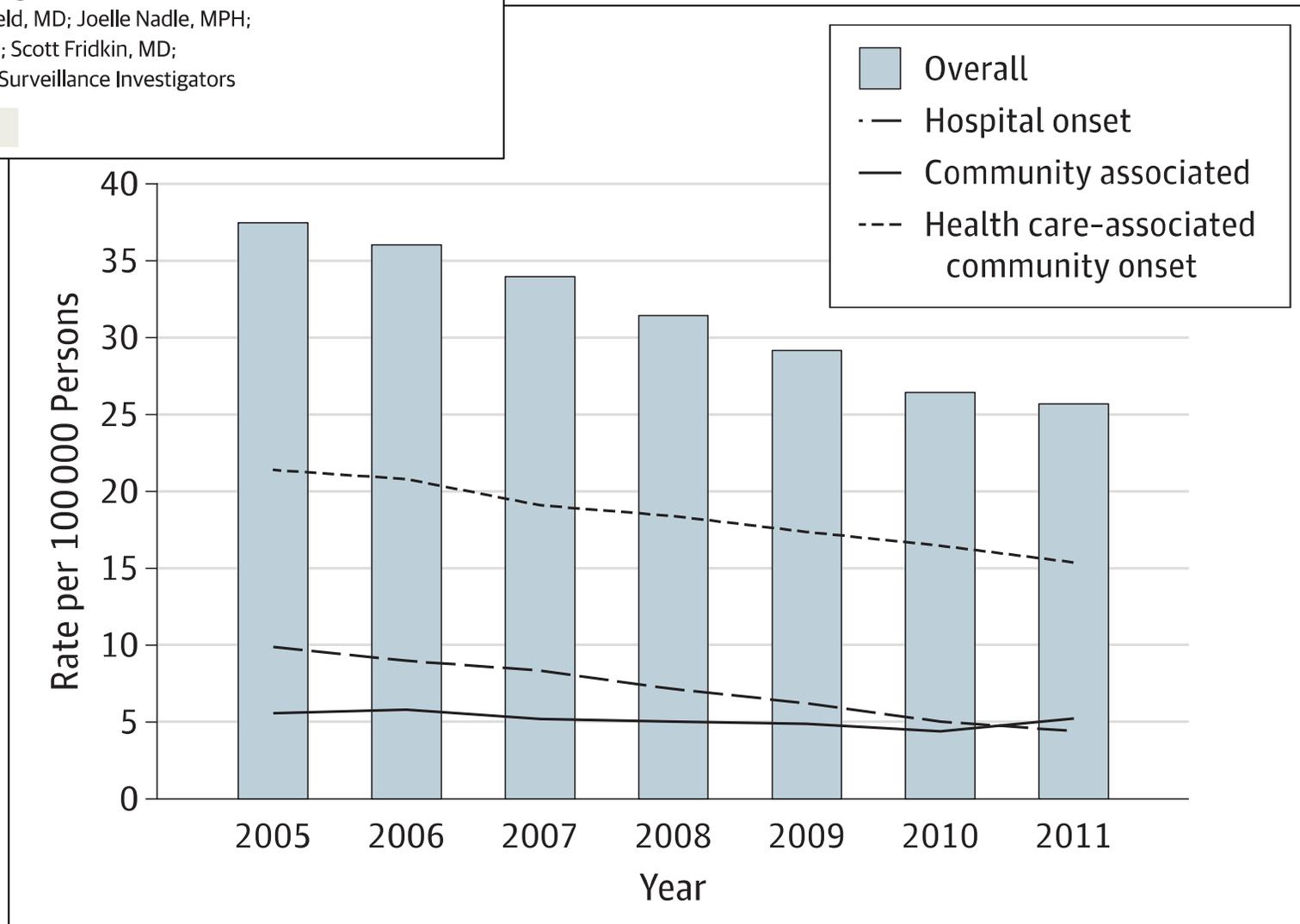
- Observed rate of MRSA HAIs
 - Jain (2011) *NEJM*
- Counterfactual rate of MRSA HAIs in absence of MRSA HAI initiative
 - Two different assumptions

Original Investigation

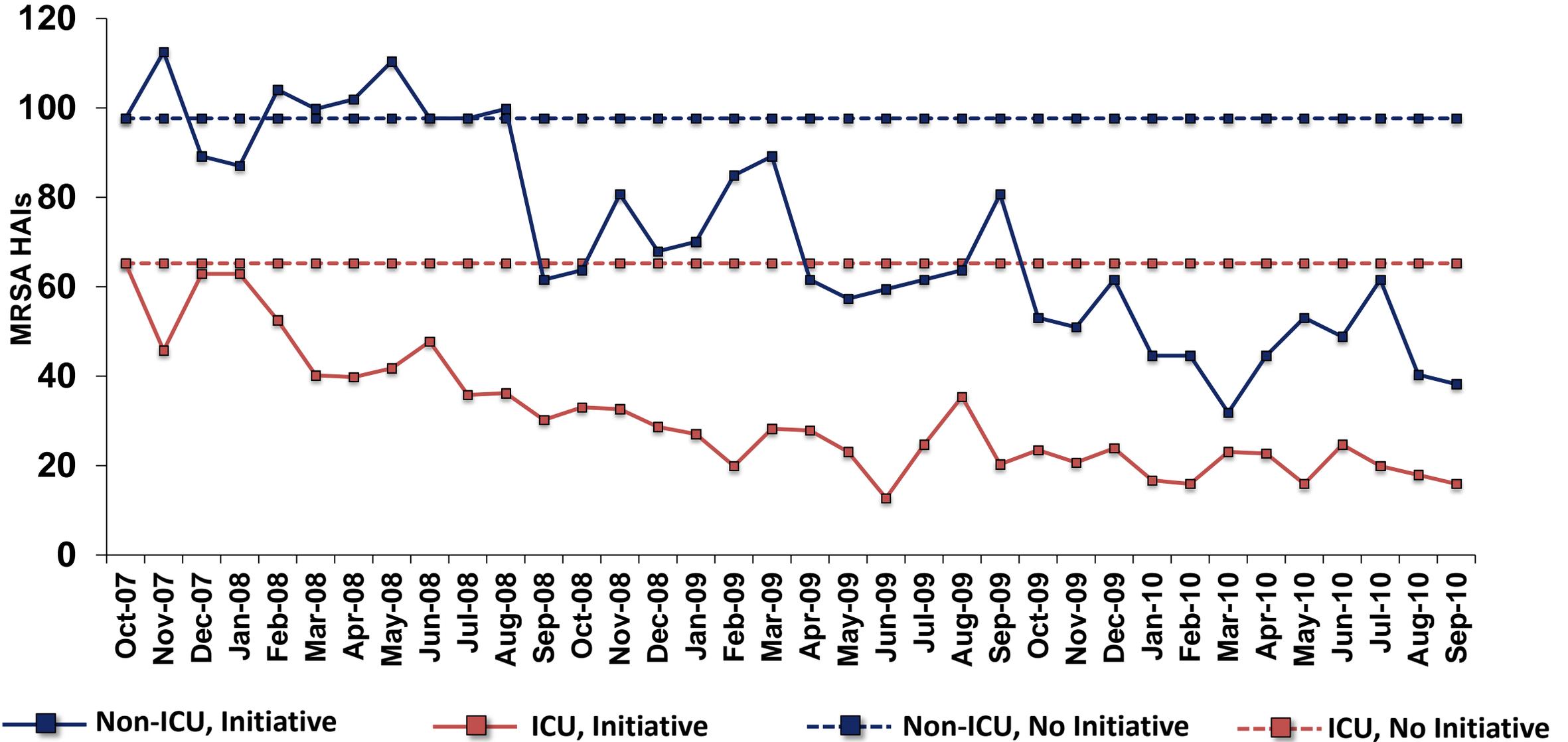
National Burden of Invasive Methicillin-Resistant *Staphylococcus aureus* Infections, United States, 2011

Raymund Dantes, MD, MPH; Yi Mu, PhD; Ruth Belflower, RN, MPH; Deborah Aragon, MSPH;
Ghinwa Dumyati, MD; Lee H. Harrison, MD; Fernanda C. Lessa, MD; Ruth Lynfield, MD; Joelle Nadle, MPH;
Susan Petit, MPH; Susan M. Ray, MD; William Schaffner, MD; John Townes, MD; Scott Fridkin, MD;
for the Emerging Infections Program-Active Bacterial Core Surveillance MRSA Surveillance Investigators

JAMA Intern Med. 2013;173(21):1970-1978. doi:10.1001/jamainternmed.2013.10423

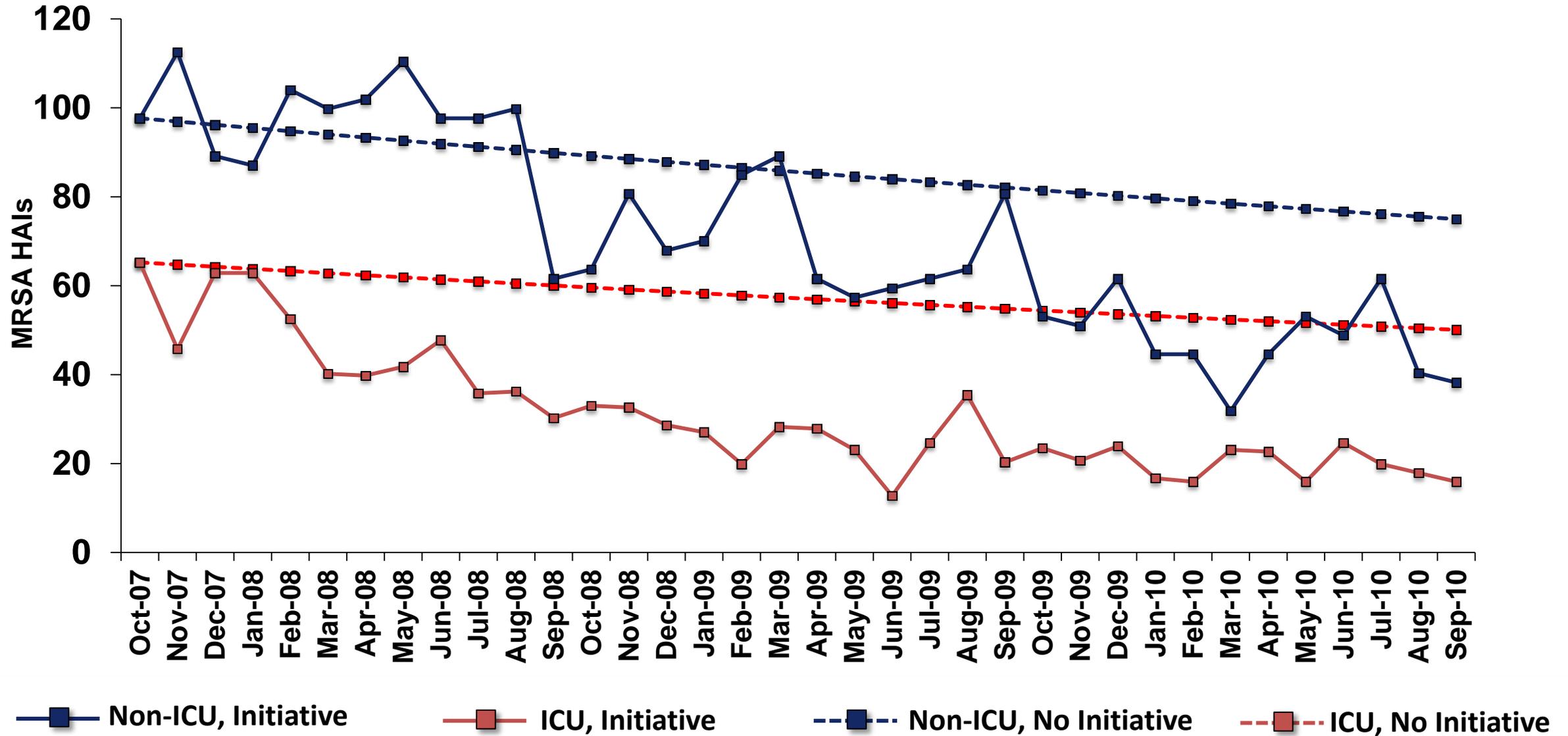


Assumption 1 Straight line



Assumption 2

Downward trend



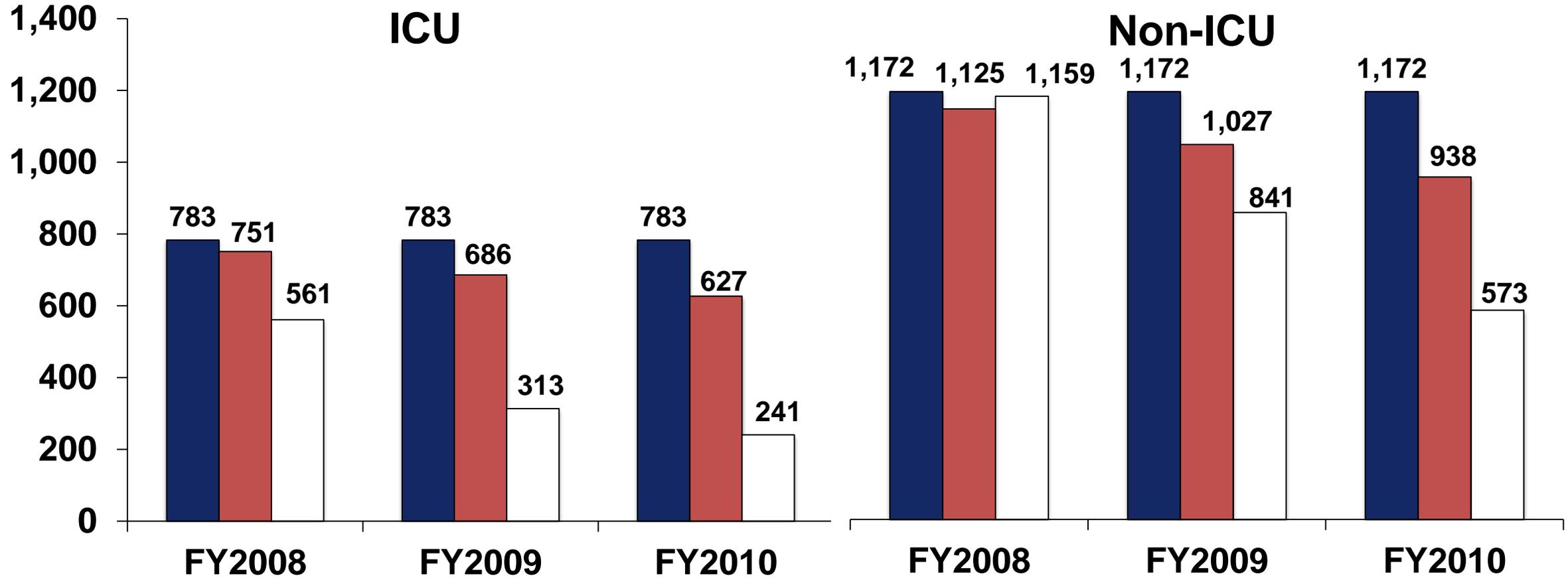
Input parameters

- Costs
 - MRSA HAIs
 - Pre-discharge
 - Post-discharge
 - Intervention
 - Screening tests
 - Gloves and gowns
 - MRSA Prevention Coordinator
 - Laboratory technician
 - Educational materials
- Effectiveness
 - Attributable mortality due to MRSA HAIs

Results

Results

Number of MRSA HAIs with and without Initiative



No MRSA Prevention Initiative
Straight-line assumption



No MRSA Prevention Initiative
Downward trend assumption

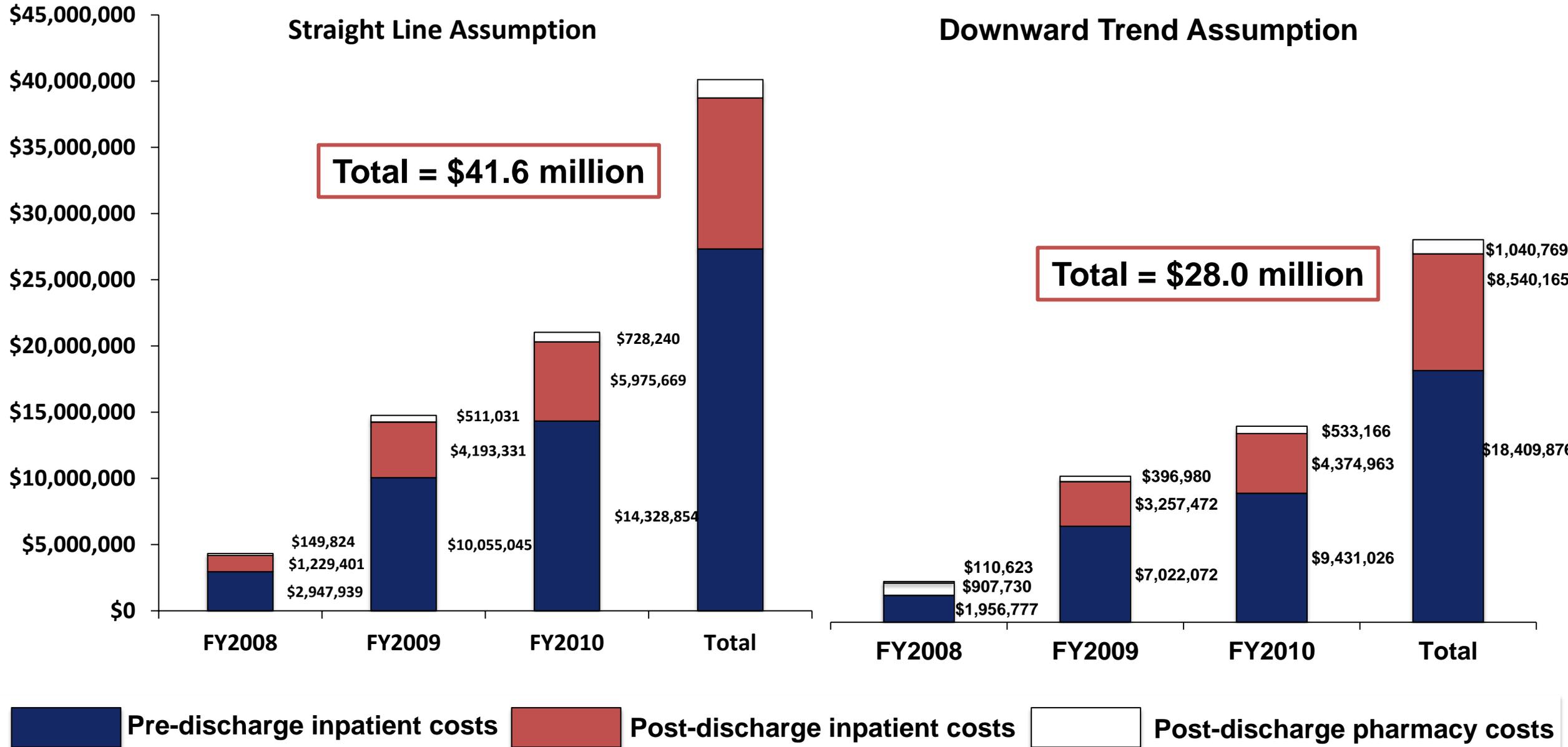


MRSA Prevention Initiative

Cost savings due to MRSA HAIs prevented

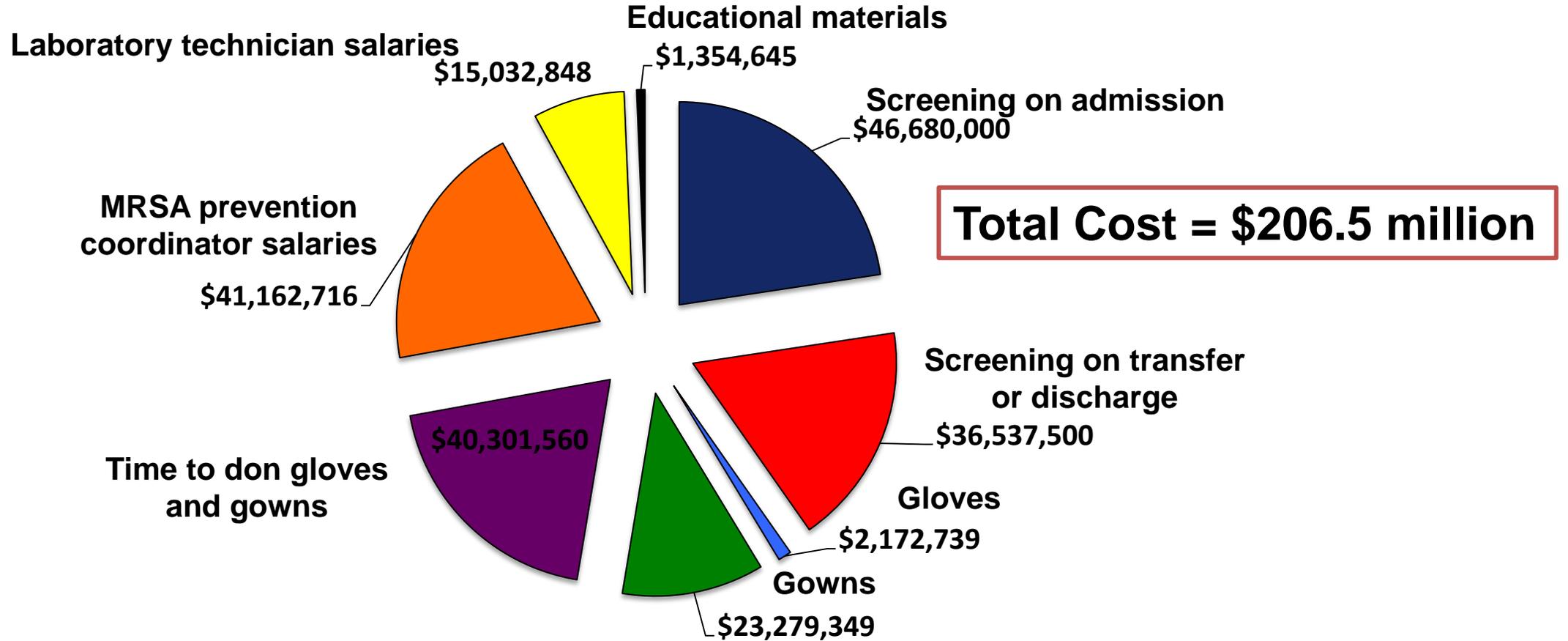
Straight Line Assumption

Downward Trend Assumption



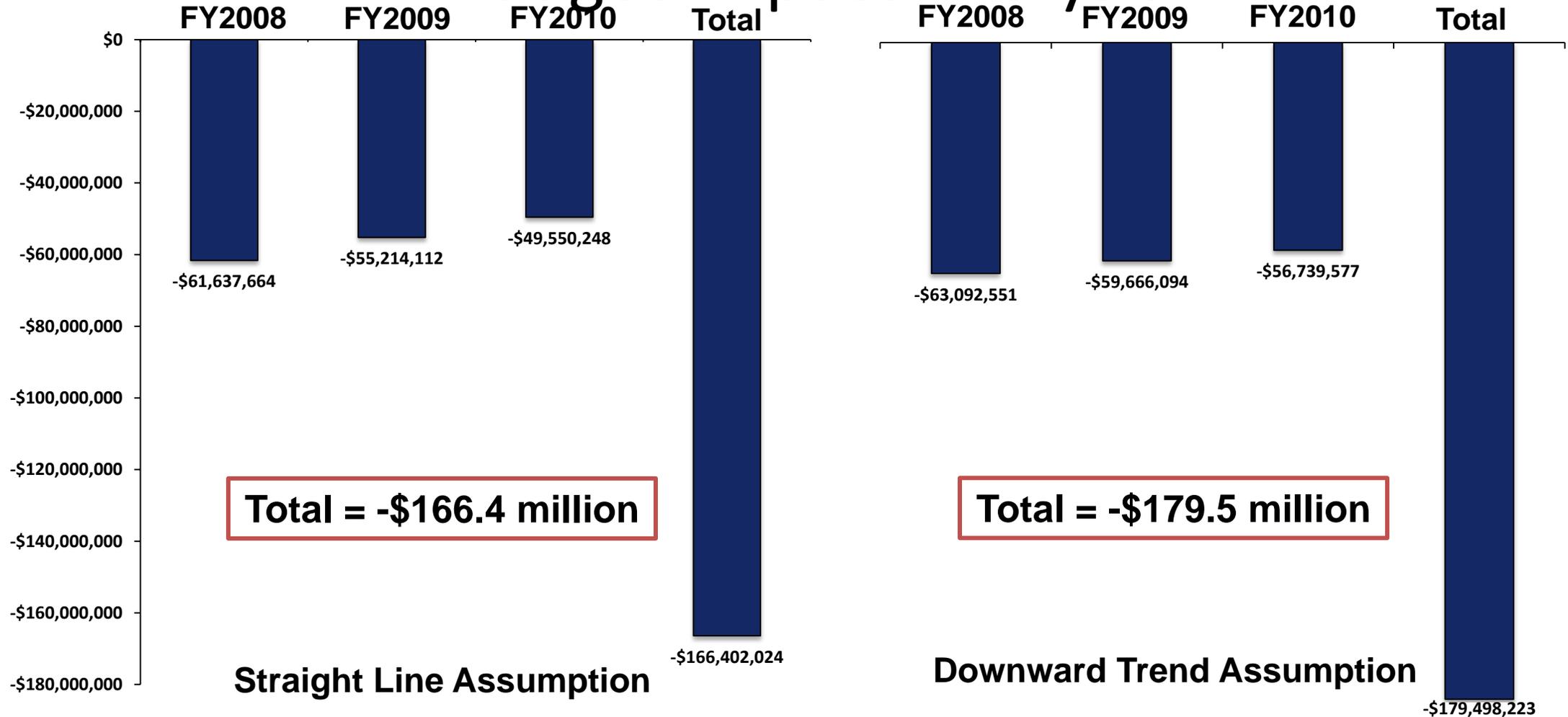
Results

VA MRSA Prevention Initiative expenses



Results

Budget Impact Analysis



Results

Cost-Effectiveness Analysis

Year	Incremental Cost (\$)	Incremental Effectiveness (LYs)	ICER (\$/LY)
<i>Straight line assumption</i>			
FY2008	\$61,637,664	504.8	\$122,114
FY2009	\$55,214,112	1,721.7	\$32,070
FY2010	\$49,550,248	2,453.4	\$20,196
Total	\$166,402,204	4,679.8	\$35,557
<i>Downward trend assumption</i>			
FY2008	\$63,092,551	335.0	\$188,310
FY2009	\$59,666,094	1,202.3	\$49,625
FY2010	\$56,739,577	1,614.8	\$35,137
Total	\$179,498,223	3,152.2	\$56,944

Note: ICER = Incremental cost-effectiveness ratio

Conclusions

- VA data
 - Improved estimates of consequences of MRSA HAIs
- Rigorous economic evaluation of MRSA Prevention Initiative
- Useful information for decision makers

Questions/Comments?

Contact Information

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