Healthcare Quality Reporting Program

HOSPITAL-ACQUIRED INFECTIONS AND PREVENTION ADVISORY SUBCOMMITTEE

8:00-9:00am, April 25, 2011
Department of Health, Room 401

Goals/Objectives
▪ To discuss HAI work to date and make policy recommendations for pending and upcoming reports

Members					
T	Nicole Alexander, MD	G	Maureen Marsella, RN, BS	T	Janet Robinson, RN, Med, CIC
T	Rosa Baier, MPH	T	Linda McDonald, RN	G	Melinda Thomas
G	Utpala Bandy, MD	T	Leonard Mermel, DO, ScM	T	Dawn Trudeau, RN (*rep*)
T	Margaret Cornell, MS, RN	T	Pat Mastors	T	Georgette Uttley, MEd, BSN, RN
T	Marlene Fishman, MPH, CIC	T	Robin Neale, MT (ASCP), SM,CIC	T	Nancy Vallande, MSM, MT, CIC
T	Jongwen Jiang	T	Kathleen O'Connell, RN	G	Cindy Vanner
G	Julie Jefferson, RN, MPH, CIC	G	Lee Ann Quinn, RN, BS, CIC	T	Samara Viner-Brown, MS

Time	Topic/Notes

8:00am **Welcome & Administrative Updates**
Leonard Mermel, DO, ScM

- Len opened the meeting and reviewed today's objectives, which included voting on recommendations to the Steering Committee regarding ICU vs. hospital data displays for CLABSI and MRSA CLABSI.
- Rosa reviewed the previous meeting's action items*:*
  - **Add *C. difficile* calculation to the measure sheet** (Julie/ICP SNE group) – Pending

    Julie is finalizing the measure sheet.
  - **Incorporate feedback into the report templates** (Rachel/Rosa) – Complete

    Rachel incorporated the group's edits into the reports. Finalizing the report templates is dependent on today's SIR discussion (ICU or facility-level data for MRSA CLABSI), but the reports will be ready for MRSA CLABSI data ahead of the May deadline for Q2 2011 submission.
  - **Follow-up re: conferred rights for MRSA CLABSI** (Maureen) – Pending

    Maureen's follow-up is ongoing and dependent on information from the CDC, but she believes she will be able to access MRSA CLABSI (once data are entered) by the end of this year using conferred rights. This may be preferable to a data use agreement between the hospitals and HEALTH, since the DUA includes some restrictions that could affect reporting.

Nancy suggested that the Subcommittee use the ICP SNE group's grid (created by Julie and Liz) to document agreed-upon decisions regarding NHSN, conferring rights, etc.

- **Discuss SIR methodology at the April meeting** (Rosa) – Complete

  Rachel and Rosa are presenting on SIRs today.

- **Share the Birnbaum article with the group** (Len/Rosa) – Complete

  Rosa shared the article from Len with the previous meeting's minutes.

8:05am **Standardized Incidence Ratios (SIRs)**
Rachel Voss, MPH
Rosa Baier, MPH

- Rachel and Rosa presented on the SIR methodology (see handout), focusing on:

  - Purpose

    SIRs standardize incidence relative to 1.0, controlling for patient risk and allowing easy comparison between ICUs or hospitals. This is helpful because raw incidence rates may not allow direct comparison between locations with different risks and because incidence may not be easily interpreted by a lay audience.

  - Calculation

    SIRs use benchmarks to determine the number of "expected" cases in a particular location, like an ICU, if that location had the same rate of cases per patient-days as the benchmark:

    Expected cases = (benchmark rate x number of patient-days)

    The SIR formula is:

    SIR = (observed cases/expected cases)

    To account for variability, the diamonds are based on both SIR and 90% confidence intervals (CIs). To be classified as "better" (◆◆◆) or "worse" (◆) than expected, the SIR's CI must not overlap 1.0. This means that the public reports use a very conservative method for flagging providers as better or worse; most facilities will be considered "about the same" as expected (◆◆).

  - Use at ICU- and facility-level

    SIRs are scalable and can be calculated for like units (e.g., ICUs of the same type) or facilities. Previously, the Subcommittee used them at the ICU level for CLABSI reporting. Today's discussion focused on CLABSI, MRSA CLABSI, and *C. difficile* reporting recommendations.

- Discussion focused on whether to use SIRs to calculate diamonds by ICU or by facility (i.e., all ICUs aggregated into one score) and whether to calculate four-quarter rolling averages or continue to use single quarters. Quarterly reports may be more useful for internal QI and allow facilities to see changes more quickly. Rolling averages could provide more stable (less variability) results and, per Stefan, account for seasonal variation, but the use of 90% confidence intervals (CIs) adjusts for variability and rolling averages may be more difficult to data-check.

- Gina also inquired about the use of 90% vs. 95% CIs. Although 95% CIs are more conservative (resulting in more two-diamond scores), when calculating the first CLABSI report, the analysts tried both methods and the diamond assignments did not change.

- **Votes**: The Subcommittee voted to:
  - Continue to report CLABSI as-is (i.e., by ICU, rather than by facility or as rolling averages) (Yes – 12, No – 0, Abstain – 3).
  - Report both MRSA and MRSA CLABSI by ICU (By ICU – 7; by facility – 0; by facility with link to Methods – 6; abstain – 3).
  - Some meeting participants indicated that they voted to report by ICUs because they were unaware what reporting by facility would look like on the public reports. Marlene suggested reviewing mock reports (with dummy data), so Rachel and Rosa will create mock-ups for Subcommittee members to vote on via email prior to the next meeting. MRSA CLABSI data are due before the 5/23 meeting, so if the group has voted in the interim, the analysts should be able to populate the preview reports for that meeting.

8:45am **Data Submission for CLABSI, MRSA CLABSI, *C. difficile***
Rachel Voss, MPH
Rosa Baier, MPH

- Rosa quickly reviewed the current data submission mechanisms:

Topic	Submitted to:
CLABSI - Adult ICUs	ICU Collaborative
CLABSI - PICU and NICU	Ria Mehta (email)
MRSA CLABSI	NHSN (planned, but proxy rights not conferred)
C. difficile	NHSN (planned, but NSHN not ready for submission)

- Data submission:

  Since NHSN is not yet ready for MRSA CLABSI or C. difficile data submission, Rosa asked the group to review a draft "survey" to collect data on a quarterly basis. Hospitals would be able to use the same link every quarter for all three topics (CLABSI, MRSA CLABSI, and *C. difficile*).

- Reminders:
  - MRSA CLABSI – Q1 2011 data due 5/12
  - *C. difficile* – Q2 2011 pilot ongoing

8:55am **Action Items & Next Steps**
Rosa Baier, MPH

- **Action items**:
  - Verify the use of 90% vs. 95% CIs (Rachel/Blake)
  - Create mock-up data reports by ICU and facility (Rosa/Rachel)
  - Vote on mock-up data reports (Voting Members)
  - Provide Rosa with feedback on the data submission template by 5/4 (All)
- Next meeting: 5/23/11

Standardized Incidence Ratios (SIRs)

Rachel Voss, MPH
Rosa Baier, MPH

HAI Subcommittee, 4/25

Discussion Topics

Questions:

- How do we calculate incidence?
- How do SIRs help understand incidence?
- How do you compare incidence across facilities?
  - ICU-level or facility-level?
  - What is valid using SIRs?
  - ***What is useful for consumers?***
- If we report at the facility-level, how are ICU data aggregated to one score, then diamonds?

Incidence

- The number of new (hospital-acquired) cases of an infection within a certain population over a certain period of time

  Incidence = cases ÷ line days x 1,000

- *Example*:

  CLABSI infections in Med/Surg ICUs

ICU	Cases	Line Days	Rate
Med/Surg ICU A	3	627	4.78

- Useful to evaluate prevention efforts

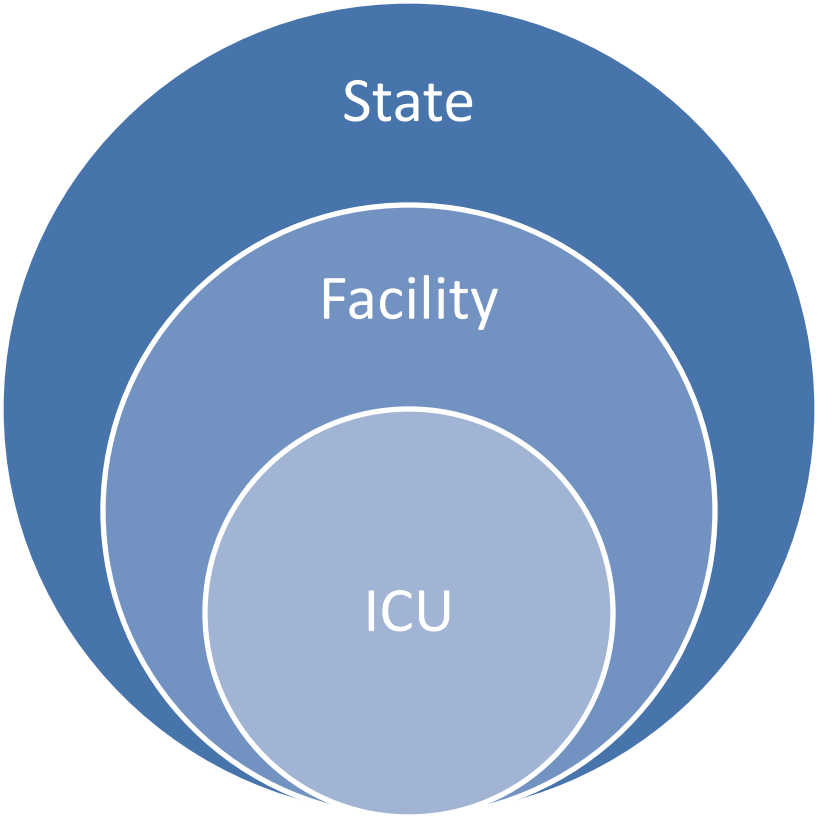
SIRs

- Often rare occurrences (few cases), with rates that vary based on casemix
- Need to compare rates from a subgroup to the entire population
  - Similar risk (conditions, severity, LOS, etc.)
- *Example*:

ICU	Cases	Line-Days	Rate
Med/Surg ICU A	3	627	4.78
Med/Surg ICU B	5	894	5.59

SIRs, Cont'd

- **Scalable metric**: Can validly measure HAI experience over different aggregation levels:
  - Single location
  - Multiple locations that comprise a larger entity
    - ICU, facility, or state



Source: Laura McAllister, CDC, 3/3/11

ICU-Level SIRs

- Even among units of the same type, raw incidence rates may not be meaningful
  - Differences in unit size and LOS (risk)
- *Example*:

  Q: Is ICU A outperforming ICU B?

ICU	Cases	Line-Days	Rate
Med/Surg ICU A	3	627	4.78
Med/Surg ICU B	5	894	5.59

ICU-Level SIRs, Cont'd

- SIRs allow easy comparison of like ICUs
  - Adjusts for unit differences (risk)
  - SIR = (observed cases ÷ expected cases)
  - Expected cases can be derived from state or national rates, as long they are the same overall population
- *Example*:

ICU	Cases	Line-Days	Rate	NHSN Rate	Expected Cases	SIR
Med/Surg ICU A	3	627	4.78	2.00	1.254	2.39
Med/Surg ICU B	5	894	5.59		1.788	2.80

"CLABSI incidence in ICU A is 139% higher than expected; ICU B is 180% higher."

ICU-Level Confidence Intervals (CIs)

- Example:

ICU	SIR	90% CI
Med/Surg ICU A	2.39	0.65–6.2
Med/Surg ICU B	2.80	1.1–5.9

- Q: Are these SIRs meaningfully different?

  >1.0 = Worse than expected

  =1.0 = Same as expected

  <1.0 = Better than expected

- A: ICU A is the same as expected; ICU B is worse.

ICU-Level Diamonds

- Example:

ICU	SIR	90% CI
Med/Surg ICU A	2.39	0.65–6.2
Med/Surg ICU B	2.80	1.1–5.9

"The confidence interval for the CLABSI SIR in ICU A includes 1.0 and is about the same as expected; in ICU B, it does not include 1.0, so it is worse than expected."

vs.

ICU	SIR	90% CI	Diamonds
Med/Surg ICU A	2.39	0.65–6.2	◆◆
Med/Surg ICU B	2.80	1.1–5.9	◆

- ***Helps consumers interpret data*** (cognitive science)

Facility-Level SIRs

- Summarize data across locations
  - SIR = (sum observed cases ÷ sum expected cases)
- Example:

Hospital A	Cases	Line-Days	NHSN	Expected	*Overall SIR*
Med/Surg ICU	3	627	2.00	1.254	*2.10*
Coronary ICU	0	82	2.10	0.1722	
Total	*3*	-	-	*1.4262*	

Hospital B	Cases	Line-Days	NHSN	Expected	*Overall SIR*
Med/Surg ICU	5	894	2.00	1.788	*0.77*
Step-down	0	227	2.40	5.448	
Surg CardioTx	1	425	1.40	0.595	
Total	*6*	-	-	*7.831*	

Facility-Level SIRs, Cont'd

- Valid because uses appropriate rates for each location type to calculate expected cases*
  - Calculate SIR for each unit before "rolling up"
  - Describes overall experience of a given entity
  - Accounts for differences in HAI risk among units
- Useful to evaluate overall facility performance (internal QI)
- ***Consumer friendly***

*Source: Laura McAllister, CDC, 3/3/11

Facility-Level CIs

- Calculated in same way as individual ICUs
- Example:

	Total Cases	*Overall SIR*	CI	Diamonds
Hospital A	3	2.10	0.57 – 5.42	◆◆
Hospital B	6	0.77	0.33 – 1.52	◆◆

Shows consumers that Hospitals A's and B's CLABSI rates are not meaningfully different from what's expected, despite differences in the incidence rates and SIRs.

Additional Information

- NHSN issue brief: https://www.gha.org/pha/Provider/tips/ProviderRes/NHSNStandardizedInfectionRatio111610.pdf

Department of Health - CLABSI MRSA Data Submission

Welcome

This is the hospital data submission form for the Department of Health's mandate to publicly report MRSA CLABSI data. Data are due 6 weeks after each quarter, beginning with Q1 2011 (due 5/15/11). Please reuse this same link and form to submit your data every quarter.

Please note: Data submitted after the deadline will be incorporated into the public report, but not the preview report shared in advance with each hospital. If you submit data more than once for the same quarter, we will use the data submitted most recently.

With questions, please contact Ria Mehta, data analyst for the Healthcare Quality Reporting Program.

Demographics

* Please provide the following information:

Name:

Title:

Hospital:

Preferred email:

Preferred phone:

What quarter of data are you submitting?

* Does your facility have adult ICUs?

- No
- Yes

Adult ICUs and PICU

Adult Step-Down Units (Post-Critical Care)

Numerator:

Denominator:

Indicate n/a if not applicable:

Coronary Critical Care Units (CCUs)

Numerator:

Denominator:

Indicate n/a if not applicable:

Medical Intensive Care Units (MICUs)

Numerator:

Denominator:

Indicate n/a if not applicable:

Department of Health - CLABSI MRSA Data Submission

Medical/Surgical Critical Care Units (ICUs) at Major Teaching Hospitals

Numerator:

Denominator:

Indicate n/a if not applicable:

Medical/Surgical Critical Care Units (ICUs) at All Other (Non-Teaching) Hospitals

Numerator:

Denominator:

Indicate n/a if not applicable:

Neurosurgical Intensive Care Units (INCs)

Numerator:

Denominator:

Indicate n/a if not applicable:

Respiratory Intermediate Care Units (RICUs)

Numerator:

Denominator:

Indicate n/a if not applicable:

Respiratory Intermediate Care Units (RICUs)

Numerator:

Denominator:

Indicate n/a if not applicable:

Surgical Intensive Care Units (SICUs)

Numerator:

Denominator:

Indicate n/a if not applicable:

Surgical Cardiothoracic Critical Care Units

Numerator:

Denominator:

Indicate n/a if not applicable:

Trauma Intensive Care Units (TICUs)

Numerator:

Denominator:

Indicate n/a if not applicable:

* Does your hospital have a PICU or NICU?

- ◯ No
- ◯ Yes

Department of Health - CLABSI MRSA Data Submission

PICU and NICU

The following data fields are limited to Rhode Island Hospital (PICU) and Women & Infants' Hospital (NICU). If an ICU does not apply to your facility, please skip that data field.

Pediatric Medical/Surgical Intensive Care Units (PICUs)

Numerator:

Denominator:

Indicate n/a if not applicable:

Level III Neonatal Intensive Care Units (NICU): <750 grams

Numerator:

Denominator:

Indicate n/a if not applicable:

Level III NICU: 751-1,000 grams

Numerator:

Denominator:

Indicate n/a if not applicable:

Level III NICU: 1,001-1,500 grams

Numerator:

Denominator:

Indicate n/a if not applicable:

Level III NICU: >2,500 grams

Numerator:

Denominator:

Indicate n/a if not applicable:

Level III NICU: >2,500 grams

Numerator:

Denominator:

Indicate n/a if not applicable:

Thank You

Please provide any comments.

Thank you. If you would like confirmation of your data submission, please print this screen and retain a copy for your files.

If you have any questions about MRSA CLABSI reporting, please contact Ria Mehta, data analyst for the Healthcare Quality Reporting Program.

SHEA 2011 ANNUAL SCIENTIFIC MEETING
APRIL 1-4 DALLAS, TEXAS
Innovative research and best practices: driving better outcomes through the science of healthcare epidemiology

154 New York State Department of Health: Mandatory Reporting of Clostridium difficile via National Healthcare Safety Network LabID Event – Survey to Determine Testing Methods and Policies

Saturday, April 2, 2011
Trinity Ballroom (Hilton Anatole)

Kathleen A. Gase *, New York State Department of Health, Albany, NY*
KuangNan Xiong , New York State Department of Health, Albany, NY
Johanna B. Lee , New York State Department of Health, Albany, NY
Valerie Haley , New York State Department of Health, Albany, NY
Boldt Tserenpuntsag , New York State Department of Health, Albany, NY
Diana Doughty , New York State Department of Health, Albany, NY
Peggy Hazamy , New York State Department of Health, Albany, NY
Rachel L. Stricof , New York State Department of Health, Albany, NY
Marie Tsivitis , New York State Department of Health, Albany, NY
Victor Tucci , New York State Department of Health, Albany, NY
Carole Van Antwerpen , New York State Department of Health, Albany, NY

Background:

In 2009, the Center for Disease Control (CDC) introduced a module in the National Healthcare Safety Network (NHSN) allowing reporting of *Clostridium difficile* (*C. diff*). Beginning July 1, 2009, New York State (NYS) began using the LabID Event reporting function to report facility-wide *C. diff* at all NYS hospitals as part of the mandatory public reporting law. Data collected in 2009 will be used as pilot data and will not be reported to the public.

Objective:

Collect baseline data regarding laboratory testing policies and testing methods used by NYS facilities to diagnose *C. diff.*

Methods:

In May 2010, an on-line Survey Monkey tool was developed and sent to 179 NYS facilities reporting *C. diff* LabID Events to assess testing policies and methods. All surveys were completed within one month.

Results:

179 (100%) hospitals responded to the survey. See Table 1 for results.

Table 1: Summary of *C. diff* Hospital Survey

	Count	Percent
Is *C. diff* testing outsourced to a laboratory?		
Yes	35	19.6
No	144	80.4
Does the lab routinely perform tests on formed stool specimens?		
Yes	46	25.7
No	132	73.7
No answer	1	0.6
Does the lab have a rejection policy for duplicate stool specimens?		
Yes	106	59.2
No	68	38.0
No answer	5	2.8
What is the primary test method the lab uses to detect *C. diff*?		
Toxin A and B antibody (ELISA or EIA)	146	81.6
PCR	19	10.6
Glutamate dehydrogenase (GDH) or common antigen	5	2.8
Toxin A antibody only (ELISA or EIA)	3	1.7
Cytotoxin (CTX) assay (Toxin B)	2	1.1
Anaerobic microbiology culture	0	0.0
No answer	4	2.2
Is confirmatory test performed for equivocal test results?		
Yes	93	52.0
No	78	43.6
No answer	8	4.4
If not currently using a PCR test method, is there consideration for use? (160 facilities)		

No	103	64.4
Yes, start date identified	7	4.4
Yes, start date unknown	41	25.6
No answer	9	5.6

Conclusions:

The vast majority (80%) of NYS facilities perform their own *C. diff* tests; the most common testing method (82%) is Toxin A and B antibody (ELISA or EIA). Only 19 (11%) facilities are using PCR technology as their primary testing method; an additional 7 (4%) facilities will begin using PCR, and 41 facilities are considering its use.

Despite evidence against testing formed stool or duplicate specimens[1], many laboratories do not have policies rejecting these specimens (26% and 38%, respectively).

NYS will continue to survey facilities on a yearly basis to monitor changes in testing methods and policies. It will be important to monitor these factors and their association with infection rates.

[1]Gerding DN, Johnson S, Peterson LR, Mulligan ME, Silva J Jr. *Clostridium difficile*-associated diarrhea and colitis. *Infect Control Hosp Epidemiol*. 1995;16(8):459-477.

See more of: *Clostridium difficile*
See more of: Abstracts

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SHEA 2011 ANNUAL SCIENTIFIC MEETING
APRIL 1-4 DALLAS, TEXAS
Innovative research and best practices: driving better outcomes through the science of healthcare epidemiology

305 Interobserver Variability in Bloodstream Infection Determinations Using National Healthcare Safety Network Definitions

Saturday, April 2, 2011: 2:45 PM
Cortez Ballroom (Hilton Anatole)

Paul Malpiedi, MPH *, Centers for Disease Control and Prevention, Atlanta, GA*
Bala Hota, MD, MPH , Stroger Hospital of Cook County/Rush University Medical Center, Chicago, IL
Shelley Magill, MD, PhD , Centers for Disease Control and Prevention, Atlanta, GA
William Trick, MD , John H. Stroger, Jr. Hospital of Cook County, Chicago, IL
Teresa Horan, MPH, CIC , Centers for Disease Control and Prevention, Atlanta, GA
Rosie Lyles, MD, MS , John H. Stroger, Jr. Hospital of Cook County, Chicago, IL
John Martin, MPH , Premier, Inc., Philadelphia, PA
Chris Craver, MA , Premier, Inc., Charlotte, NC
Scott K. Fridkin, MD , Centers for Disease Control and Prevention, Atlanta, GA

Background: CDC's National Healthcare Safety Network (NHSN) provides standard surveillance definitions for healthcare-associated bloodstream infections (BSI). Variations in interpretation and understanding of definition criteria can reduce interobserver agreement and the accuracy of inter-facility comparisons.

Objective: To determine the agreement between 2 experienced infection preventionists (IPs) reviewing medical records of patients with positive blood cultures to identify NHSN-defined BSI.

Methods: NHSN hospitals using Premier Inc.'s SafetySurveillor™ software system were recruited to participate. All blood culture results from 1/2008–6/2009 were extracted from the SafetySurveillor™ data warehouse. A positive blood culture episode eligible for IP review was defined as a patient's first positive blood culture in a 30 day period obtained > 2 days after admission, excluding single positive cultures for common skin contaminants. Two experienced IPs trained in use of NHSN definitions reviewed medical records of a random sample of patients with eligible positive blood culture episodes and independently categorized episodes into 1 of 5 groups: contaminant, community-onset (CO) BSI, primary non-central line associated BSI, central line-associated BSI (CLABSI), or healthcare-associated infection with secondary BSI. We calculated descriptive statistics, compared proportions of IP determination categories using McNemar's test, and assessed interobserver agreement using the kappa (κ) statistic.

Results: 14 hospitals participated, yielding a total of 5,929 positive blood culture episodes eligible for sampling. 1,140 (19%) episodes were sampled. Of these, 1,009 (89%) were categorized by both reviewers. Overall agreement was 64% (κ 0.35, 95% CI 0.30, 0.39). Although IPs categorized similar proportions of episodes as CLABSI (~9%), the proportion categorized as contaminants or CO BSI differed between IPs (Table). Agreement was fair to moderate in each category. One or both IPs categorized 155 episodes as CLABSI; 127 (82%) of these episodes had a discrepancy in IP categorization, where one reviewer categorized the episode as secondary BSI (71, 56%), CO BSI (33, 26%), or contaminant (21, 17%).

Category	Reviewer 1 Determinations (N, %)	Reviewer 2 Determinations (N, %)	p-value	Kappa
Secondary BSI	657 (65.1)	640 (63.4)	0.31	0.39
Community-onset BSI	225 (22.3)	143 (14.2)	0.01	0.41
CLABSI	90 (8.9)	93 (9.2)	0.79	0.23
Contaminant	22 (2.2)	112 (11.1)	0.01	0.21
Primary non-central line associated BSI	15 (1.5)	21 (2.0)	0.25	0.21

Conclusions: We found evidence of limited agreement between experienced IPs in applying the NHSN BSI definition. Continued efforts to understand reasons for limited agreement are needed. One potential solution is to apply algorithms that only use objective criteria, which could dramatically improve agreement.

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SHEA 2011 ANNUAL SCIENTIFIC MEETING
APRIL 1-4 DALLAS, TEXAS
Innovative research and best practices: driving better outcomes through the science of healthcare epidemiology

360 Does Hospital Infection Reporting Affect Actual Infection Rates, Reported Rates, or Both?: A Case Study of Pennsylvania

Sunday, April 3, 2011: 9:15 AM
Chantilly Ballroom (Hilton Anatole)

Hyun K. Kim, Ph.D, candidate *, University of Texas at Austin, Department of Economics, Austin, TX*
Bernard S. Black, JD , Northwestern University, Law School and Kellogg School of Management, Chicago, IL

Background: Health-care associated infections (HAIs) kill about 100,000 people annually; many are preventable. In response to this epidemic, 15 states require hospitals to publicly report their infection rates and national reporting of central-line associated bloodstream infection (CLABSI) is planned. Yet the effect of public reporting on hospital behavior, and thus on infection rates is unknown.

Objective: We examine two broad questions. The first involves reputation markets and whether public reporting of quality measures leads to higher quality. The second involves the incentives of those subject to public reporting to game the reporting rules.

Methods: Our key innovation is to study both the directly reported CLABSI rate, available on the Pennsylvania Health Care Cost Containment Council (PHC4) website for 2005-2007, and a related proxy infection rate, derived from hospital inpatient "billing" records for 1998-2008 ("inpatient CLABSI rates"), which is not publicly reported, and hence not directly subject to gaming incentives. Two sources of inpatient data are 1) Pennsylvania Inpatient Data and 2) Nationwide Inpatient Sample for ten non-reporting states ("control states"). Using inpatient CLABSI rates in both Pennsylvania and control states, we conduct difference-in-differences (DiD) analysis to identify the impact of public reporting. By comparing inpatient rates to publicly reported rates, we assess whether hospitals appear to be gaming the public rates.

Results: We find evidence for both effects. First, public reporting appears to affect actual infection rates. Inpatient CLABSI rates show similar trends in Pennsylvania and control states during the pre-reporting period of 1998-2004. Pennsylvania diverges from the control states during the reporting period of 2004-2008; with inpatient rates dropping on average by 21% in Pennsylvania, versus negligible change in the control states. This estimate is reliable *because* hospitals do not publicly report inpatient rates and thus have no incentive to manipulate them. Hospitals with high publicly reported rates in 2005 (> 0.40/1,000 discharges) experience drops by 2007; the higher the initial rate, the larger the decline. Hospitals with lower 2005 rates do not. Second, public reporting appears to induce at least some gaming. Publicly reported infection rates drop by 40% over 2005-2007, far faster than inpatient rates; the correlation between the two rates drops over this period, and the correlation between inpatient rate changes and public reporting changes is surprising low.

Conclusions: Public reporting appears to cause the relative decline in Pennsylvania CLABSI rates. However, evidence of gaming confirms the value of measuring the impact of public reporting on quality using non-public measures (such as our inpatient rate), and offers reasons to be skeptical about studies that rely solely on reported measures.

See more of: Featured Abstracts of SHEA 2011
See more of: Plenary Sessions

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From: Zimmerman, Kim (CDC/OID/NCEZID) [kxz3@cdc.gov]
Sent: Friday, April 15, 2011 12:59 PM
To: Aarikha D'Souza; Al Demaria; Alessandra Litro; Sites, Ann (CDC maine.gov); Beth Daly; Betty Wood; Carol Wood-Koob; Donna Dunton; Eileen McHale; Giovanna Santovito-Carducci; Jay Kvam; Jessica Rigler; Jon Rosenberg; Kara Stanley; Katrina Hansen; Zimmerman, Kim (CDC/OID/NCEZID); Laura Erhart; Leticia Metherell; Lynn Janssen; Matthew Thomas; Marsella, Maureen; Melinda Thomas; Patsy Tassler-Kelso; Peg Shore; Richard Melchreit; Rike Weiss; Baier, Rosa; Samara Viner-Brown; Shoana Anderson; Steffany Cavallo; Stephen Sears; Sue Chen; Teresa Nelson
Subject: CDC Releases: Bloodstream Infection Guidelines, Policy Toolkit, and Clinical Reminder

Hello Everyone,
CDC released several resources that may be of interest to you or the membership of your organizations. Thanks and have a great weekend!
Kim

Updated bloodstream infection prevention guidelines

CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC) have updated guidelines for the prevention of catheter-related bloodstream infections in patients. Replacing a 2002 edition, the new guidelines are titled "Guidelines for the Prevention of Intravascular Catheter-Related Infections" and were published April 1, 2011, in Clinical Infectious Diseases and are available on CDC's HICPAC website. They will also be included in a special supplement to the American Journal of Infection Control. CDC and NIH will be releasing a joint press release on Monday, April 4th about the new guideline. The press release will be available on www.cdc.gov/media.

CDC and ASTHO Release Policy Toolkit for Healthcare-associated Infection Prevention

The Association of State and Territorial Health Officials (ASTHO) and CDC are pleased to announce the release of a state policy toolkit for the elimination of healthcare-associated infections (HAIs): *Eliminating Healthcare-Associated Infections: State Policy Options.*
State health agencies have a central role to play in HAI elimination because they are responsible for protection of patients across the healthcare system and serve as a bridge between healthcare and the community. The purpose of this toolkit is to provide guidance and examples to senior policy makers on various promising ways to use legal and policy interventions in a comprehensive HAI prevention program.
View the toolkit at: http://www.cdc.gov/HAI/prevent/astho-policy-toolkit.html

CDC Issues Clinical Reminder on use of Facemasks during Spinal Injections

CDC is reminding clinicians to use facemasks when injecting medicine or inserting catheters into epidural or subdural spaces of the spine. This includes epidurals during childbirth labor and injection of contrast dye during imaging procedures. Outbreaks of bacterial meningitis following these spinal injection procedures continue to be identified among patients whose procedures were performed by a healthcare provider who did not wear a facemask.
Read CDC's Clinical Reminder.
Read a commentary on this topic on CDC's Safe Healthcare Blog.

From: Zimmerman, Kim (CDC/OID/NCEZID) [kxz3@cdc.gov]
Sent: Thursday, April 14, 2011 12:40 PM
To: Aarikha D'Souza; Al Demaria; Alessandra Litro; Sites, Ann (CDC maine.gov); Beth Daly; Betty Wood; Carol Wood-Koob; Donna Dunton; Eileen McHale; Giovanna Santovito-Carducci; Jay Kvam; Jessica Rigler; Jon Rosenberg; Kara Stanley; Katrina Hansen; Zimmerman, Kim (CDC/OID/NCEZID); Laura Erhart; Leticia Metherell; Lynn Janssen; Matthew Thomas; Marsella, Maureen; Melinda Thomas; Patsy Tassler-Kelso; Peg Shore; Richard Melchreit; Rike Weiss; Baier, Rosa; Samara Viner-Brown; Shoana Anderson; Steffany Cavallo; Stephen Sears; Sue Chen; Teresa Nelson
Subject: FYI: NEJM papers on MRSA research

Hello Everyone,

As an fyi, today, the New England Journal of Medicine is releasing two papers on MRSA prevention in healthcare facilities and a companion editorial. CDC has authors on both papers.

In an effort to assist you in communicating on this topic, we are providing you links to the publications as well as CDC's key messages at the bottom of this email.

You can access both publications and the editorial from the NEJM home page at http://www.nejm.org/

http://www.nejm.org/doi/full/10.1056/NEJMoa1007474 - VA study
http://www.nejm.org/doi/full/10.1056/NEJMoa1000373 - STAR*ICU study
http://www.nejm.org/doi/full/10.1056/NEJMe1014292?query=featured_home – Editorial by Dr. Richard Platt

CDC's Safe Healthcare blog is hosting a three-part commentary with the lead authors and CDC's Dr. John Jernigan: http://blogs.cdc.gov/safehealthcare/

Medscape is hosting a commentary from Dr. Jernigan at the following location:
http://www.medscape.com/viewarticle/738551

The NY Times also has a feature article on these two publications:
http://www.nytimes.com/2011/04/14/health/14infections.html?_r=2&hp

Please let us know if you need anything else.

CDC messages regarding findings published in the April 14th issue of the New England Journal of Medicine related to preventing MRSA infections in healthcare facilities

Key Messages:

MRSA prevention and control is possible, even though there remains scientific debate about the best way to do it. All HAIs should be considered preventable unless proven otherwise.

When a prevention strategy is chosen, rigorous measurement of the strategy's impact should be in place, with the expectation that facilities should achieve results similar to those observed in the recently published VA studies. If not, the prevention strategy should be modified. In some cases, facilities may benefit from use of active detection and isolation (ADI) of patients colonized with MRSA bacteria.

Healthcare facilities should develop a customized, comprehensive strategy to control MRSA and other multi-drug resistant infections.

CDC guidelines are available to develop a customized comprehensive strategy that will lead to effective control of MRSA and other multi-drug resistant infections.

Many studies have shown that MRSA infections are often preventable.

Additional Messages:
New studies appearing in the New England Journal of Medicine are consistent with the current belief that MRSA is too complex a problem to be controlled with any single intervention.
One of these studies, the STAR ICU Trial, was a large randomized, controlled study designed to measure the effectiveness of ADI. It found that ADI as implemented in the study was not effective in reducing transmission of MRSA or VRE.
Focusing all prevention efforts on a single intervention like ADI does not appear to be a broadly effective strategy.

A separate observational study involving VA hospitals and published in the same issue, found that after implementing a multifaceted MRSA prevention program that included ADI, MRSA transmission and MRSA-associated HAIs decreased significantly across the entire national VA system of hospitals.
While the strategy chosen by the VA did include use of ADI, the study design does not allow for assessment of the contribution of ADI to the overall success.

Again, the most important message here is that MRSA can be prevented and controlled.

CDC recommendations for the prevention of multi-drug resistant infections (MDRO), including MRSA:
First and foremost, these infections should be prevented.
Perform rigorous surveillance for MDRO incidence so that changes over time can be monitored.
Measure adherence to infection control practices and make sure adherence is maintained at high levels.
Put systems in place to ensure providers are using antimicrobials correctly.
If, after implementing your chosen steps, MRSA rates are not declining, implement additional measures until you are able to document effective control.

ORIGINAL ARTICLE

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

Rajiv Jain, M.D., Stephen M. Kralovic, M.D., M.P.H., Martin E. Evans, M.D., Meredith Ambrose, M.H.A., Loretta A. Simbartl, M.S., D. Scott Obrosky, M.S., Marta L. Render, M.D., Ron W. Freyberg, M.S., John A. Jernigan, M.D., Robert R. Muder, M.D., LaToya J. Miller, M.P.H., and Gary A. Roselle, M.D.

ABSTRACT

BACKGROUND

Health care–associated infections with methicillin-resistant *Staphylococcus aureus* (MRSA) have been an increasing concern in Veterans Affairs (VA) hospitals.

METHODS

A "MRSA bundle" was implemented in 2007 in acute care VA hospitals nationwide in an effort to decrease health care–associated infections with MRSA. The bundle consisted of universal nasal surveillance for MRSA, contact precautions for patients colonized or infected with MRSA, hand hygiene, and a change in the institutional culture whereby infection control would become the responsibility of everyone who had contact with patients. Each month, personnel at each facility entered into a central database aggregate data on adherence to surveillance practice, the prevalence of MRSA colonization or infection, and health care–associated transmissions of and infections with MRSA. We assessed the effect of the MRSA bundle on health care–associated MRSA infections.

RESULTS

From October 2007, when the bundle was fully implemented, through June 2010, there were 1,934,598 admissions to or transfers or discharges from intensive care units (ICUs) and non-ICUs (ICUs, 365,139; non-ICUs, 1,569,459) and 8,318,675 patient-days (ICUs, 1,312,840; and non-ICUs, 7,005,835). During this period, the percentage of patients who were screened at admission increased from 82% to 96%, and the percentage who were screened at transfer or discharge increased from 72% to 93%. The mean (±SD) prevalence of MRSA colonization or infection at the time of hospital admission was 13.6±3.7%. The rates of health care–associated MRSA infections in ICUs had not changed in the 2 years before October 2007 ($P=0.50$ for trend) but declined with implementation of the bundle, from 1.64 infections per 1000 patient-days in October 2007 to 0.62 per 1000 patient-days in June 2010, a decrease of 62% ($P<0.001$ for trend). During this same period, the rates of health care–associated MRSA infections in non-ICUs fell from 0.47 per 1000 patient-days to 0.26 per 1000 patient-days, a decrease of 45% ($P<0.001$ for trend).

CONCLUSIONS

A program of universal surveillance, contact precautions, hand hygiene, and institutional culture change was associated with a decrease in health care–associated transmissions of and infections with MRSA in a large health care system.

From the Veterans Health Administration MRSA Program Office, Patient Care Services, Veterans Affairs (VA) Central Office, and the VA Pittsburgh Healthcare System (R.J., M.E.E., M.A., L.J.M.); the Department of Internal Medicine, VA Pittsburgh Healthcare System, and the University of Pittsburgh School of Medicine (R.J., R.R.M.); and the Center for Health Equity Research and Promotion, VA Pittsburgh Healthcare System (D.S.O.) — all in Pittsburgh; the National Infectious Diseases Program Office, Patient Care Services, VA Central Office, and the Cincinnati VA Medical Center (S.M.K., L.A.S., G.A.R.); the Department of Internal Medicine, University of Cincinnati College of Medicine (S.M.K., M.L.R., G.A.R.); and the VA Inpatient Evaluation Center (M.L.R., R.W.F.) — all in Cincinnati; the Department of Internal Medicine, University of Kentucky School of Medicine, Lexington (M.E.E.); and the Prevention and Response Branch, Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta (J.A.J.). Address reprint requests to Dr. Evans at the VHA MDRO Program, Lexington VAMC, 1101 Veterans Dr., 11i–CDD, Lexington, KY 40502, or at martin.evans@va.gov.

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Methicillin-resistant *Staphylococcus aureus* (MRSA) infections are a problem in the United States[1] and elsewhere. MRSA is one of the most common causes of ventilator-associated pneumonia, bloodstream infection associated with central venous catheters, and surgical-site infections.[1,2]

In 2001, the Veterans Affairs (VA) Pittsburgh Healthcare System began working with the Pittsburgh Regional Healthcare Initiative and the Centers for Disease Control and Prevention (CDC) to eliminate health care–associated MRSA infections with the use of a "MRSA bundle." The bundle, which was based on published guidelines, comprised universal nasal surveillance for MRSA colonization, contact precautions for patients who were carriers of MRSA, hand hygiene, and an institutional culture change whereby infection control became the responsibility of everyone who had contact with patients.[3] After implementation of this approach in a pilot project, the rates of health care–associated MRSA infections were reduced by 60% on a surgical ward and by 75% in a surgical intensive care unit (ICU) within 4 years.[4]

On the basis of the success of the pilot study in the VA Pittsburgh Healthcare System, and recognizing the importance of preventing MRSA infections for all veterans, the Veterans Health Administration (VHA), a division of the Department of Veterans Affairs, issued a directive (see the Supplementary Appendix, available with the full text of this article at NEJM.org) implementing a nationwide initiative to decrease health care–associated MRSA infections in acute care facilities. In this article, we report an analysis of the effect of the MRSA Prevention Initiative during the period from October 2007, when the program was fully implemented in ICUs and non-ICUs nationwide, through June 2010.

METHODS

INTERVENTIONS

Medical centers were directed to implement the MRSA bundle in one patient care unit (preferably an ICU) beginning in March 2007 and to implement the bundle in all remaining acute care units (with the exception of mental health units) by October 1, 2007. The bundle consisted of surveillance for nasal colonization with MRSA for all patients admitted to the hospital, all patients transferred from one unit to another within the hospital, and all patients discharged from the hospital; contact precautions for patients who were either colonized or infected with MRSA; hand hygiene; and a change in the institutional culture. The recommended approach to achieve culture change was "positive deviance"[5] (a problem-solving approach that is based on the observation that in every community, there are certain persons or groups whose uncommon behaviors or strategies, as compared with those of their peers, enable them to find better solutions to problems). The goal of the culture change was to foster alterations in practice so that infection control and prevention would become the responsibility of everyone involved in the care of patients and thus a natural component of patient care.

PATIENTS

All patients admitted to VA acute health care facilities (except patients admitted to mental health units) were eligible to participate in the MRSA Prevention Initiative. Because this was not a research project, but rather a quality-improvement initiative, written informed consent from individual patients was not required, consistent with VA policy.[6] Written information was available for each patient or his or her caregiver, with details about MRSA, relevant principles of infection control, the purpose and goals of the MRSA Prevention Initiative, and patients' rights and oral assent (see the Supplementary Appendix).

RESOURCES AND TRAINING

The VA Central Office provided funds to each facility in the United States for educational materials, laboratory equipment and supplies, and salaries for dedicated laboratory personnel and for a newly created position, the MRSA prevention coordinator. The coordinator at each facility oversaw implementation of the initiative at that facility, collected and reported data on the program at that facility, provided feedback to frontline health care workers, and dealt with local challenges. Regional and national educational and training sessions for the coordinators were conducted by the MRSA Program Office.

ACTIVE SURVEILLANCE AND CONTACT PRECAUTIONS

Training on the method of obtaining nasal swabs was provided to all MRSA prevention coordinators through the MRSA Program Office. Samples of nasal secretions were obtained with a swab from both anterior nares of patients within 24 hours after their admission to the hospital. Swabs were

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also obtained from patients who were not known to be colonized or infected with MRSA when they were transferred between, or discharged from, units within each facility. The local clinical microbiology laboratory processed the swabs with the use of standard or selective chromogenic agar for the isolation of MRSA or with polymerase-chain-reaction (PCR)–based tests for rapid molecular detection of the organism. Positive results were reported to the patient's nursing unit and were recorded in the electronic health record.

Patients who were found to be colonized or infected with MRSA or who were known to have been colonized or infected with MRSA within the previous 12 months were assigned to contact precautions.[7] These patients were cared for with contact precautions during their hospital stay and all subsequent hospitalizations. Contact precautions remained in effect until two nasal swabs and cultures of infected sites (if still present), obtained 1 week apart, were negative, provided that the patients were not receiving antibiotics for an active MRSA (or other) infection at the time of these subsequent surveillance tests. Routine MRSA decolonization was not recommended (see the Supplementary Appendix).

DEFINITIONS OF PREVALENCE, TRANSMISSION, AND HEALTH CARE–ASSOCIATED INFECTION

We calculated the facility-wide rate of colonization at admission by dividing the number of patient admissions with MRSA, as detected by nasal swabbing or clinical cultures within 48 hours after admission, by the total number of admissions to the facility. As of April 2008, all persons who had a history of colonization or infection with MRSA within the previous 12 months were also considered to be positive for MRSA at the time of admission. A clinical culture was defined as a specimen obtained from any body site, fluid, or drainage area other than specimens obtained for surveillance. If MRSA was detected in both the nasal-swab specimen and a clinical culture, the event was counted once in the category of clinical culture. Geographic variation in prevalence was examined according to the four regions of the United States (Northeast, South, Midwest, and West) defined by the Census Bureau (www.census.gov).

Patients who were negative for MRSA at the time of admission and during the 12 months before admission and were found to be colonized or infected with MRSA after they had been in a unit for more than 48 hours were considered to have an event of MRSA transmission attributable to that unit. Patients not known to be colonized or infected with MRSA who were readmitted to the hospital within 48 hours after discharge and were found to be positive at the time of readmission were considered to have a transmission event attributable to the unit from which they had been discharged.

Health care–associated MRSA infections were defined according to guidelines of the CDC's National Healthcare Safety Network (NHSN),[8] with the following adaptations: a diagnosis of MRSA infection required a positive culture, rather than just a clinical diagnosis by a physician, and a positive clinical culture was considered to be community-associated if it was obtained within 48 hours after admission. After 48 hours, a positive clinical culture obtained from a patient in whom infection was not present or incubating at the time of admission, as defined by NHSN criteria,[9] was considered to be a health care–associated event. No molecular typing of the MRSA isolates was performed. A physician or other professional in infection prevention and control reviewed the patient's record to determine whether the criteria for a health care–associated infection had been met.

DATA MANAGEMENT

Beginning in October 2007, MRSA prevention coordinators at all facilities entered, for each month, aggregate data on active surveillance testing and on the prevalence and transmission of MRSA and health care–associated MRSA infections into a database that was developed and maintained by the VA Inpatient Evaluation Center (IPEC). The coordinators at all facilities also collected retrospective information on health care–associated MRSA infections detected in ICUs between October 2005 and the end of September 2007 in order to establish a baseline before implementation of the MRSA Prevention Initiative. With the exception of the category of systemic infection, data entered into the MRSA data management Web site at IPEC included all major categories of health care–associated infections surveyed by the NHSN (e.g., urinary tract infections, bloodstream infections, pneumonia, and skin and soft-tissue infections).[8]

In addition to data on health care–associated MRSA infections, MRSA prevention coordinators were asked to enter into the IPEC database, on an optional basis, data on health care–associated

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infections with vancomycin-resistant enterococcus (VRE) and *Clostridium difficile* (defined according to NHSN guidelines[8]), each month from October 2007 through June 2010.

For the purpose of the dissemination of this information beyond the programmatic needs of the MRSA Prevention Initiative, the analysis was approved by the institutional review boards at the VA Pittsburgh Healthcare System and the Cincinnati VA Medical Center.

STATISTICAL ANALYSIS

We used the SAS statistical program, version 9.2 (SAS Institute), to extract monthly data on facility-level and unit-level variables from a Microsoft SQL Server 2005 Analysis Services online analytical processing cube (Microsoft) that was maintained in secure files on a server at IPEC.

Data from all facilities were pooled for the analyses. Facility-specific data were available for stratification when necessary. Adherence to active surveillance testing was reported as the percentage of eligible patients who were tested, and the rates of transmission and health care–associated infection were expressed as the number per 1000 patient-days. The rates of ventilator-associated pneumonia and bloodstream infection associated with central venous catheters were expressed as the number per 1000 device-days. All data were analyzed monthly except for data on MRSA bloodstream infections not associated with a device, pneumonias, urinary tract infections, and skin and soft-tissue infections (defined according to NHSN guidelines[8]), which were evaluated quarterly owing to the small numbers of events.

Quantitative and qualitative variables are reported with the use of descriptive statistics. Trends were examined by means of Poisson regression models, and Student's t-tests and analyses of variance with Duncan's multiple-comparisons method were used to compare groups of interest. The Durbin–Watson (*d*) statistic was used to test for the presence of autocorrelation in the rates of health care–associated infections. No strong evidence was found; therefore, data transformations were deemed to be unnecessary.

RESULTS

CHARACTERISTICS OF PATIENTS AND FACILITIES

The mean (±SD) age of patients admitted to VA acute care facilities during the period included in the analysis (October 2007 through June 2010) was 62.6±14.4 years; 95% of the patients were men. The median length of stay was 3.0 days (interquartile range, 2.0 to 7.0).

The VA has 153 hospitals nationwide. During the period included in the analysis, 196 medical, coronary care, and surgical ICUs and 428 medical, surgical, rehabilitation medicine, and spinal-cord injury units provided data to IPEC. These units represented all VA medical centers nationwide except for 3 that were exempted from participation.

There were 1,934,598 admissions to, transfers within, or discharges from these units (ICUs, 365,139; non-ICUs, 1,569,459) and 8,318,675 patient-days (ICUs, 1,312,840; non-ICUs, 7,005,835).

ACTIVE SURVEILLANCE

A total of 1,712,537 surveillance screening tests were obtained during the analysis period from patients who were admitted to or transferred or discharged from acute care facilities nationwide (329,903 obtained in ICUs and 1,382,634 in non-ICUs). During this period, the percentage of patients who were screened at admission increased from 82% to 96%, and the percentage who were screened at transfer or discharge increased from 72% to 93% (Fig. 1).

Figure 1 (facing page). Active Surveillance Testing for Methicillin-Resistant *Staphylococcus aureus* (MRSA) among Patients Admitted to and Those Transferred or Discharged from Acute Care Veterans Affairs (VA) Medical Units Nationwide.

A "MRSA bundle," comprising universal nasal surveillance for MRSA colonization, contact precautions for patients who were carriers of MRSA, hand hygiene, and an institutional culture change whereby infection control became the responsibility of everyone who had contact with patients, was implemented in 2007 in acute care VA hospitals nationwide. The shaded area represents the transition period between the time when all hospitals were required to have the program functional in at least one intensive care unit (ICU) (March 2007) to full implementation of the MRSA bundle in all ICUs and non-ICUs (October 2007). The period of analysis was from October 2007 through June 2010. The number of patients who were screened at admission and the number who were screened at transfer or discharge are shown in Panel A; the rates at screening at admission and at transfer or discharge are shown in Panel B. Although only 35% of patients admitted to the hospital were being screened when the MRSA Prevention Directive was issued in January 2007, this percentage rapidly increased to 82% by October 2007 and to 96% by June 2010. The surveillance rate at the time of transfer or discharge increased from 72% in October 2007 to 93% in June 2010.

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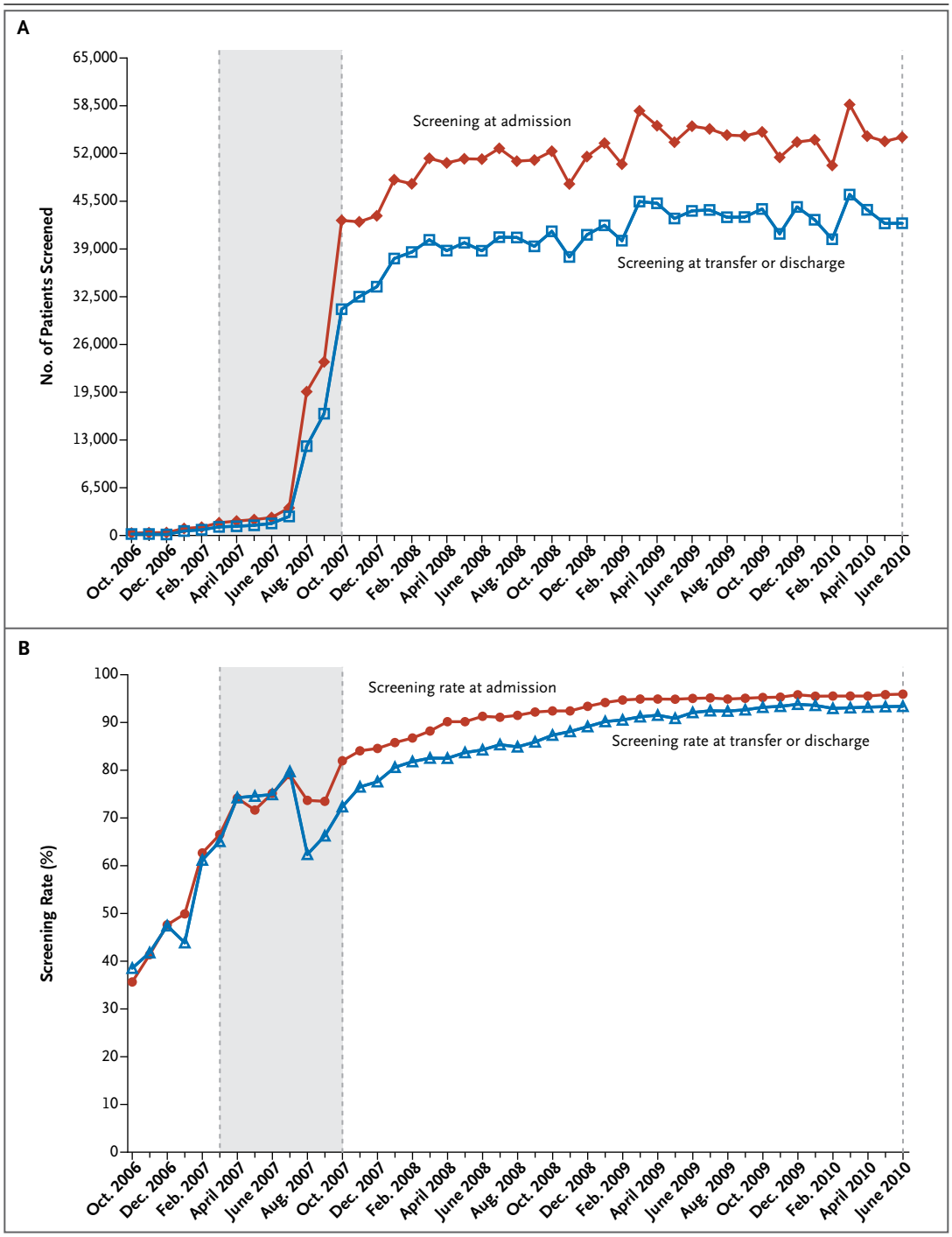

PREVALENCE OF MRSA COLONIZATION OR INFECTION AT ADMISSION

The mean (±SD) monthly prevalence of MRSA colonization or infection at admission in all medical centers during the analysis period was 13.6±3.7% (range of means across facilities, 5.4 to 28.1). The ratio of patients with MRSA colonization or infection who were identified by active surveillance to those identified by clinical cultures alone was 10:1 (Fig. 2). The prevalence of colonization or infection at admission was higher among patients living in southern or northeastern regions of the United States than among those living in western or midwestern regions (15.3% and 14.6%, respectively, for southern and northeastern regions vs. 11.3% and 12.5%, re-

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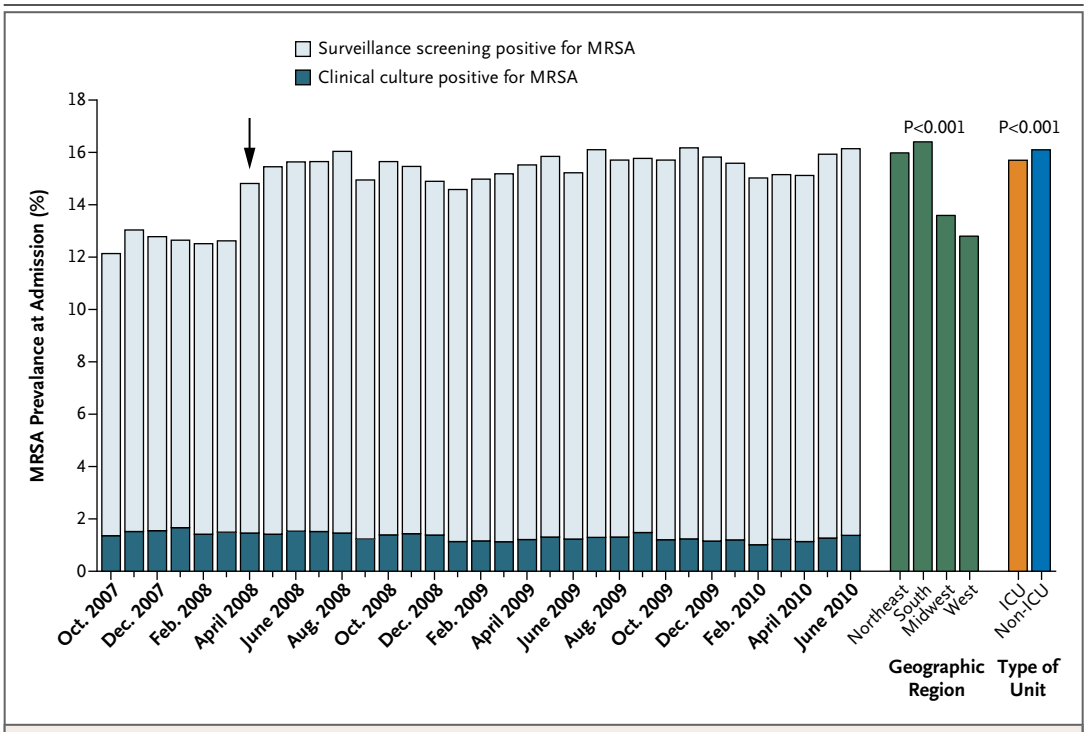

Figure 2. Mean National Prevalence of Methicillin-Resistant *Staphylococcus aureus* (MRSA) at the Time of Admission to Veterans Affairs (VA) Medical Centers.

The monthly mean national prevalence of MRSA, as detected by surveillance screening tests or clinical cultures, at the time of admission to VA medical centers nationwide is shown. The arrow indicates the time at which, owing to a change in policy, patients who had been colonized or infected within the previous 12 months were considered to be positive for MRSA at admission. Also shown is the mean prevalence of colonization or infection with MRSA at the time of admission according to geographic region and type of admission (intensive care unit [ICU] or non-ICU). The comparison among geographic regions was performed with the use of an analysis of variance with Duncan's multiple comparisons, and the comparison between ICUs and non-ICUs was performed with the use of Student's t-test.

spectively, for western and midwestern regions; P<0.001). More non-ICU patients than ICU patients were colonized or infected at admission (15.7±11.4% vs. 14.5±9.1%, P<0.001).

RATES OF TRANSMISSION

During the analysis period, the rate of transmission of MRSA in the ICUs was reduced from 3.02 per 1000 patient-days in October 2007 to 2.50 per 1000 patient-days in June 2010, a decrease of 17% (P<0.001 for trend). During the same period, the rate of transmission in the non-ICUs was reduced from 2.54 per 1000 patient-days to 2.00 per 1000 patient-days, a decrease of 21% (P<0.001 for trend).

RATES OF HEALTH CARE—ASSOCIATED INFECTION

The rate of health care–associated MRSA infection in ICUs did not change significantly from October 2005 through September 2007, which was the period before implementation of the MRSA bundle in all facilities (1.45 per 1000 patient-days in October 2005 and 1.75 per 1000 patient-days in September 2007, P=0.50 for trend) but declined during the analysis period, from 1.64 per 1000 patient-days in October 2007 to 0.62 per 1000 patient-days in June 2010, a decrease of 62% (P<0.001 for trend) (Fig. 3). After implementation of the MRSA bundle, there was a decline in the rate of bloodstream MRSA infection not related to a device, from 0.14 per 1000 patient-days in the fourth quarter (October through December) of 2007 to 0.03 per 1000 patient-days in the second quarter (April through June) of 2010, a decrease of 79% (P<0.001 for trend). During the same period, there was a decline in the quarterly rate of bloodstream MRSA infection re-

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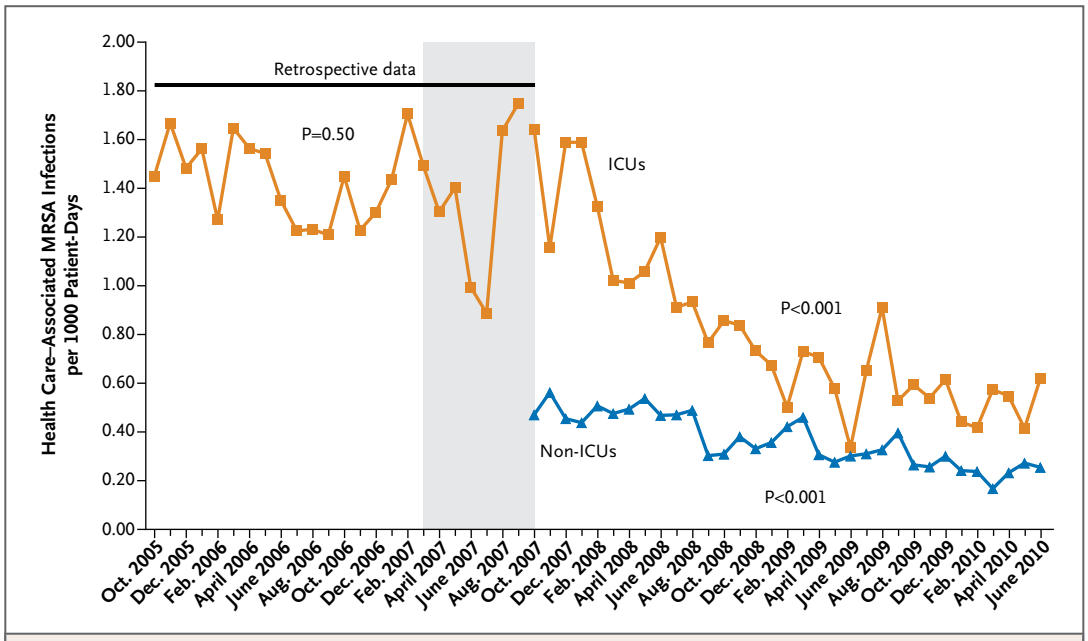

Figure 3. Nationwide Rates of Health Care–Associated Infections with Methicillin-Resistant *Staphylococcus aureus* (MRSA) in Veterans Affairs (VA) Facilities.

Between October 2007, when the MRSA bundle was fully implemented, and the end of June 2010, the rates of health care–associated MRSA infections declined by 62% in intensive care units (ICUs) and by 45% in non-ICUs. There was no significant change in the rates of health care–associated MRSA infections in the ICUs for the 2-year period (October 2005 through September 2007) before full implementation of the MRSA bundle; data for that 2-year period were not available for non-ICUs. The shaded area represents the transition period when the VA MRSA Prevention Initiative was being introduced. The analysis of trends was performed with the use of Poisson regression.

lated to a device, from 0.16 to 0.06 per 1000 patient-days, a decrease of 62% (P<0.001 for trend); a decline in the quarterly rate of pneumonia not related to a device, from 0.35 to 0.22 per 1000 patient-days, a decrease of 37% (P=0.001 for trend); a decline in the rate of pneumonia related to a device, from 0.32 to 0.08 per 1000 patient-days, a decrease of 75% (P<0.001 for trend); a decline in the rate of urinary tract infection, from 0.16 to 0.04 per 1000 patient-days, a decrease of 75% (P<0.001 for trend); and a decline in the rate of skin and soft-tissue infections, from 0.16 to 0.04 per 1000 patient days, a decrease of 75% (P<0.001 for trend) (Fig. 4A).

There was no significant change in the rates of ventilator-associated MRSA pneumonia or bloodstream MRSA infection associated with central venous catheters in ICUs from April 2006 through March 2007, which was the period in which programs to reduce the rate of health care–associated infections due to all pathogens were fully implemented (P=0.86 for trend and P=0.26 for trend, respectively); however, between October 2007, when the MRSA bundle was fully implemented, and June 2010, the rate of ventilator-associated MRSA pneumonia declined from 1.17 per 1000 device-days in October 2007 to 0.33 per 1000 device-days in June 2010, a decrease of 72% (P<0.001 for trend), and the rate of bloodstream MRSA infection associated with central venous catheters declined from 0.46 to 0.31 per 1000 device-days, a decrease of 33% (P<0.001 for trend) (Fig. 5). The ratio of patient-days in the ICU on which mechanical ventilation was received to the total number of patient-days in the ICU declined from 0.29 in October 2007 to 0.25 in June 2010, a decrease of 14% (P=0.005 for trend); the ratio of patient-days in the ICU on which central venous catheters were used to the total number of patient-days in the ICU did not change significantly (0.46 in October 2007 and 0.44 in June 2010, P=0.75 for trend).

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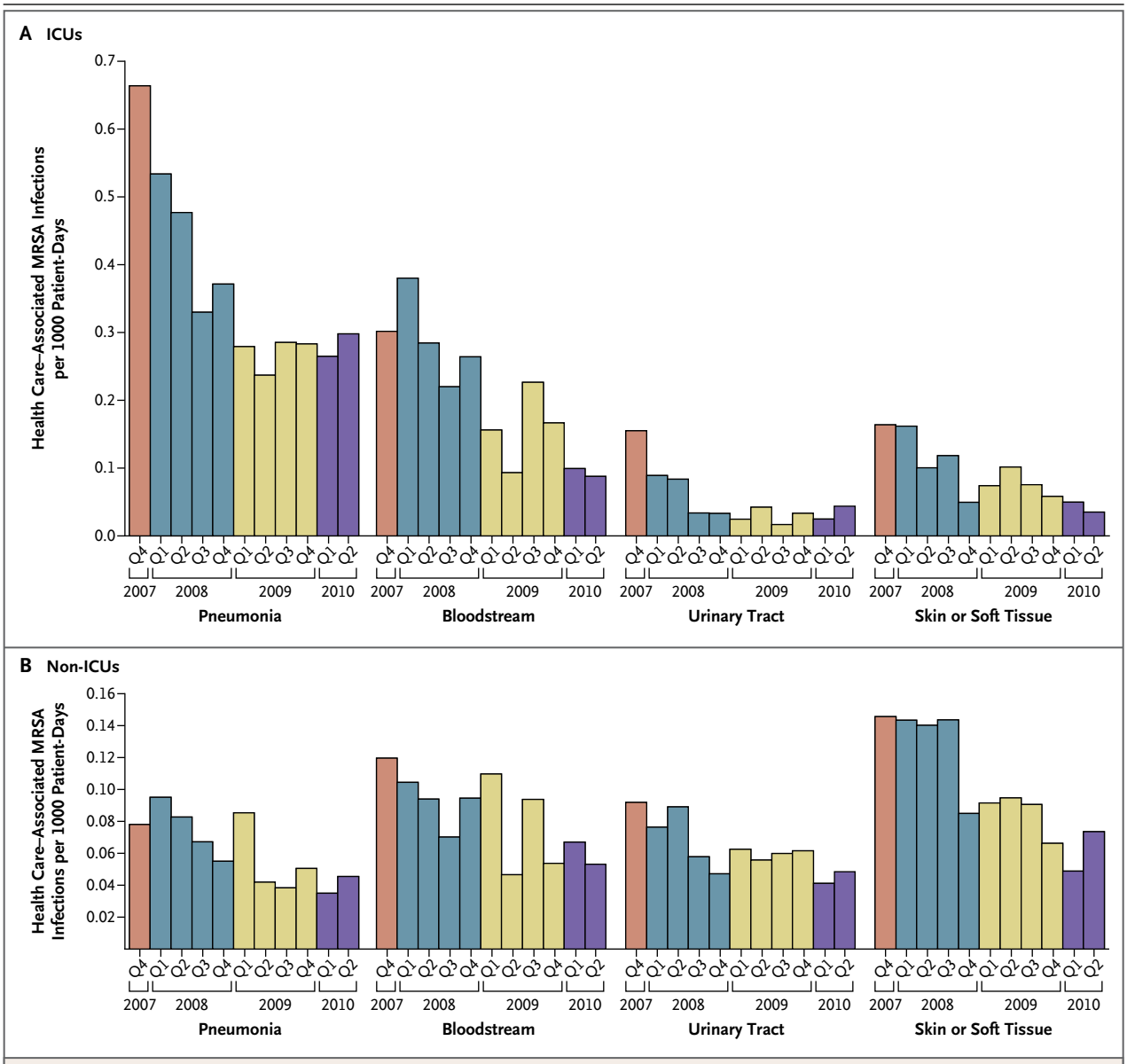

Figure 4. Nationwide Quarterly Rates of Health Care–Associated Infection with Methicillin-Resistant *Staphylococcus aureus* (MRSA) in Veterans Affairs Facilities, According to the Type of Infection.

Quarterly rates of health care–associated MRSA infections in intensive care units (ICUs, Panel A) and in non-ICUs (Panel B) are shown. Data on health care–associated pneumonias and bloodstream and urinary tract infections in ICUs were collected separately for infections related to a device and infections not related to a device but are presented as aggregate data reflecting both sources of infections; conversely, data on all three infection types in the non-ICUs were collected without respect to association with a device (devices are not usually associated with skin and soft-tissue infections). Downward trends for all health care–associated infections in ICUs were significant (P<0.001 for trend, with the use of Poisson regression). Downward trends for health care–associated pneumonia and skin and soft-tissue infections in non-ICUs were significant (P=0.02 and P=0.009, respectively, for trend, with the use of Poisson regression). Q denotes quarter.

In non-ICUs, the rate of health care–associated MRSA infection fell from 0.47 per 1000 patient-days in October 2007 to 0.26 per 1000 patient-days in June 2010, a decrease of 45% (P<0.001 for trend) (Fig. 3). The rate of bloodstream infection declined from 0.12 per 1000 patient-days in the last quarter (October through December) of 2007 to 0.05 per 1000 patient-days

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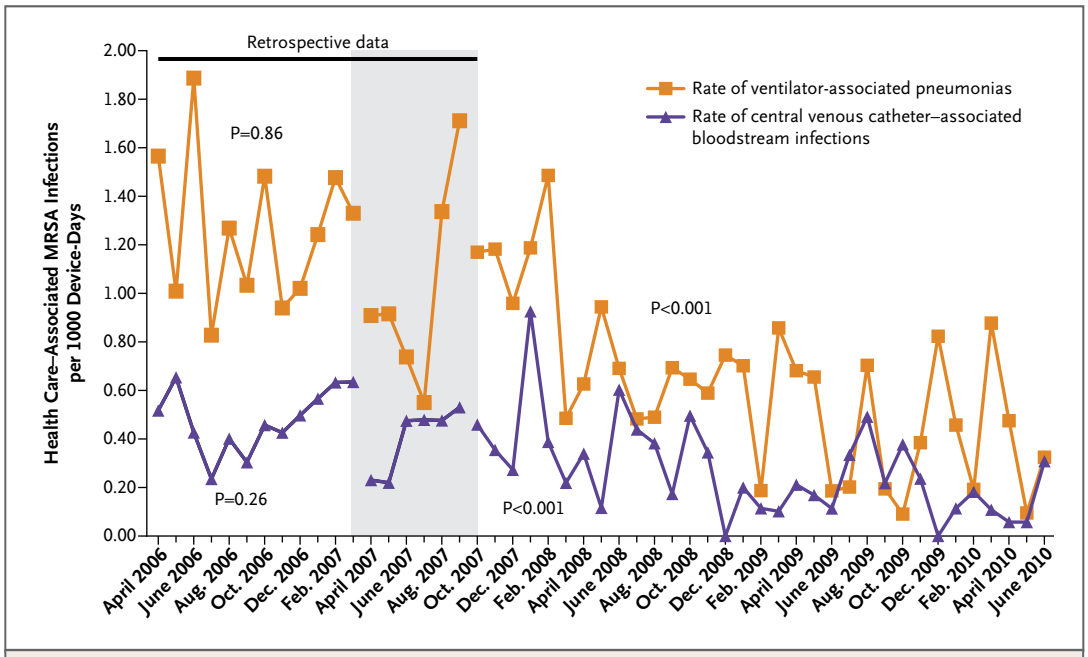

Figure 5. Nationwide Monthly Rates of Ventilator-Associated Pneumonias and Central Venous Catheter–Associated Bloodstream Infections with Methicillin-Resistant *Staphylococcus aureus* (MRSA) in Veterans Affairs (VA) Intensive Care Units.

Data are shown for the period during which bundles for these device-related health care–associated infections due to all pathogens were in place (April 2006 through March 2007), during a transition period (shaded area) when the VA MRSA Prevention Initiative was being introduced, and from October 2007 through June 2010, when the initiative was implemented in all intensive care units nationwide. P values are for trends (with the use of Poisson regression) for the respective periods and health care–associated infections. The P value for the retrospective data is only for data for the period from April 2006 to March 2007.

in the second quarter (April through June) of 2010, a decrease of 58% (P=0.11). During the same period, there were declines in the quarterly rates of pneumonia, from 0.08 to 0.05 per 1000 patient-days, a decrease of 38% (P=0.02); urinary tract infection, from 0.09 to 0.05 per 1000 patient-days, a decrease of 44% (P=0.43); and skin and soft-tissue infections, from 0.15 to 0.07 per 1000 patient-days, a decrease of 53% (P=0.009) (Fig. 4B).

A total of 16 hospitals entered data on the incidence of health care–associated VRE and *C. difficile* infections in ICUs consistently during the analysis period, and 17 hospitals entered data on the incidence of these infections in non-ICUs. Poisson regression analysis for this subgroup of hospitals showed that between October 2007 and June 2010, there was a decline in the rate of health care–associated MRSA infection from 2.81 to 0.22 per 1000 patient-days in the ICUs, a decrease of 92% (P<0.001), and from 0.79 to 0.22 per 1000 patient-days in non-ICUs, a decrease of 72% (P<0.001). There was also a decline in the rate of health care–associated *C. difficile* infection in non-ICUs, from 1.44 to 0.56 per 1000 patient-days, a decrease of 61% (P<0.001); there was no significant change noted in the rate of health care–associated *C. difficile* infection in ICUs (P=0.99). During the same period, there was a significant decrease in the rates of health care–associated VRE infection in the ICUs, from 1.51 to 0.00 per 1000 patient days (P<0.001), and in non-ICUs, from 0.33 to 0.09 per 1000 patient-days, a decrease of 73% (P<0.001).

DISCUSSION

Implementation of a bundle comprising universal active surveillance, contact precautions, hand hygiene, and a change in the institutional culture was followed by significant declines in health care–associated MRSA infections in a large health

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care system. These declines were sustained during the 33 months of the analysis and were greater than those reported recently in other U.S. venues.[10,11] Investigations in smaller settings have also shown reductions in health care–associated MRSA infections when an approach similar to that of the VA was used.[12-20]

The prevalence of MRSA carriage among VA patients at admission was 13.6%, as compared with a prevalence of 1.5% in the general U.S. population and 6.3% among patients in non-VA hospitals, as determined, in both cases, by means of universal surveillance.[16,21] We might have seen a larger decrease in health care–associated infections if the prevalence had been lower, since there is a correlation between the prevalence of carriers and the incidence of health care–associated infections.[22,23]

Because this VA initiative was a quality-improvement program rather than a prospectively designed trial, data are not available to evaluate the extent to which each component of the bundle may have contributed to the overall reduction in health care–associated infections. Adherence to surveillance at admission, transfer, and discharge may be a surrogate marker for adherence to the bundle.

Active surveillance identified more than 90% of MRSA carriers who would have been missed with clinical cultures alone. The sensitivity and specificity of direct plating to a chromogenic medium are similar to those of PCR, which range from about 81% to 100% and 93% to 100%, respectively.[24] Identifying patients who were colonized with MRSA and isolating them with contact precautions was probably important, since the environment surrounding asymptomatic carriers can be contaminated to the same extent as the environment surrounding infected patients.[25] Preventing transmission and subsequent colonization with MRSA reduces the risk of infection, which may occur in more than a third of recently colonized patients,[16,26-30] and decreases the reservoir of patients who can transmit MRSA during future health care encounters.

The increase in adherence to active surveillance in the months after issuance of the VHA directive and the subsequent declines in health care–associated MRSA infections were consistent with an institutional culture change that resulted in health care workers being more aware of health care–associated MRSA infections and increasing their adherence to hand hygiene and contact precautions. The MRSA Prevention Initiative may have also affected the rates of health care–associated *C. difficile* and VRE infections. It is known that hand hygiene reduces health care–associated infections, and contact precautions are effective in preventing the transmission of MRSA and other pathogens.[31,32]

We do not know the extent to which concomitant infection-control initiatives may have contributed to the decrease in health care–associated MRSA infections that we observed. Guidelines were given for decolonization (see the Supplementary Appendix). Data from the national VHA Pharmacy Benefits Management database showed that, nationwide, inpatient orders for 2% mupirocin ointment, a surrogate for decolonization efforts, were reduced from 0.013 orders per unique patient in October 2007 to 0.009 orders per unique patient in April 2010, suggesting that the use of decolonization regimens did not increase during the analysis period. Recommendations for hand hygiene and transmission precautions had been in place for years, and as part of a program to improve outcomes in VA ICUs, initiatives to decrease overall rates of bloodstream infection associated with central venous catheters and ventilator-associated pneumonia were implemented in all VA ICUs as of April 2006. However, device-associated and non–device-associated MRSA infections did not decline significantly until after full implementation of the MRSA bundle in October 2007. The MRSA bundle may have had a complementary or synergistic effect when it was added to the other initiatives that were already in place.

An important approach to dealing with multidrug-resistant bacteria is to control their spread among patients. The data from the VA suggest that proactive efforts to prevent the transmission of MRSA are associated with a reduction in health care–associated MRSA infections. Patients in acute care hospitals outside the VA system may also benefit from the implementation of an aggressive campaign to eradicate health care–associated MRSA infections that uses a strategy similar to the VA strategy, but this would need to be tested. A phased-in approach targeting high-risk patients may be reasonable initially, but optimal control of health care–associated

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MRSA infections and the best ratio of cost to benefit may be realized only with universal surveillance.[16,33] Although we did not make a formal cost–benefit assessment of the VA MRSA Prevention Initiative, others have reported that programs of active surveillance are cost-effective over a wide range of prevalence and transmission rates.[34,35] Expanding elements of the program to long-term and ambulatory care settings may be necessary to deal with reservoirs of MRSA throughout the health care system.

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Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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REFERENCES

1. Klein E, Smith DL, Laxminarayan R. Hospitalizations and deaths caused by methicillin-resistant *Staphylococcus aureus*, United States, 1999-2005. Emerg Infect Dis 2007;13:1840-6.

2. Hidron AI, Edwards JR, Patel J, et al. NHSN annual update: antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2006-2007. Infect Control Hosp Epidemiol 2008; 29:996-1011. [Erratum, Infect Control Hosp Epidemiol 2009;30:107.]

3. Muto CA, Jernigan JA, Ostrowsky BE, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of *Staphylococcus aureus* and *enterococcus.* Infect Control Hosp Epidemiol 2003;24:362-86.

4. Muder RR, Cunningham C, McCray E, et al. Implementation of an industrial systems-engineering approach to reduce the incidence of methicillin-resistant *Staphylococcus aureus* infection. Infect Control Hosp Epidemiol 2008;29:702-8.

5. Positive Deviance Initiative home page. (http://www.positivedeviance.org.)

6. Informed consent for clinical treatments and procedures. VHA handbook 1004.01. Washington, DC: Veterans Health Administration Office of Ethics, 2009. (http://www.ethics.va.gov/docs/policy/VHA_Handbook_1004-01_Informed_Consent_Policy_20090814.pdf.)

7. Siegel JD, Rhinehart E, Jackson M, Chiarello L. 2007 Guideline for isolation precautions: preventing transmission of infectious agents in health care settings. Am J Infect Control 2007;35:Suppl 2:S65-S164.

8. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;36:309-32. [Erratum, Am J Infect Control 2008;36:655.]

9. Centers for Disease Control and Prevention. Identifying healthcare-associated infections (HAI) in NHSN. (http://www.cdc.gov/nhsn/PDFs/pscManual/2PSC_IdentifyingHAIs_NHSNcurrent.pdf.)

10. Burton DC, Edwards JR, Horan TC, Jernigan JA, Fridkin SK. Methicillin-resistant *Staphylococcus aureus* central line-associated bloodstream infections in US intensive care units, 1997-2007. JAMA 2009; 301:727-36.

11. Kallen AJ, Mu Y, Bulens S, et al. Health care-associated invasive MRSA infections, 2005-2008. JAMA 2010;304:641-8.

12. Harbarth S, Martin Y, Rohner P, Henry N, Auckenthaler R, Pittet D. Effect of delayed infection control measures on a hospital outbreak of methicillin-resistant *Staphylococcus aureus.* J Hosp Infect 2000; 46:43-9.

13. Lucet JC, Paoletti X, Lolom I, et al. Successful long-term program for controlling methicillin-resistant *Staphylococcus aureus* in intensive care units. Intensive Care Med 2005;31:1051-7.

14. Huang SS, Yokoe DS, Hinrichsen VL, et al. Impact of routine intensive care unit surveillance cultures and resultant barrier precautions on hospital-wide methicillin-resistant *Staphylococcus aureus* bacteremia. Clin Infect Dis 2006;43:971-8.

15. Boyce JM, Havill NL, Kohan C, Dumigan DG, Ligi CE. Do infection control measures work for methicillin-resistant *Staphylococcus aureus*? Infect Control Hosp Epidemiol 2004;25:395-401.

16. Robicsek A, Beaumont JL, Paule SM, et al. Universal surveillance for methicillin-resistant *Staphylococcus aureus* in 3 affiliated hospitals. Ann Intern Med 2008;148: 409-18.

17. Clancy M, Graepler A, Wilson M, Douglas I, Johnson J, Price CS. Active screening in high-risk units is an effective and cost-avoidant method to reduce the rate of methicillin-resistant *Staphylococcus aureus* infection in the hospital. Infect Control Hosp Epidemiol 2006;27:1009-17.

18. Chowers MY, Paitan Y, Gottesman BS, Gerber B, Ben-Nissan Y, Shitrit P. Hospital-wide methicillin-resistant *Staphylococcus aureus* control program: a 5-year follow-up. Infect Control Hosp Epidemiol 2009; 30:778-81.

19. Pan A, Carnevale G, Catenazzi P, et al. Trends in methicillin-resistant *Staphylococcus aureus* (MRSA) bloodstream infections: effect of the MRSA "search and isolate" strategy in a hospital in Italy with hyperendemic MRSA. Infect Control Hosp Epidemiol 2005;26:127-33.

20. Vos MC, Behrendt MD, Melles DC, et al. 5 Years of experience implementing a methicillin-resistant *Staphylococcus aureus* search and destroy policy at the largest university medical center in the Netherlands. Infect Control Hosp Epidemiol 2009;30:977-84.

21. Gorwitz RJ, Kruszon-Moran D, McAllister SK, et al. Changes in the prevalence of nasal colonization with *Staphylococcus aureus* in the United States, 2001-2004. J Infect Dis 2008;197:1226-34.

22. Merrer J, Santoli F, Appéré de Vecchi C, Tran B, De Jonghe B, Outin H. "Colonization pressure" and risk of acquisition of methicillin-resistant *Staphylococcus aureus* in a medical intensive care unit. Infect Control Hosp Epidemiol 2000;21:718-23.

23. Williams VR, Callery S, Vearncombe M, Simor AE. The role of colonization pressure in nosocomial transmission of methicillin-resistant *Staphylococcus aureus.* Am J Infect Control 2009;37:106-10.

24. Wolk DM, Picton E, Johnson D, et al. Multicenter evaluation of the Cepheid

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Xpert methicillin-resistant *Staphylococcus aureus* (MRSA) test as a rapid screening method for detection of MRSA in nares. J Clin Microbiol 2009;47:758-64.
25. Chang S, Sethi AK, Eckstein BC, Stiefel U, Cadnum JL, Donskey CJ. Skin and environmental contamination with methicillin-resistant *Staphylococcus aureus* among carriers identified clinically versus through active surveillance. Clin Infect Dis 2009; 48:1423-8.
26. Croft CA, Mejia VA, Barker DE, et al. Methicillin-resistant *Staphylococcus aureus* in a trauma population: does colonization predict infection? Am Surg 2009;75:458-61.
27. Huang SS, Platt R. Risk of methicillin-resistant *Staphylococcus aureus* infection after previous infection or colonization. Clin Infect Dis 2003;36:281-5.
28. Pujol M, Peña C, Pallares R, et al. Nosocomial *Staphylococcus aureus* bacteremia among nasal carriers of methicillin-resistant and methicillin-susceptible strains. Am J Med 1996;100:509-16.
29. Davis KA, Stewart JJ, Crouch HK, Florez CE, Hospenthal DR. Methicillin-resistant *Staphylococcus aureus* (MRSA) nares colonization at hospital admission and its effect on subsequent MRSA infection. Clin Infect Dis 2004;39:776-82.
30. Robicsek A, Beaumont JL, Thomson RB Jr, Govindarajan G, Peterson LR. Topical therapy for methicillin-resistant *Staphylococcus aureus* colonization: impact on infection risk. Infect Control Hosp Epidemiol 2009;30:623-32.
31. WHO guidelines on hand hygiene in health care. Geneva: World Health Organization, 2009. (http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf.)
32. Boyce JM, Potter-Bynoe G, Chenevert C, King T. Environmental contamination due to methicillin-resistant *Staphylococcus aureus*: possible infection control implications. Infect Control Hosp Epidemiol 1997; 18:622-7.
33. Lucet JC, Chevret S, Durand-Zaleski I, Chastang C, Régnier B. Prevalence and risk factors for carriage of methicillin-resistant *Staphylococcus aureus* at admission to the intensive care unit: results of a multicenter study. Arch Intern Med 2003;163: 181-8.
34. Lee BY, Bailey RR, Smith KJ, et al. Universal methicillin-resistant *Staphylococcus aureus* (MRSA) surveillance for adults at hospital admission: an economic model and analysis. Infect Control Hosp Epidemiol 2010;31:598-606.
35. Nyman JA, Lees CH, Bockstedt LA, et al. Cost of screening intensive care unit patients for methicillin-resistant Staphylococcus aureus in hospitals. Am J Infect Control 2011;39:27-34.
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ORIGINAL ARTICLE

Intervention to Reduce Transmission of Resistant Bacteria in Intensive Care

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ABSTRACT

BACKGROUND

Intensive care units (ICUs) are high-risk settings for the transmission of methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococcus (VRE).

METHODS

In a cluster-randomized trial, we evaluated the effect of surveillance for MRSA and VRE colonization and of the expanded use of barrier precautions (intervention) as compared with existing practice (control) on the incidence of MRSA or VRE colonization or infection in adult ICUs. Surveillance cultures were obtained from patients in all participating ICUs; the results were reported only to ICUs assigned to the intervention. In intervention ICUs, patients who were colonized or infected with MRSA or VRE were assigned to care with contact precautions; all the other patients were assigned to care with universal gloving until their discharge or until surveillance cultures obtained at admission were reported to be negative.

RESULTS

During a 6-month intervention period, there were 5434 admissions to 10 intervention ICUs, and 3705 admissions to 8 control ICUs. Patients who were colonized or infected with MRSA or VRE were assigned to barrier precautions more frequently in intervention ICUs than in control ICUs (a median of 92% of ICU days with either contact precautions or universal gloving [51% with contact precautions and 43% with universal gloving] in intervention ICUs vs. a median of 38% of ICU days with contact precautions in control ICUs, $P<0.001$). In intervention ICUs, health care providers used clean gloves, gowns, and hand hygiene less frequently than required for contacts with patients assigned to barrier precautions; when contact precautions were specified, gloves were used for a median of 82% of contacts, gowns for 77% of contacts, and hand hygiene after 69% of contacts, and when universal gloving was specified, gloves were used for a median of 72% of contacts and hand hygiene after 62% of contacts. The mean (±SE) ICU-level incidence of events of colonization or infection with MRSA or VRE per 1000 patient-days at risk, adjusted for baseline incidence, did not differ significantly between the intervention and control ICUs (40.4±3.3 and 35.6±3.7 in the two groups, respectively; $P=0.35$).

CONCLUSIONS

The intervention was not effective in reducing the transmission of MRSA or VRE, although the use of barrier precautions by providers was less than what was required. (Funded by the National Institute of Allergy and Infectious Diseases and others; STAR*ICU ClinicalTrials.gov number, NCT00100386.)

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*The investigators and participating centers in the Strategies to Reduce Transmission of Antimicrobial Resistant Bacteria in Intensive Care Units (STAR*ICU) trial are listed in the Supplementary Appendix, available at NEJM.org.

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Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococcus (VRE) are major causes of health care–associated infection.[1] Infections caused by these bacteria are usually preceded by colonization of mucous membranes, skin, wounds, or the gastrointestinal tract. Colonization occurs by means of indirect patient-to-patient transmission of MRSA and VRE through the hands of health care providers and through contaminated fomites and environmental surfaces[2,3] or, less commonly, by direct transmission from colonized health care providers.[4]

Standard interventions to prevent the transmission of MRSA and VRE in health care facilities include hand hygiene, the use of barrier precautions (gloves and gowns) in the care of colonized and infected patients, the use of dedicated instruments and equipment for these patients, and the placement of colonized or infected patients in single rooms or multibed rooms or areas reserved for such patients.[5,6] Additional interventions, including active surveillance — screening to identify asymptomatically colonized patients who may serve as undetected reservoirs of MRSA and VRE — and topical antimicrobial treatments, are supported by ecologic, observational, and quasi-experimental studies and mathematical models.[7-18]

We hypothesized that culture-based active surveillance for MRSA and VRE and the expanded use of barrier precautions, as compared with existing practice, would reduce the incidence of colonization or infection with MRSA or VRE in adult intensive care units (ICUs).

METHODS

DESIGN

We conducted an unmasked, cluster-randomized, controlled trial with the ICU as the unit of randomization and inference. The trial consisted of three periods: baseline (April through November 2005), randomization and implementation (December 2005 through February 2006), and intervention (March through August 2006). The intervention period began when the Web-based system for reporting the results of surveillance cultures was activated.

The study was designed and conducted by the authors with guidance from the principal investigators of the Bacteriology and Mycology Study Group and members of the Risk Group 4 Research Committee (see the Supplementary Appendix, available with the full text of this article at NEJM.org). The staff at the coordinating center and the authors analyzed the data and vouch for the completeness and accuracy of the report. The commercial sponsors had no role in the design of the study, the accrual or analysis of the data, the reporting of the results, or the decision to submit the manuscript for publication. The protocol, including the statistical analysis plan, is available at NEJM.org.

ELIGIBILITY AND RANDOMIZATION

ICUs were eligible for inclusion in the study if they were adult medical, surgical, or medical–surgical ICUs with 1200 or more patient-days in a 6-month period and an estimated incidence of at least nine events of MRSA or VRE colonization or infection per 1000 patient-days as estimated on the basis of historical data. The study was approved by the physician and nurse directors in each ICU and the institutional review board at each participating site. The requirements for informed consent and for authorization by the federal Health Insurance Portability and Accountability Act (HIPAA) were waived on the basis of the criteria of Title 45, Section 46.116(d), of the Code of Federal Regulations and of Section 164.512(i) of the Privacy Rule, respectively. ICUs were randomly assigned, in a 1:1 ratio, to the intervention or to existing practice (control), with stratification according to type of ICU and the baseline incidence of MRSA or VRE colonization or infection.

INTERVENTION

In intervention ICUs, nasal swabs for MRSA surveillance cultures and stool or perianal swabs for VRE surveillance cultures were obtained from patients within 2 days after their admission to the ICU, weekly thereafter, and within 2 days before or after their discharge from the ICU. Swabs were shipped overnight, 6 days a week, for processing at the Clinical Microbiology Laboratory of the National Institutes of Health Clinical Center. Broth enrichment and extended incubation were used to enhance the sensitivity of the culture methods (see Table 1 in the Supplementary Appendix).[19,20] Results were reported by means of an access-controlled, Web-based system.

In intervention ICUs, the assignment of a patient to care with contact precautions was made at the time of admission if a patient had been infected or colonized with MRSA or VRE during

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the previous year and at any time during the ICU stay if a clinical or surveillance culture was reported to be positive for MRSA or VRE. Once contact precautions were initiated, they were continued for the entire ICU stay. All other patients were assigned to care with universal gloving from the time of admission until their discharge or until the results of surveillance cultures for both MRSA and VRE obtained at admission were reported to be negative, at which time they were assigned to standard precautions (unless isolation precautions were required for other conditions). The requirements for contact precautions, universal gloving, and standard precautions are specified in Table 1. No recommendations for the use of topical or systemic antimicrobial agents were provided.

In control ICUs, swabs for surveillance cultures were obtained and shipped with the use of procedures that were identical to those used in intervention ICUs, but the ICU staff did not have access to the results. Existing hospital procedures were used to identify patients who were colonized or infected with MRSA or VRE. Such patients were assigned to care with isolation precautions, which were generally consistent with contact precautions. All other patients were assigned to standard precautions (unless isolation precautions were required for other conditions).

Before randomization, all the ICUs received an aggregate report of the providers' use of standard precautions during the baseline period and a promotional program to improve the providers' use of standard precautions (see Additional Methods in the Supplementary Appendix). After randomization, intervention ICUs received training in the intervention, door signs describing each category of precautions, and an aggregate report on the providers' use of universal gloving during the first month of the intervention period.

In all the ICUs, monitors located in patients' rooms observed contacts between health care providers and patients or their immediate environment on random dates and times during daytime and evening hours and recorded the precaution category assigned to the patient, the type of contact, and the providers' use of hand hygiene, clean gloves, and a gown (Table 1 in the Supplementary Appendix).

MEASUREMENTS

Both patient-level and ICU-level data were collected (Table 1 in the Supplementary Appendix); all analyses were based on ICU-level aggregates, except as noted. A new event of colonization or infection was identified by a surveillance or clinical culture that was positive for MRSA or VRE. No attempt was made to distinguish colonization from infection. The event date was the date the earliest positive culture was obtained.

A patient was eligible to be considered as having a new event of colonization or infection if he or she had a length of stay in the ICU of at least 3 days, no history of colonization or infection during the previous year, no positive clinical culture within 2 days after admission to the ICU, and a negative surveillance culture obtained within 2 days after admission to the ICU. Days at risk were calculated from the date of the third ICU day through the event date or through either the date of discharge from the ICU or the date the last surveillance culture was obtained, whichever was later.

The primary outcome was the ICU-level incidence of new events of colonization or infection with MRSA or VRE per 1000 ICU patient-days at risk. Secondary ICU-level outcomes were the incidences of colonization or infection with MRSA and VRE calculated separately and the following implementation process measures: the percentage of ICU patient-days on which patients colonized or infected with MRSA or VRE were assigned to each of the precautions categories, the percentage of health care provider contacts with patients or their environment during which the provider performed hand hygiene before or after the contact or wore clean gloves or a gown (component measures), and the percentage of provider contacts during which the provider both wore clean gloves during the contact and performed hand hygiene after the contact (composite measure).

STATISTICAL ANALYSIS

We estimated the sample size on the basis of published data[22] and assumed a mean baseline incidence of MRSA or VRE colonization or infection of 30 per 1000 patient-days, a variance of 49 with a 20% reduction in that variance obtained from adjustment for baseline incidence, and a 25% reduction in incidence from baseline in both intervention and control ICUs, owing to the program promoting standard precautions. Using those assumptions, we estimated that with 10 ICUs in each group, the study would have at least 85% power to show an additional 40% reduction in incidence in intervention ICUs, with a two-sided

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Table 1. Minimum Requirements for Hand Hygiene and Use of Gloves and Gowns by Health Care Providers during Contacts with Patients or Their Immediate Environment.*

Type of Contact†	Standard Precautions				Universal Gloving				Contact Precautions			
	Hand Hygiene‡		Gloves§	Gown§	Hand Hygiene‡		Gloves§	Gown§	Hand Hygiene‡		Gloves§	Gown§
	before contact	*after contact*			*before contact*	*after contact*			*before contact*	*after contact*		
Sterile	+	+	+	+	+	+	+	+	+	+	+	+
Contaminated	+	+	+		+	+	+		+	+	+	+
Blood or body fluid	+	+	+		+	+	+		+	+	+	+
Invasive device	+	+			+	+	+		+	+	+	+
Other patient	+	+			+	+	+		+	+	+	+
Environment only		+				+	+			+	+	+

* A plus sign indicates that the practice was required. Requirements for the room assignments of patients, the use of dedicated instruments and equipment, and the cleaning and disinfecting of contaminated items were specified by guidelines that were current when the trial was initiated.[21]

† Sterile contacts involved performing a sterile procedure; contaminated contacts involved potential contact with secretions, excretions, mucous membranes, non-intact skin, or items or surfaces that are likely to be contaminated with body secretions or excretions; blood or body-fluid contacts involved potential contact with blood or body fluids capable of transmitting bloodborne viruses; invasive-device contacts involved opening or accessing an invasive device that entered a sterile body site directly; and other patient contact involved contacts not included in the previously described categories. Environment-only contacts involved touching items or surfaces in the patient's immediate environment only. Examples of each type of contact are provided in Table 2 in the Supplementary Appendix.

‡ Hand hygiene involved rubbing hands with a waterless, alcohol-based hand rub or washing hands with soap and water.

§ Sterile gloves and gowns were needed for sterile contacts; otherwise clean nonsterile gloves and gowns were sufficient.

type I error of 0.05. On the basis of observed factors, the 18-site study had a post hoc power of 80% to detect a 30% reduction in the incidence of MRSA or VRE colonization or infection in intervention ICUs.

The primary analysis was a comparison of the primary outcome between the intervention and control ICUs during the intervention period, with the use of an ICU-level analysis-of-covariance model with adjustment for baseline incidence and with the use of an F-test, with a two-sided P value of 0.05. We used similar models to evaluate the secondary outcomes and the relationship between the primary outcome and implementation process measures. ICU-level and patient-level variables and implementation process measures were compared between the groups within the baseline and intervention periods with the use of Wilcoxon rank-sum tests and between periods within groups with the use of Wilcoxon signed-rank tests, with no adjustment for multiple comparisons.

Patient-level exploratory analyses were performed with time from admission to a new event of colonization or infection with MRSA or VRE as the outcome, with the use of Cox proportional-hazards models with adjustment for within-ICU correlation.[23] Data were censored at the time of a patient's discharge from the ICU or at the end of the study in the case of patients who were still in the ICU and were negative for both MRSA and VRE colonization or infection. ICU-level and patient-level variables were evaluated as possible confounders with the use of paired models that examined the effect of the intervention on the risk of a new colonization or infection event with and without the variable. We generated a "best fit" multivariable model using backward elimination and including all potential confounders with P values of less than 0.10. This model was also used to assess the effect of the intervention by month.

RESULTS

CHARACTERISTICS OF ICUs AND PATIENTS

Figure 1 shows the random assignment of ICUs to the intervention or control group and the follow-up of patients in the intervention and control ICUs. There were no significant differences in key characteristics between patients in the intervention ICUs and those in the control ICUs, except with respect to the prescription of some topical and systemic antimicrobial agents (Table 2, and Table 3 in the Supplementary Appendix).

RESULTS OF SURVEILLANCE CULTURES

In intervention ICUs, the mean (±SD) number of days from the time a surveillance culture was obtained until the time it was reported was 5.2±1.4.

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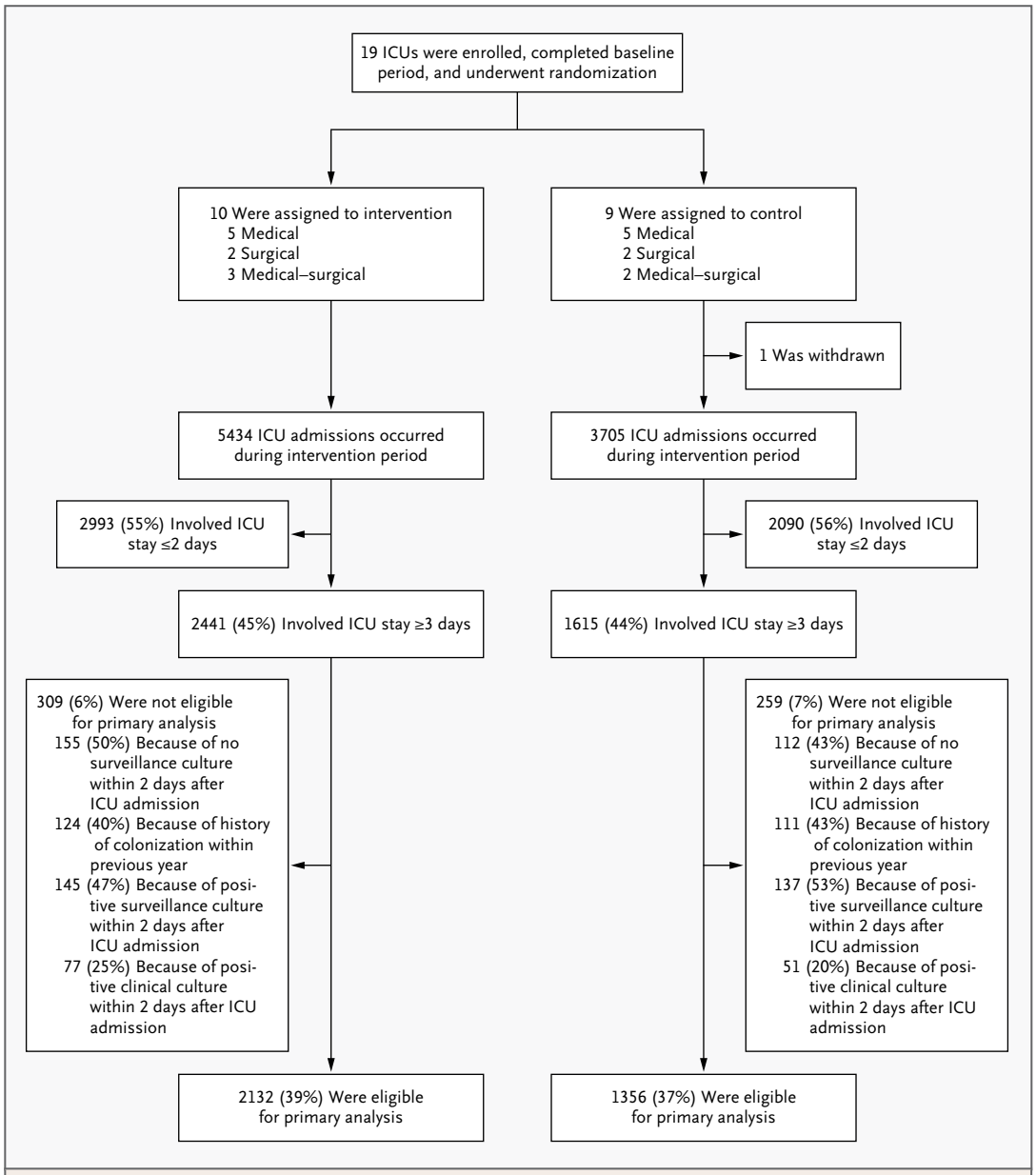

Figure 1. Randomization of Intensive Care Units (ICUs) and Follow-up of Patients.

The ICU-level percentage of patients with multiple admissions was 7.6% among all ICU stays and 6.1% among ICU stays of 3 days or more; therefore, each admission was treated as an independent event. A total of 20 ICUs were eligible for the study, of which 19 participated. In addition, 1 medical ICU assigned to the control group was withdrawn from the study owing to a failure to collect surveillance cultures according to the study protocol. Data from this ICU were excluded from all analyses. During the intervention period, there were 24,484 total ICU patient-days in the intervention ICUs and 16,579 total ICU patient-days in the control ICUs. A total of 18,136 ICU patient-days at risk (74% of total ICU patient-days) in the intervention group and 11,827 ICU patient-days at risk (71% of total ICU patient-days) in the control group were included in the primary analysis. ICU stays could have multiple reasons for not being eligible for the primary analysis.

Among patients with an ICU stay of 3 days or more, 41% (range, 30 to 66) of all ICU patient-days coincided with or followed the day on which the results of surveillance cultures were reported. In a substantial proportion of patients in all ICUs who were colonized or infected with MRSA or VRE at the time of admission or who had new colonization or infection events during their stay in the

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ICU, MRSA or VRE was detected only by means of surveillance cultures, with no evidence of a significant difference between intervention and control ICUs. The median proportions of patients with positive surveillance cultures were 46% (range, 16 to 56) in intervention ICUs and 38% (range, 14 to 77) in control ICUs for detection of MRSA at admission (P=0.81); 62% (range, 29 to 83) and 77% (range, 43 to 92) in the two groups, respectively, for detection of VRE at admission (P=0.18); 77% (range, 43 to 96) and 86% (range, 24 to 100) in the respective groups for detection of a new MRSA event (P=0.30); and 100% (range, 91 to 100) and 99% (range, 80 to 100) in the respective groups for detection of a new VRE event (P=0.51) (Table 4 in the Supplementary Appendix).

ASSIGNMENT OF PRECAUTIONS CATEGORIES

Patients who were colonized or infected with MRSA or VRE were assigned to expanded barrier precautions more frequently in intervention ICUs than in control ICUs. In the intervention ICUs, these patients were assigned to contact precautions for a median of 51% (range, 30 to 85) of

Table 2. Characteristics of Patient Populations.*

Characteristic	Baseline Period			Intervention Period		
	Intervention ICUs (N=10)	Control ICUs (N=8)	P Value†	Intervention ICUs (N=10)	Control ICUs (N=8)	P Value†
	median (range)‡			*median (range)‡*		
Colonization or infection during previous year — %						
MRSA	6.6 (1.9–16.2)	5.7 (2.7–13.9)	0.97	6.5 (3.1–13.4)	5.8 (2.0–14.7)	1.00
VRE	4.0 (0.0–14.4)	4.3 (1.4–8.5)	0.46	4.4 (1.6–16.8)	4.4 (0.7–10.5)	0.90
Positive clinical culture on admission — %§						
MRSA	4.0 (1.1–19.2)	3.1 (1.1–9.4)	0.97	3.0 (1.7–14.2)	2.8 (0.4–7.0)	0.70
VRE	1.9 (0.0–23.1)	0.9 (0.7–3.0)	0.41	1.5 (0.4–23.0)	1.5 (0.0–7.4)	0.70
Positive surveillance culture on admission — %§						
MRSA	9.5 (6.3–14.8)	12.4 (8.7–24.3)	0.08	10.6 (8.3–19.8)	12.6 (6.2–17.6)	0.97
VRE	13.6 (6.9–24.4)	17.2 (8.9–26.2)	0.57	16.9 (7.9–39.9)	22.1 (12.3–34.4)	0.63
Use of topical antimicrobial agent — %						
Any	9.0 (2.3–33.3)	4.2 (0.2–11.3)	0.10	12.0 (2.5–36.1)	3.2 (0.3–13.0)	0.07
Bacitracin	3.6 (0.9–7.6)	2.2 (0.0–3.7)	0.10	2.8 (0.1–11.8)	1.2 (0.2–8.6)	0.41
Mupirocin¶	0.3 (0.0–24.5)	0.1 (0.0–1.1)	0.48	0.1 (0.0–24.4)	0.0 (0.0–0.5)	0.33
Chlorhexidine gluconate¶	0.0 (0.0–25.3)	0.0 (0.0–1.6)	0.71	0.0 (0.0–30.9)	0.0 (0.0–8.4)	0.71
Vancomycin, enteric	0.0 (0.0–0.5)	0.4 (0.0–2.9)	0.02	0.0 (0.0–1.3)	0.5 (0.0–3.6)	0.04
Use of systemic antimicrobial agent — %						
Regimen with anti-anaerobic activity	35.8 (19.5–48.4)	41.9 (31.8–55.0)	0.41	35.4 (21.6–46.2)	43.8 (34.9–52.9)	0.01
Vancomycin	24.6 (11.8–33.8)	28.0 (18.0–39.6)	0.46	23.8 (12.8–40.0)	32.0 (18.8–37.2)	0.17
Piperacillin–tazobactam	15.2 (0.0–27.0)	24.6 (6.9–36.8)	0.10	13.6 (0.0–19.9)	22.6 (6.4–28.9)	0.03
Cefepime	11.2 (0.0–25.8)	1.1 (0.0–8.6)	0.03	13.4 (0.0–23.2)	3.5 (0.0–20.0)	0.09
Levofloxacin	12.7 (0.0–24.2)	0.1 (0.0–27.8)	0.82	9.9 (0.0–23.7)	0.2 (0.0–23.8)	0.55
Metronidazole	7.3 (1.4–21.4)	11.1 (0.0–19.8)	0.83	6.6 (4.8–19.9)	13.3 (5.8–25.3)	0.20

* A complete list of the characteristics of the intensive care units (ICUs) and the patient populations is provided in Table 2 in the Supplementary Appendix. MRSA denotes methicillin-resistant *Staphylococcus aureus,* and VRE vancomycin-resistant enterococcus.
† P values were calculated with the use of the Wilcoxon rank-sum test.
‡ Values are ICU-level estimates.
§ Cultures were obtained within 2 days after admission to the ICU.
¶ Mupirocin was almost always administered by intranasal application, and chlorhexidine by intraoral application.

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all ICU patient-days, universal gloving for 43% (range, 9 to 56) of ICU patient-days, and either contact precautions or universal gloving for 92% (range, 80 to 95) of ICU patient-days. In control ICUs, these patients were assigned to contact precautions for a median of 38% (range, 12 to 59) of all ICU patient-days; universal gloving was not used (P<0.001 for the comparison of either contact precautions or universal gloving in intervention ICUs with contact precautions in control ICUs) (Table 5 in the Supplementary Appendix).

HEALTH CARE PROVIDERS' USE OF HAND HYGIENE, CLEAN GLOVES, AND GOWNS

Across all contacts, regardless of the type or category of precautions, the composite measure of providers' use of both clean gloves during the contact and hand hygiene after the contact was higher in intervention ICUs than in the control ICUs by a factor of almost 2 (a median of 47% of contacts [range, 26 to 63] vs. 25% of contacts [range, 4 to 61], P=0.02). For contacts with patients assigned to contact precautions, providers in intervention ICUs used clean gloves and a gown and performed hand hygiene after contact less frequently than required, but marginally more frequently, and with less site-to-site variability, than did providers in control ICUs (Fig. 2A and 2C). Clean gloves were used for a median of 82% of contacts (range, 55 to 87) in intervention ICUs, as compared with 72% (range, 27 to 95) in control ICUs; gowns, for 77% of contacts (range, 60 to 88) in intervention ICUs, as compared with 59% (range, 0 to 93) in control ICUs; and hygiene after contact, for 69% of contacts (range, 38 to 77) in intervention ICUs, as compared with 59% (range, 20 to 88) in control ICUs. For contacts with patients assigned to universal gloving in intervention ICUs, providers used clean gloves and performed hand hygiene after contact less frequently than required and marginally less frequently than for contacts with patients assigned to contact precautions (Fig. 2B); clean gloves were used for a median of 72% of contacts (range, 46 to 77), and hygiene after contact for 62% of contacts (range, 38 to 82). Regardless of the precautions category or the ICU group assignment, providers used clean gloves and a gown and performed hygiene after contact less frequently for contacts with the environment than for all other contact types (Fig. 2). Individual ICU data are provided in Tables 6 through 11 in the Supplementary Appendix.

COLONIZATION OR INFECTION WITH MRSA OR VRE

The monthly ICU-level incidence of MRSA or VRE colonization or infection varied considerably within both ICU groups during the baseline and intervention periods (Fig. 3; see also the figure and Table 12 in the Supplementary Appendix). The percentage change from baseline in the incidence of colonization or infection during the intervention period varied widely in both ICU groups — a median change in the intervention ICUs of 30% (range, –29 to 105) in the incidence of MRSA or VRE, of 10% (range, –43 to 148) in the incidence of MRSA, and of 35% (range, –32 to 197) in the incidence of VRE; and a median change in the control ICUs of 5% (range, –40 to 36) in the incidence of MRSA or VRE, of –9% (range, –52 to 75) in the incidence of MRSA, and of 13% (range, –27 to 90) in the incidence of VRE.

The mean (±SE) ICU-level incidence of events of colonization or infection with MRSA or VRE per 1000 patient-days at risk, adjusted for baseline incidence, did not differ significantly between the intervention and control ICUs (40.4±3.3 and 35.6±3.7 in the two groups, respectively; P=0.35), nor did the ICU-level incidence of MRSA or VRE considered separately (16.0±1.8 and 13.5±2.1 in the two groups, respectively, for MRSA; P=0.39; and 38.9±5.6 and 33.4±6.3 in the two groups, respectively, for VRE; P=0.53).

The ICU-level incidence of MRSA or VRE colonization or infection was not significantly associated with the percentage of ICU patient-days on which colonized or infected patients were assigned to contact precautions (P=0.26) or the percentage of health care provider contacts during which the provider both wore clean gloves during the contact and performed hand hygiene after the contact, either when caring for patients assigned to all precaution categories (P=0.61) or when caring for patients assigned to contact precautions (P=0.92).

The patient-level risk of MRSA or VRE colonization or infection showed little evidence of confounding between patient-level and ICU-level covariates and the intervention (unadjusted hazard ratio for care in an intervention ICU, 1.17; 95% confidence interval [CI], 0.88 to 1.54; P=0.28, with adjusted hazard ratios in bivariable models ranging from 1.04 to 1.25; P>0.13 for all models) (Table 13 in the Supplementary Appendix). An adjusted multivariable model including all potential confounders showed no evidence of an inter-

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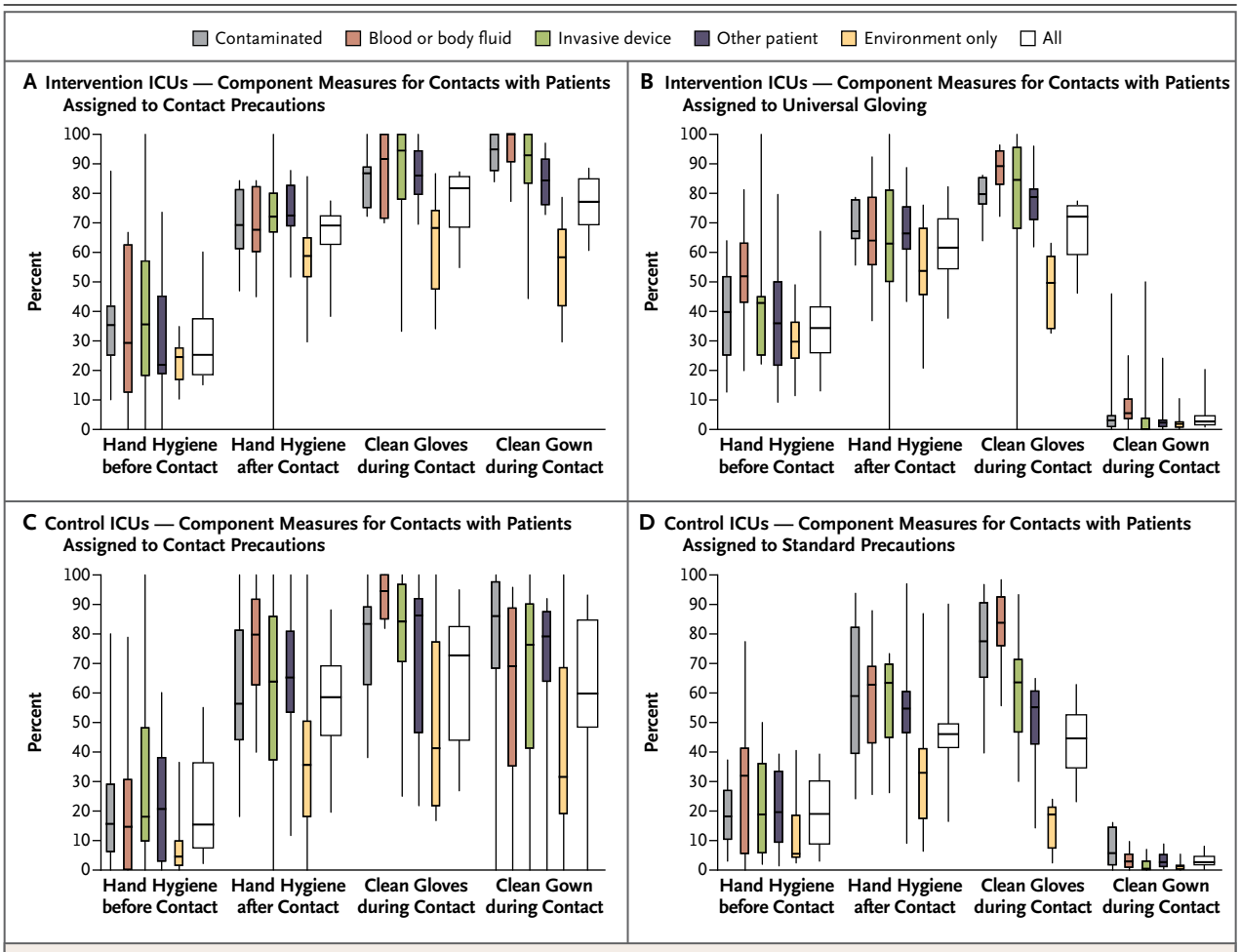

Figure 2. Use of Hand Hygiene, Gloves, and Gowns by Health Care Providers in Intensive Care Units (ICUs) during Contacts with Patients or Their Immediate Environment.

The box plot diagram shows the distribution of ICU-level percentages for the use of component measures for all contacts (white boxes) and according to type of contact (colored boxes). The box represents the interquartile range and the horizontal line inside the box the median; vertical lines represent the maximum and minimum percentages. Contaminated refers to actual or potential contact with secretions, excretions, mucous membranes, non-intact skin, or items or surfaces that are likely to be contaminated with body secretions or excretions. Data regarding sterile contacts in both ICU groups and the use of standard precautions in intervention ICUs are not presented because of the small number of observed contacts. The distributions of types of contacts across all precaution categories were as follows: in intervention ICUs, contaminated, 15%; blood or body fluid, 8%; invasive device, 6%; any other patient, 34%; and environment only, 37%; in control ICUs, contaminated, 15%; blood or body fluid, 8%; invasive device, 8%; any other patient, 32%; and environment only, 37%. Data for individual ICUs are provided in Tables 6 through 11 in the Supplementary Appendix.

vention effect overall (adjusted hazard ratio for care in an intervention ICU, 1.05; 95% CI, 0.81 to 1.36; P=0.72) (Table 14 in the Supplementary Appendix) or a consistent effect over time (adjusted hazard ratio for care in an intervention ICU, 0.86; 95% CI, 0.56 to 1.22; P=0.50 for month 1 of the intervention period; hazard ratio, 1.59; 95% CI, 1.14 to 2.22; P=0.006 for month 2; hazard ratio, 1.73; 95% CI, 1.09 to 2.74; P=0.02 for month 3; hazard ratio, 0.98; 95% CI, 0.62 to 1.54; P=0.92 for month 4; hazard ratio, 1.16; 95% CI, 0.63 to 2.16; P=0.63 for month 5; and hazard ratio, 0.76; 95% CI, 0.35 to 1.63; P=0.48 for month 6).

DISCUSSION

In this trial, an intervention that included culture-based active surveillance and the expanded use of

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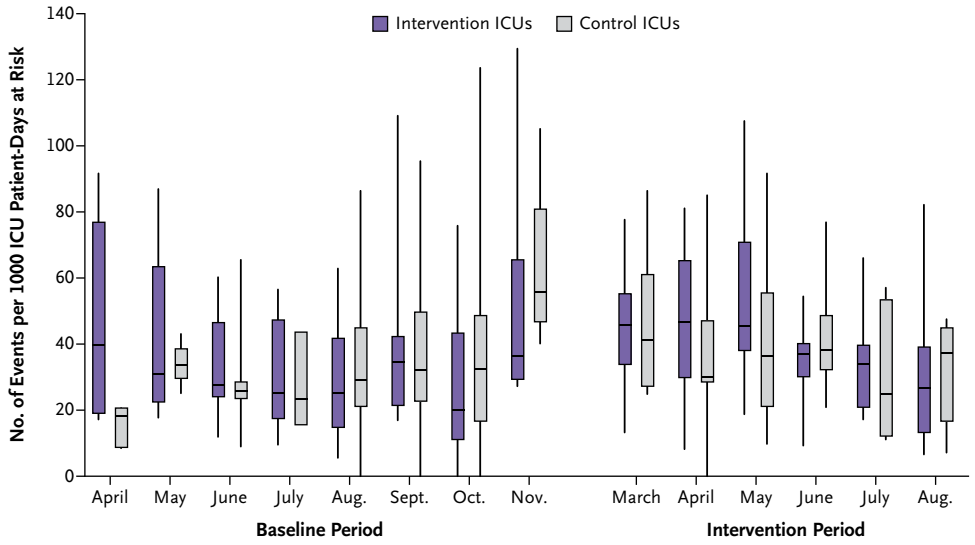

Figure 3. Monthly Incidence of Colonization or Infection with Methicillin-Resistant *Staphylococcus aureus* (MRSA) or Vancomycin-Resistant Enterococcus (VRE) among Patients in Intensive Care Units (ICUs).

The box plot diagram shows the distribution of ICU-level incidences of colonization or infection with MRSA or VRE. The box represents the interquartile range, and the horizontal line inside the box the median; vertical lines represent the maximum and minimum percentages. The median number of incidences of colonization or infection according to period were as follows: in intervention ICUs during the baseline period, 30.1 (range, 14.5 to 76.1) for MRSA or VRE, 11.9 (range, 6.8 to 19.6) for MRSA, and 25.7 (range, 9.7 to 78.2) for VRE, and in intervention ICUs during the intervention period, 40.3 (range, 20.8 to 54.9) for MRSA or VRE, 14.6 (range, 6.8 to 21.8) for MRSA, and 36.8 (range, 6.6 to 87.0) for VRE; in control ICUs during the baseline period, 32.5 (range, 12.3 to 58.4) for MRSA or VRE, 13.2 (range, 3.8 to 39.4) for MRSA, and 27.1 (range 9.9 to 53.4) for VRE, and in control ICUs during the intervention period, 32.6 (range, 15.8 to 60.7) for MRSA or VRE, 11.1 (range, 6.6 to 48.9) for MRSA, and 29.9 (range, 11.1 to 71.1) for VRE. Individual ICU data are provided in the figure and Table 2 in the Supplementary Appendix.

barrier precautions, as compared with existing hospital practice, was not effective in reducing the incidence of MRSA or VRE colonization or infection in adult ICUs. This finding was surprising, given that surveillance cultures identified a sizable subgroup of colonized patients who were not otherwise recognized and that colonized or infected patients were assigned to either contact precautions or universal gloving for nearly all their ICU patient-days. Several factors may explain this result.

Studies with less rigorous designs may have overestimated the effectiveness of MRSA and VRE control programs. Indeed, systematic reviews have identified major methodologic weaknesses in many previous studies, including the lack of concurrent control groups.[6,24,25] More recent studies have yielded mixed results.[14,26]

The expanded use of barrier precautions may have been insufficient to reduce the transmission of MRSA or VRE for two reasons. First, the turnaround time for reporting a positive result on a surveillance culture was prolonged, which increased the proportion of days that patients who were colonized or infected with MRSA or VRE were assigned to universal gloving instead of contact precautions. Contact precautions are recommended for the care of colonized or infected patients because these precautions specify the use of gowns to prevent contamination of clothing and the use of dedicated instruments and equipment.[5,6] In addition, the practice of hand hygiene and the use of gloves by providers may be enhanced.[27] However, the evidence that gowns prevent transmission of MRSA or VRE or that contact precautions increase the practice of hand hygiene or the use of gloves is mixed.[27-32] We observed that providers used gloves only marginally more often when they cared for patients assigned to contact precautions than when they cared for

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patients assigned to universal gloving (Fig. 2), and we found no evidence of an inverse relationship between the percentage of ICU patient-days that colonized or infected patients were assigned to contact precautions and the primary outcome.

Second, the use by health care providers of the required components of contact precautions and universal gloving was less than required (Fig. 2), particularly with respect to contacts with the environment only, and may have been overestimated because monitoring was not surreptitious and was performed only during daytime and evening hours. However, we found no evidence of an inverse relationship between providers' use of both gloves during contact and hand hygiene after contact with patients or their environment and the primary outcome. Nonetheless, faster turnaround time for reporting the results of surveillance cultures and exemplary performance with respect to providers' use of barrier precautions and hand hygiene may reduce transmission more effectively.

Colonized patients who were not identified at the time of admission could have served as persistent reservoirs of MRSA or VRE and could have been misclassified as having incident events later in their ICU stay. Detection of MRSA colonization in patients is enhanced when body sites in addition to the anterior nares are cultured, including the pharynx, open wounds, skin, respiratory secretions, and the rectum or stool.[33,34] We performed surveillance cultures for MRSA and VRE from single body sites only but used broth enrichment and extended incubation to enhance the sensitivity of our culture methods.[19,20] This probably explains why the prevalence of colonization at the time of ICU admission in this trial was 15% higher for MRSA and 64% higher for VRE than that reported previously.[11,12]

MRSA and VRE may have been transmitted by routes other than those the intervention was designed to interrupt, such as by contaminated instruments or equipment or by colonized health care workers.[4] However, these events were unlikely to have been frequent enough across multiple ICUs to account for the findings.

The intervention period may not have been long enough to show an effect. Previous studies have observed that a reduction in the incidence of MRSA infection may not be evident until a year or more after initiation of an intervention.[13,14] However, the trial design and methods make a delayed intervention effect unlikely, and there was no evidence of a small effect by month that might have become significant if the intervention period had been longer.

Additional interventions that reduce the density of colonization of body sites or contamination of the environment may be necessary. Intranasal mupirocin, coupled with other systemic and topical agents, reduces MRSA colonization in the short term, but its long-term effect is limited and is associated with the development of mupirocin resistance.[35] Daily bathing of patients with chlorhexidine and improved environmental cleaning have, in quasi-experimental studies, shown promise in reducing the incidence of MRSA and VRE colonization among ICU patients.[15,16,36] Treatment with systemic antibiotics that have antianaerobic activity promotes high-density colonization of VRE in the gastrointestinal tract, and the use of fluoroquinolone has been associated with increased rates of MRSA colonization or infection.[37,38] Efforts to reduce the unnecessary use of these agents may complement other interventions.

The results of this trial indicate that merely improving the identification of colonized patients and expanding the use of barrier precautions, at least as achieved during this trial, are measures that are not likely to be broadly effective. If transmission of MRSA and VRE in health care facilities is to be decreased substantially, improvement in reliable, sustainable adherence to isolation precautions is important and may need to be complemented by interventions to reduce the density of MRSA or VRE colonization of body sites and to decrease environmental contamination.

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Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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REFERENCES

1. Hidron AI, Edwards JR, Patel J, et al. NHSN annual update: antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2006-2007. Infect Control Hosp Epidemiol 2008;29:996-1011. [Erratum, Infect Control Hosp Epidemiol 2009;30:107.]

2. Duckro AN, Blom DW, Lyle EA, Weinstein RA, Hayden MK. Transfer of vancomycin-resistant enterococci via health care worker hands. Arch Intern Med 2005; 165:302-7.

3. Hardy KJ, Oppenheim BA, Gossain S, Gao F, Hawkey PM. A study of the relationship between environmental contamination with methicillin-resistant *Staphylococcus aureus* (MRSA) and patients' acquisition of MRSA. Infect Control Hosp Epidemiol 2006;27:127-32.

4. Albrich WC, Harbarth S. Health-care workers: source, vector, or victim of MRSA? Lancet Infect Dis 2008;8:289-301.

5. Muto CA, Jernigan JA, Ostrowsky BE, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of *Staphylococcus aureus* and enterococcus. Infect Control Hosp Epidemiol 2003;24:362-86.

6. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Atlanta: Centers for Disease Control and Prevention, 2006. (http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf.)

7. Tiemersma EW, Bronzwaer SL, Lyytikainen O, et al. Methicillin-resistant *Staphylococcus aureus* in Europe, 1999-2002. Emerg Infect Dis 2004;10:1627-34.

8. Jernigan JA, Titus MG, Groschel DH, Getchell-White S, Farr BM. Effectiveness of contact isolation during a hospital outbreak of methicillin-resistant *Staphylococcus aureus.* Am J Epidemiol 1996;143:496-504. [Erratum, Am J Epidemiol 1996;143:1079.]

9. Ostrowsky BE, Trick WE, Sohn AH, et al. Control of vancomycin-resistant enterococcus in health care facilities in a region. N Engl J Med 2001;344:1427-33.

10. Lucet JC, Paoletti X, Lolom I, et al. Successful long-term program for controlling methicillin-resistant *Staphylococcus aureus* in intensive care units. Intensive Care Med 2005;31:1051-7.

11. Huang SS, Rifas-Shiman SL, Pottinger JM, et al. Improving the assessment of vancomycin-resistant enterococci by routine screening. J Infect Dis 2007;195: 339-46.

12. Huang SS, Rifas-Shiman SL, Warren DK, et al. Improving methicillin-resistant *Staphylococcus aureus* surveillance and reporting in intensive care units. J Infect Dis 2007;195:330-8.

13. Huang SS, Yokoe DS, Hinrichsen VL, et al. Impact of routine intensive care unit surveillance cultures and resultant barrier precautions on hospital-wide methicillin-resistant *Staphylococcus aureus* bacteremia. Clin Infect Dis 2006;43:971-8.

14. Robicsek A, Beaumont JL, Paule SM, et al. Universal surveillance for methicillin-resistant *Staphylococcus aureus* in 3 affiliated hospitals. Ann Intern Med 2008; 148:409-18.

15. Vernon MO, Hayden MK, Trick WE, Hayes RA, Blom DW, Weinstein RA. Chlorhexidine gluconate to cleanse patients in a medical intensive care unit: the effectiveness of source control to reduce the bioburden of vancomycin-resistant enterococci. Arch Intern Med 2006;166: 306-12.

16. Climo MW, Sepkowitz KA, Zuccotti G, et al. The effect of daily bathing with chlorhexidine on the acquisition of methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, and healthcare-associated bloodstream infections: results of a quasi-experimental multicenter trial. Crit Care Med 2009;37:1858-65.

17. Bootsma MC, Diekmann O, Bonten MJ. Controlling methicillin-resistant *Staphylococcus aureus*: quantifying the effects of interventions and rapid diagnostic testing. Proc Natl Acad Sci U S A 2006; 103:5620-5.

18. Perencevich EN, Fisman DN, Lipsitch M, Harris AD, Morris JG Jr, Smith DL. Projected benefits of active surveillance for vancomycin-resistant enterococci in intensive care units. Clin Infect Dis 2004; 38:1108-15.

19. Safdar N, Narans L, Gordon B, Maki DG. Comparison of culture screening methods for detection of nasal carriage of methicillin-resistant *Staphylococcus aureus*: a prospective study comparing 32 methods. J Clin Microbiol 2003;41:3163-6.

20. Ieven M, Vercauteren E, Descheemaeker P, van Laer F, Goossens H. Comparison of direct plating and broth enrichment culture for the detection of intestinal colonization by glycopeptide-resistant enterococci among hospitalized patients. J Clin Microbiol 1999;37:1436-40.

21. Garner JS, Hospital Infection Control Practices Advisory Committee. Guideline for isolation precautions in hospitals. Infect Control Hosp Epidemiol 1996;17:53-80. [Erratum, Infect Control Hosp Epidemiol 1996;17:214.]

22. Fridkin SK, Steward CD, Edwards JR, et al. Surveillance of antimicrobial use and antimicrobial resistance in United States hospitals: project ICARE phase 2 — Project Intensive Care Antimicrobial Resistance Epidemiology (ICARE) hospitals. Clin Infect Dis 1999;29:245-52.

23. Lee EW, Wei LJ, Amato D. Cox-type regression analysis for large numbers of small groups of correlated failure time observations. In: Klein JP, Goel PK, eds. Survival analysis: state of the art. Dordrecht, the Netherlands: Kluwer Academic, 1992:237-47.

24. Cooper BS, Stone SP, Kibbler CC, et al. Isolation measures in the hospital management of methicillin resistant *Staphylococcus aureus* (MRSA): systematic review of the literature. BMJ 2004;329:533.

25. Loveday HP, Pellowe CM, Jones SR, Pratt RJ. A systematic review of the evidence for interventions for the prevention and control of meticillin-resistant *Staphylococcus aureus* (1996-2004): report to the Joint MRSA Working Party (Subgroup A). J Hosp Infect 2006;63:Suppl 1:S45-S70.

26. Harbarth S, Fankhauser C, Schrenzel J, et al. Universal screening for methicillin-resistant *Staphylococcus aureus* at hospital admission and nosocomial infection in surgical patients. JAMA 2008;299:1149-57.

27. Slaughter S, Hayden MK, Nathan C, et al. A comparison of the effect of universal use of gloves and gowns with that of glove use alone on acquisition of vancomycin-resistant enterococci in a medical intensive care unit. Ann Intern Med 1996; 125:448-56.

28. Srinivasan A, Song X, Ross T, Merz W, Brower R, Perl TM. A prospective study to determine whether cover gowns in addition to gloves decrease nosocomial transmission of vancomycin-resistant enterococci in an intensive care unit. Infect Control Hosp Epidemiol 2002;23:424-8.

29. Puzniak LA, Leet T, Mayfield J, Kollef M, Mundy LM. To gown or not to gown: the effect on acquisition of vancomycin-resistant enterococci. Clin Infect Dis 2002;35:18-25.

30. Grant J, Ramman-Haddad L, Dendukuri N, Libman MD. The role of gowns in preventing nosocomial transmission of methicillin-resistant *Staphylococcus aureus* (MRSA): gown use in MRSA control. Infect Control Hosp Epidemiol 2006;27: 191-4.

31. Golan Y, Doron S, Griffith J, et al. The impact of gown-use requirement on hand hygiene compliance. Clin Infect Dis 2006; 42:370-6.

32. Bearman GM, Marra AR, Sessler CN, et al. A controlled trial of universal gloving versus contact precautions for preventing the transmission of multidrug-resistant organisms. Am J Infect Control 2007;35:650-5.

33. Currie A, Davis L, Odrobina E, et al. Sensitivities of nasal and rectal swabs for detection of methicillin-resistant *Staphylococcus aureus* colonization in an active surveillance program. J Clin Microbiol 2008;46:3101-3.

34. Acton DS, Plat-Sinnige MJ, van Wamel W, de Groot N, van Belkum A. Intestinal carriage of *Staphylococcus aureus*: how does

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its frequency compare with that of nasal carriage and what is its clinical impact? Eur J Clin Microbiol Infect Dis 2009;28:115-27.

35. Ammerlaan HS, Kluytmans JA, Wertheim HF, Nouwen JL, Bonten MJ. Eradication of methicillin-resistant *Staphylococcus aureus* carriage: a systematic review. Clin Infect Dis 2009;48:922-30.

36. Hayden MK, Bonten MJ, Blom DW, Lyle EA, van de Vijver DA, Weinstein RA. Reduction in acquisition of vancomycin-resistant enterococcus after enforcement of routine environmental cleaning measures. Clin Infect Dis 2006;42:1552-60.

37. Donskey CJ, Chowdhry TK, Hecker MT, et al. Effect of antibiotic therapy on the density of vancomycin-resistant enterococci in the stool of colonized patients. N Engl J Med 2000;343:1925-32.

38. Muller A, Mauny F, Talon D, Donnan PT, Harbarth S, Bertrand X. Effect of individual- and group-level antibiotic exposure on MRSA isolation: a multilevel analysis. J Antimicrob Chemother 2006;58:878-81.

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Time for a Culture Change?

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Health care–associated infections are important, often preventable, causes of poor outcomes and unnecessary costs of medical care.[1] To address this public health problem, professional societies, quality-improvement organizations, accrediting bodies, and federal advisory committees and agencies have issued guidelines and recommendations aimed at preventing these infections.[2] Many states have legislated specific prevention measures, and the Centers for Medicare and Medicaid Services withholds payment for costs associated with certain infections.[3] Nonetheless, important gaps exist in our knowledge of the effectiveness of many recommended or mandated prevention methods.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a poster child for this problem, because of the illness it causes and the breadth of prevention measures it has engendered. Despite these measures, MRSA remains a serious problem, complicating more than a quarter million hospitalizations and contributing to thousands of deaths in the United States each year.[4] Containment strategies include barrier precautions, hand hygiene, prevention bundles, environmental decontamination, and decolonization of asymptomatic patients who carry the organism.[2] Ten states mandate that surveillance cultures be obtained for all patients who are admitted to intensive care units (ICUs).[5] This policy is based on data suggesting that active surveillance has a positive effect in limited populations; however, these data are hardly conclusive.[6] In addition, much of the data we have comes from settings and participants that may not be representative. There is no question, however, that resources that are already scarce are dedicated to these prevention strategies.

Two studies reported in this issue of the *Journal* evaluate interventions for the prevention of MRSA, but their combined message is far from clear.[6,7] Although the studies differ in important ways, both address active surveillance culturing, barrier precautions, and substantial engagement of health care providers through training and feedback. Yet they reach nearly opposite conclusions.

Huskins and colleagues[6] report an efficacy study (performed in optimal conditions) that is a rigorous, cluster-randomized, controlled trial involving more than 9000 patients admitted to 18 ICUs. The intervention included the components described above plus universal gloving until a patient's colonization status was known to be negative, supplemental materials such as precaution signs on patients' doors, and reports to personnel on adherence. This study had many admirable features: study personnel collected detailed data before and during the intervention, trained observers assessed providers' adherence at unannounced times, all ICUs used a single reference laboratory for assessment of the surveillance cultures, and the analysis took into account both individual patients and institutions. The result of the intervention was an increase in the use of precautions and improved adherence, but there was no effect on the rates of colonization or infection.

Jain et al.[7] evaluated the effectiveness (as assessed in conditions of actual practice) of a "MRSA bundle," a Veterans Affairs (VA) system-wide quality-improvement initiative, among nearly 2 million admissions, transfers, or discharges in 150 hospitals with 196 ICUs and 428 non-ICUs. Additional features of this intervention included increased attention to hand hygiene and a change in organizational culture that emphasized the responsibility of all personnel in preventing the acquisition and spread of MRSA. During the intervention period, there was a large decline in infections caused by MRSA, as well as those caused by other pathogens.

It is not clear how to reconcile these dramatically different results. Different study designs might explain part of the difference. For instance, the intervention in the study by Huskins et al. was assessed in ICUs only, whereas the VA study by Jain et al. included all the acute care units in the hospital (except for psychiatric units). Several features may have diminished the effect of the intervention in the study by Huskins et al. The average 5-day interval between the time a surveillance culture was obtained and the time the results were available certainly limited the usefulness of the surveillance; however, universal gloving should have afforded some of the benefit earlier results would have provided. The improvement in adherence to precautions may have

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been insufficient to reduce transmission. It is also possible that the benefits Jain et al. observed were due to factors other than the MRSA bundle. The VA system had introduced guidelines addressing ventilator-associated pneumonia and central-line–associated bloodstream infections in the previous year. It also issued a guidance document on decolonization of MRSA-colonized patients approximately 6 months after full implementation of the MRSA bundle, at about the time the dramatic drop in infections occurred (see the Supplementary Appendix, available with the full text of the article by Jain et al.). Interrupted time-series analyses incorporating the MRSA bundle and these other interventions might help elucidate the effect of the bundle. Analyses that include hospital-specific characteristics and address consistency across hospitals might also help us understand the factors that contributed to the good result. Taken together, these studies leave considerable uncertainty about whether the MRSA bundle, including routine surveillance cultures, is worthwhile in all settings. These studies do, however, underscore the importance of carefully evaluating the effect of existing state mandates to perform surveillance testing.

These studies also illustrate the larger challenge we confront in knowing whether health care practices produce the results we expect. Better evidence of effectiveness will require practice-based evaluation of treatments, tests, technologies, systems of care, and payment systems. The Institute of Medicine's Roundtable on Value and Science-Driven Health Care and its Clinical Effectiveness Innovation Collaborative identify the development of evidence as an essential element of the Learning Healthcare System, articulating both general principles and specific policies and programs.[8,9] These include, among others, rethinking the relationship between clinical practice and research, streamlining research oversight, and evaluating innovations in normal practice settings. Ongoing developments in information technology and analytic methods will facilitate these evaluations.

The most informative evaluations will be ones that are incorporated into the delivery of care and that compare persons who are exposed to a test or treatment with those who are not. Much of the information that is needed is already collected, or soon will be, with the use of electronic data systems. Fully observational studies will suffice in some situations. These might assess the effect of a change over time or between settings, with a comparison between exposed and unexposed patients. When implementation occurs over an extended period, sequencing the implementation to create comparable groups will allow a stronger conclusion to be reached. When these approaches are insufficient, practices, hospitals, or delivery systems may agree to be randomly assigned to one practice or another, creating comparable groups of exposed and unexposed patients.[10] Ideally, these efforts will span institutions, to improve both speed and generalizability.

Most important, it will be necessary to change the culture of clinical care. Clinicians, health system leaders, payers, purchasers, and above all, patients need to demand care that is proven to be effective as a condition of delivering, paying for, or receiving it. They must also be willing to participate in developing the evidence.

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1. Health-care-associated infections in hospitals: an overview of state reporting programs and individual hospital initiatives to reduce certain Infections. Washington, DC: Government Accounting Office, September 2008. (GAO no. 08-808.) (http://www.gao.gov/new.items/d08808.pdf.)
2. Yokoe DS, Mermel LA, Anderson DJ, et al. A compendium of strategies to prevent healthcare-associated infections in acute care hospitals. Infect Control Hosp Epidemiol 2008;29:Suppl 1: S12-S21.
3. HHS action plan to prevent healthcare-associated infections. (http://www.hhs.gov/ash/initiatives/hai/infection.html.)
4. Klein E, Smith DL, Laxminarayan R. Hospitalizations and deaths caused by methicillin-resistant Staphylococcus aureus, United States, 1999-2005. Emerg Infect Dis 2007;13:1840-6.
5. Association for Professionals in Infection Control and Epidemiology. Legislation in progress. (http://www.apic.org/map.)
6. Huskins WC, Huckabee CM, O'Grady NP, et al. Intervention to reduce transmission of resistant bacteria in intensive care. N Engl J Med 2011;364:1407-18.
7. Jain R, Kralovic SM, Evans ME, et al. Veterans Affairs initiative to prevent methicillin-resistant *Staphylococcus aureus* infections. N Engl J Med 2011;364:1419-30.
8. IOM (Institute of Medicine). Redesigning the clinical effectiveness research paradigm: innovation and practice-based approaches: workshop summary. Washington, DC: National Academies Press, 2010.
9. Field Advancement Working Group of the Clinical Effectiveness Research Innovation Collaborative. Barriers and opportunities to facilitate clinical effectiveness research innovation pace & progress. (http://iom.edu/~/media/Files/Activity%20Files/Quality/VSRT/CERICFieldAdvancementWGOct2010.pdf.)
10. Platt R, Takvorian SU, Septimus E, et al. Cluster randomized trials in comparative effectiveness research: randomizing hospitals to test methods for prevention of healthcare-associated infections. Med Care 2010;48:Suppl 6:S52-S57.

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