Management of patients colonized with MDRO: role of active surveillance and decontamination

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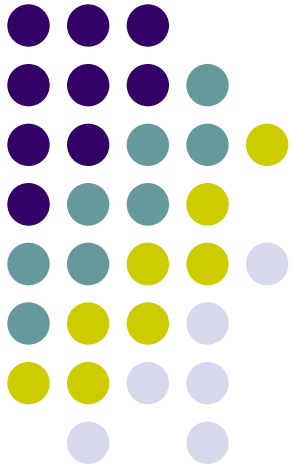
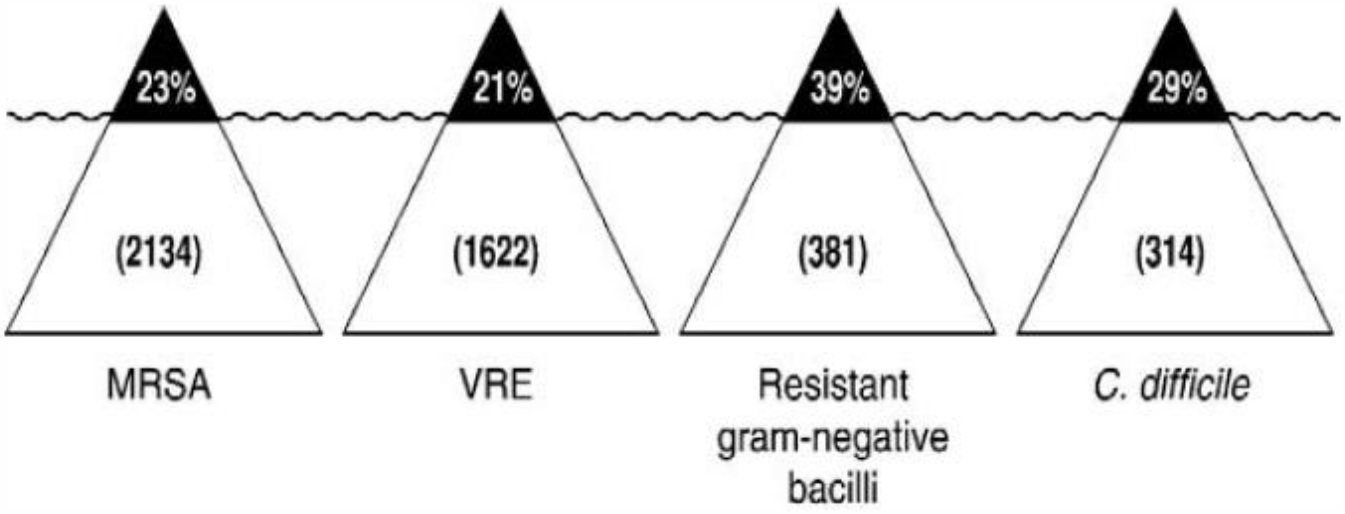


IHI MRSA Bundle

- Hand hygiene
- Decontamination of the environment and equipment
- Active surveillance testing
- Contact precautions for infected and colonized patients
- Central Line and Ventilator Bundles

The Iceberg phenomenon

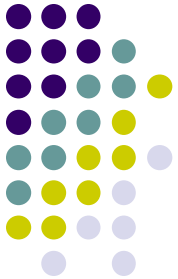


Source: Crnich C.J., Safdar N., Maki D.G.: The role of the intensive care unit environment in the pathogenesis and prevention of ventilator-associated pneumonia. *Respir Care* 50:813–838, Jun. 2005. Used with permission.

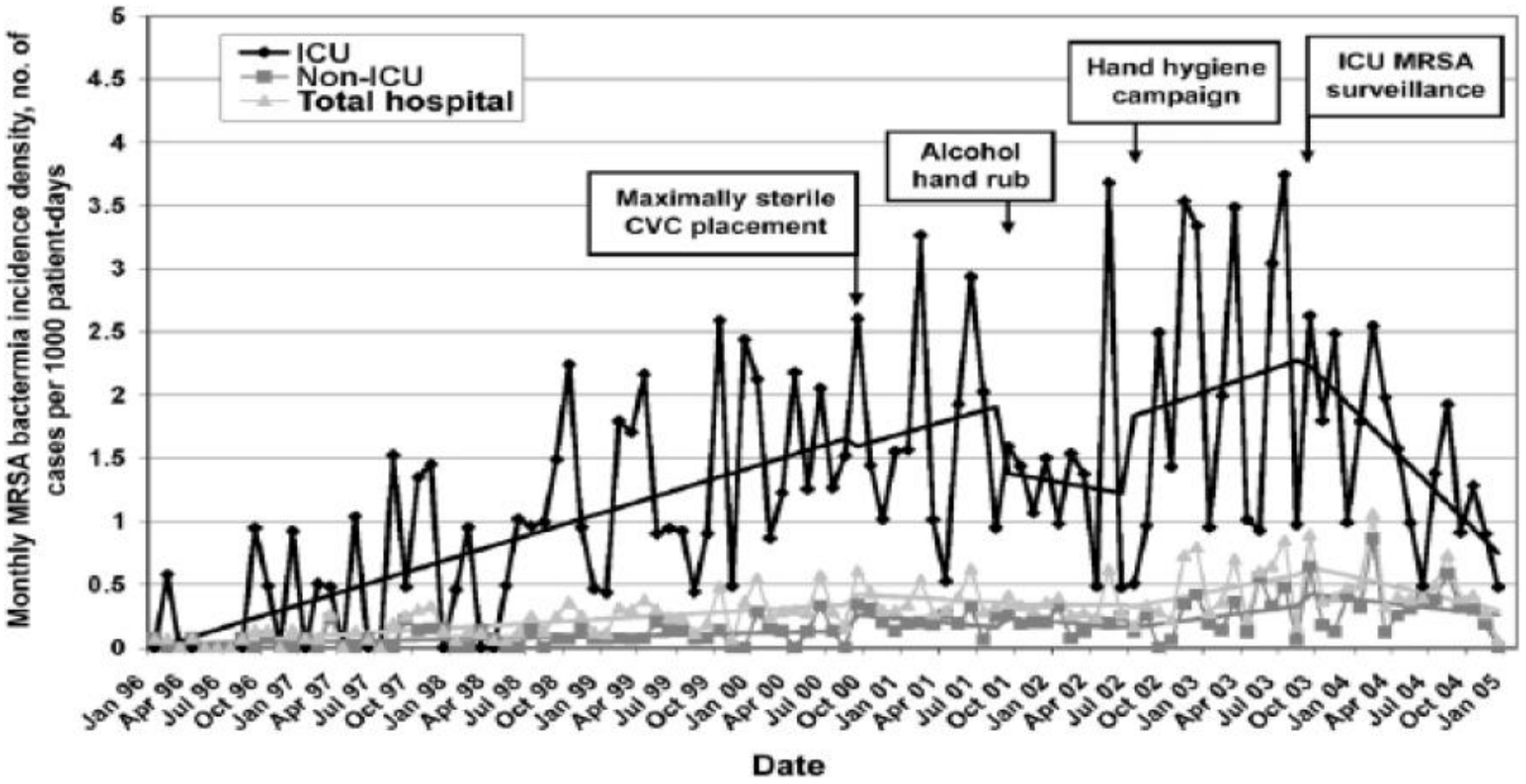
Active surveillance

- Rationale for active surveillance
  - to identify this population of patients so precautions can be implemented
  - reducing the risk that they may transmit their pathogen to other patients or the environment
    - MRSA carriers are reservoir for transmission
    - Nearly 1/3 develop infection, often after discharge
    - Long-lasting carriage

Literature on success of program

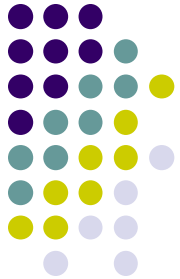


Study	Setting	Results
Chix et al, 1999	Medical ICU of a French university hospital	14% reduction in infection rate
Wernitz eta l, 2005	German 700-bed acute care teaching hospital	48% reduction in acquisition of MRSA
Petersen et al, 2007	3 hospitals in USA (academic, primary care acute care and community hospital)	Significant reduction in bacteremia following hospital-wide implementation of active surveillance
Chaberny et al, 2008	1400-bed university hospital in Germany	57% reduction in nosocomial MRSA infections following ASC in ICUs



Huang SS, Yokoe DS, Rego VH, et al. Impact of MRSA surveillance on bacteremia. *Clin Infect Dis*. 2006:43(8);971-978.

Potential benefits of screening



- Early isolation of MRSA carrier to prevent transmission
- Decolonization or optimized peri-operative prophylaxis to prevent SSI
- Avoid unnecessary isolation of at-risk patients when they are not colonized
- Decrease in morbidity
- Cost savings from shorter patient stays
- Fewer pre-emptive isolation days

Impact (1)

- 2 controlled studies concluded little or no benefit from universal rapid screening
  - Harbath et al. JAMA 2008; 299:1149-57
  - Jeyaratnam et al. BMJ 2008;336:927-30

- Recent study in Scottish hospital using chromogenic agar method for screening reported little benefit in universal screening
  - Reilly et al. J Hosp Infect 2010;74:35-41
  - Attributed to low colonization rate (2.4% pre-admission and 4.3% emergency admissions) and low success in decolonization (9.6%)

Impact (2)

- Robicsek et al (Ann Intern Med 2008;148:409-18) showed potential benefit of universal screening using PCR in 3 phase study
  - Baseline - routine cultures for surveillance ie no active surveillance
  - Screening ICU patients using PCR with contact isolation, mupirocin and chlorhexidine decolonization of MRSA carriers (8.9 dropped to 7.4 MRSA infections per 10,000 patient days)
  - Universal screening with PCR with contact isolation and decolonization (further drop to 3.9 per 10,000 patient days)
  - Disadvantage – increase in mupirocin resistant MRSA isolates

Important factor

- Baseline prevalence of MRSA carriage
  - Prevalence rate of 5.1% carriage
    - Universal rapid screening is marginally cost effective - Murthy et al (Clin Microbiol Infect 2010; 16:1747-53)

TABLE 2. Health care resource use and cost variables for cost-effectiveness analysis

Model variable	Values: Point estimate	Values: Range used in sensitivity analyses
Incremental cost of MRSA infection as a result of excess LOS[a]	HK$68,936 CHF 8292	CHF 4975–11 608
Cost of decolonization treatment, mupirocin 2%[b]	CHF 18.50	±25%
Incremental cost per day of infection control (contact precautions) for suspected carriers[c]	CHF 182	±25%
Cost of rapid PCR screening[d]	HK$344 CHF 41.36	±25%
Cost of standard chromogenic agar culture[d]	CHF 18.63 HK$155	±25%
Cost per surgical bed-day during the study period	CHF 1658	SD CHF 202

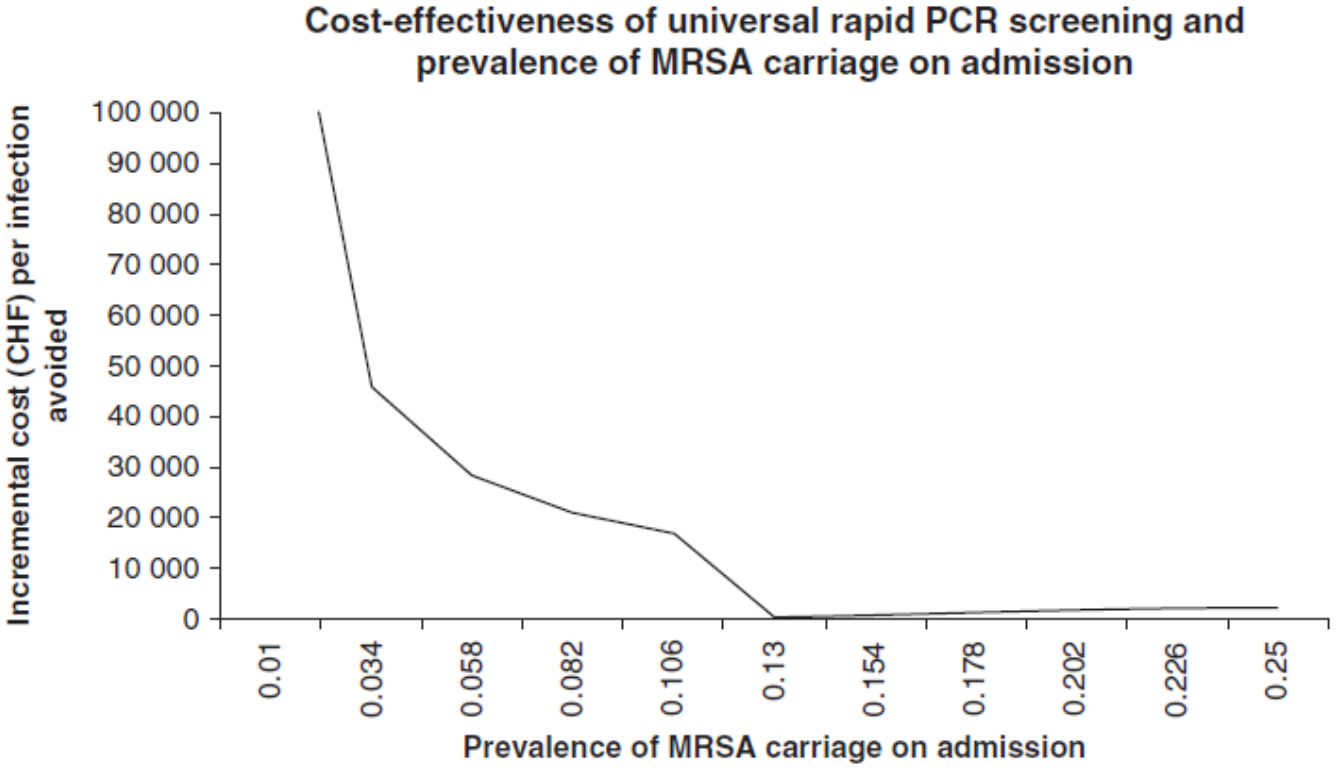
All costs are expressed in 2006 Swiss Francs (CHF).
MRSA, methicillin-resistant *Staphylococcus aureus*; LOS, length of hospital stay.
[a]Based on 5 ± 2 day estimate from time-dependent, multivariate analyses.
[b]Pharmacy acquisition cost at the University of Geneva Hospitals.
[c]Includes gloves, gowns, notification signs, and other consumables.
[d]Includes all test components and laboratory staff costs.

TABLE 3. Incremental cost-effectiveness analysis of rapid methicillin-resistant *Staphylococcus aureus* (MRSA) screening on admission to surgery

Strategy	Modelled cost (CHF)	Incremental cost (CHF)	Decision analysis infection probability	Incremental effects	Cost-effectiveness ratio	Incremental cost-effectiveness (ICER)
	HK$86,117					
No MRSA screening	10 358.46	–	0.0088	–	1 183 637.86	
Universal rapid PCR screening	10 502.53	144.07	0.0041	0.0047	2 581 048.81	CHF 30 784
Risk factor screening	10 511.04	8.51	0.0057	0.0016	1 843 826.63	(Dominated)
	HK$87,384					

All costs are expressed in 2006 Swiss Francs (CHF).
ICER, incremental cost-effectiveness ratio, or the difference in costs divided by the difference in effects. The dominated strategy (risk factor screening) is one that has higher costs but lower benefits than a competing alternative (rapid PCR screening) and would therefore not be rationally selected.

- High prevalence increases cost effectiveness

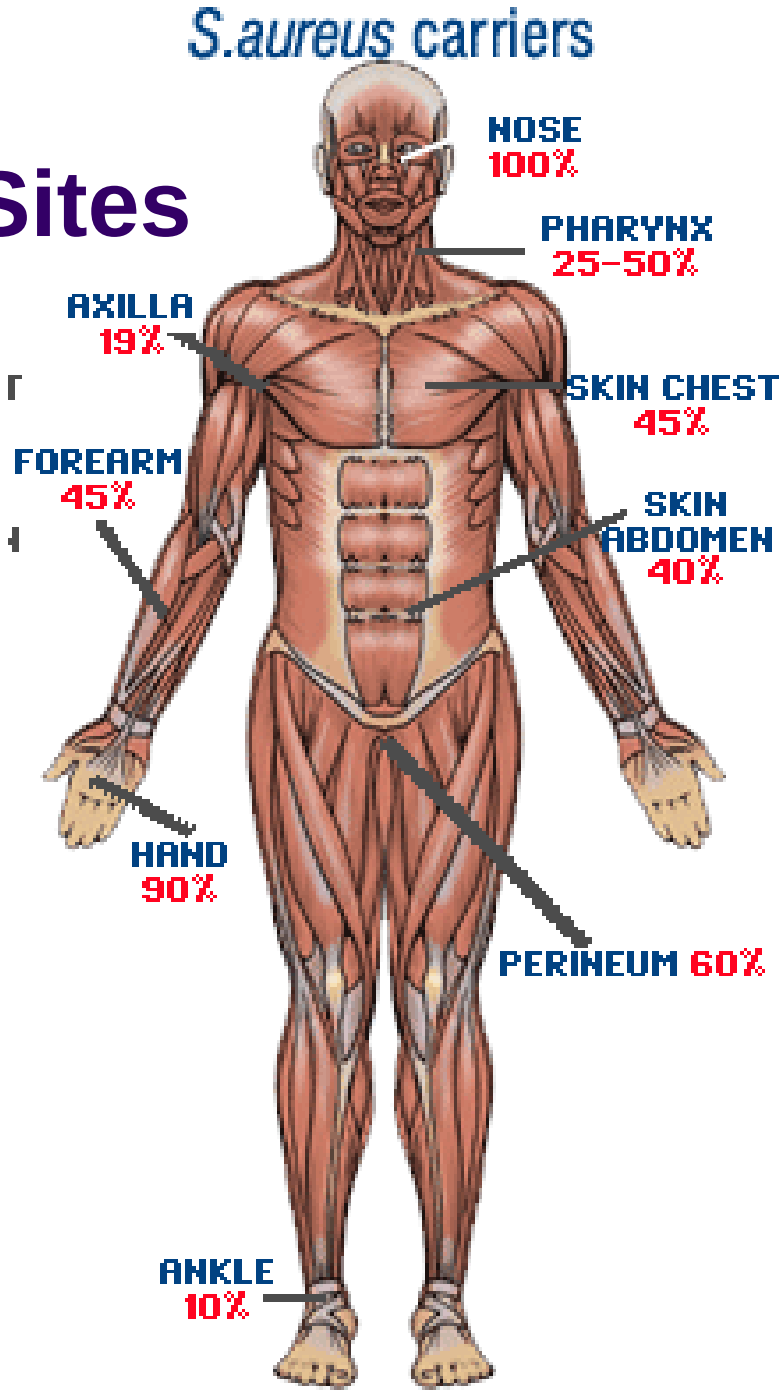


Colonization at Body Sites

Anatomic sites sampled	Number of patients with MRSA detected at anatomic site
Nares only	13 (21.7%)
Nares, groin, perineum, axilla	10 (16.7)
Nares & groin	8 (13.3%)
Nares, groin, perineum	8 (13.3%)
Negative	7 (11.7%)
Nares & perineum	3 (5.0%)
Nares, groin, axilla	3 (5.0%)
Groin & perineum	2 (3.3%)
Nares, axilla, perineum	2 (3.3%)
Groin only	2 (3.3%)
Nares & axilla	1 (1.7%)
Axilla only	1 (1.7%)

Mermel et al. MRSA colonization at different body sites: a prospective, quantitative analysis. J Clin Mic 2011 doi:10.1128/JCM.02601-10

Greatest yield from any 2 body sites: nares and groin 98% sens 88% NPV

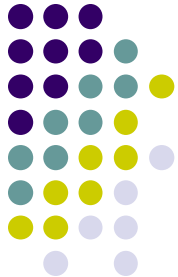


Sites sampled

- Nasal screen
  - Highest yield
  - Screening alone fail to identify those who are colonized elsewhere

- Value of 3 site sampling
  - Eveillard et al (Infect Control Hosp Epidemiol 2006; 27:181-4) demonstrated detection of 73% by nasal screen alone and additional 27% when sampled nares, skin and rectum

MRSA assays: which is suitable for screening?



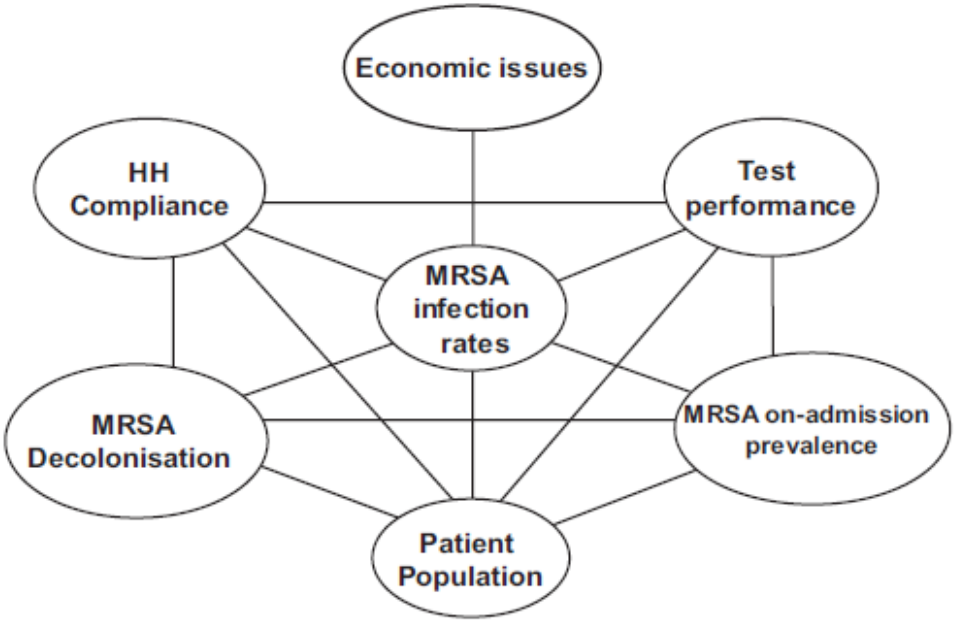
Selective Media for nasal swab specimens	Sensitivity (%)	Specificity (%)	TAT (H)
CHROMagar	82-93	97-99	24-48
BBL-CHROMagar	83-94	98-99	24-48
CHROMagar MRSA	96-100	95-97	24-48
MRSA Select	81-93	92-97	18-24
Brilliance MRSA agar	90-96	69-87	18-24
ChromID	83-94	90-96	

PCR assays	Sensitivity (%)	Specificity (%)	Sample sites
BD GeneOhm	81-100	64-99	Diverse
Hyplex SR	92	90	Nares
Genotype MRSA	68-95	96-99	Diverse
Cepheid Xpert MRSA	86-98	90-95	Nares
LightCycler MRSA	82	98	Nares
bioMerieux NucliSENS MRSA	93	98	Diverse

Harbath et al. Int J Antimic Agents 37 (20110 110-117

Issues to consider

- Prevalence
- Cost
- Infrastructure
- Capacity
- Infection control p



Harbath et al. Intern J Antimicrob Agents 2011; 37:110-7

A consensus statement from the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) MRSA Consensus Conference held in 2007

Cost of screening intensive care unit patients for methicillin-resistant *Staphylococcus aureus* in hospitals

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Minneapolis and St. Paul, Minnesota

Background: The objective of this study is to determine the costs per hospital admission of screening intensive care unit patients for methicillin-resistant *Staphylococcus aureus* (MRSA) and isolating those who are colonized.
Methods: Data on the costs of the intervention come from the Minneapolis Veterans Affairs Medical Center, a 279-bed teaching hospital and outpatient facility. A microcosting approach is used to determine the intervention costs for 3 different laboratory testing protocols. The costs of caring for MRSA-infected patients come from the experience of 241 Minneapolis Veterans Affairs Medical Center patients with MRSA infections in 2004 through 2006. The effectiveness of the intervention comes from the extant literature. To capture the effect of screening on reducing transmission of MRSA to other patients and its effect on costs, a Markov simulation model was employed.
Results: The intervention was cost saving compared with no intervention for all 3 laboratory processes evaluated and for all of the 1-way sensitivity analyses considered.
Conclusion: Because of the high cost of caring for a MRSA patient, interventions that reduce the spread of infections—such as screening intensive care unit patients upon admission studied here—are likely to pay for themselves.
Key Words: Methicillin-resistant *Staphylococcus aureus*; MRSA; screening; costs.

Table 2. Costs of screening ICU patients for MRSA

Expense category	Expense detail	Culture	Chromogenic agar	PCR
Laboratory supplies	Swab	$1.00	$1.00	$1.00
	Blood agar and Mannitol salt agar plate	$2.00		
	IDI-MRSA test kit			$25.00
	Chromogenic agar		$3.85	
	Chromogenic agar orientation plate		$1.00	
	Gram stain and catalase reagents	$1.00	$1.00	
	Agglutination	$1.00	$1.00	
	Susceptibility test (AST)	$4.00	$4.00	
	BAP use when AST set up	$1.00	$1.00	
	Mueller-Hinton plate and 4 disks used when antibiotic susceptibilities set up	$2.00	$2.00	
	Overhead (warehouse, delivery, and others)	20.84%	20.84%	20.84%
	Supply total cost/test	$6.45	$9.90	$31.42
Laboratory technician time	Average hourly (wage + fringe + overhead for laboratory technician)	$29.60	$29.60	$29.60
	Labor time from accession to report for *negative* culture	15 min	15 min	15 min
	Labor time from accession to report for *positive* culture	30 min	30 min	15 min
	Laboratory staff total cost/test	$9.32	$9.32	$7.40
Nurse collection time	Average RN hourly wage + fringe	$30.00	$30.00	$30.00
	Labor time per swab	5 min	5 min	5 min
	Nurse staff total cost/test	$2.50	$2.50	$2.50
Total cost per test	Laboratory supplies + laboratory technician time + nurse time	$18.27	$21.72	$41.32
	Number of ICU admissions and transfers	1762	1762	1762
	Number of tests per ICU patient	1.5	1.5	1.5
	Total number of tests	2643	2643	2643
Total variable cost of test		$48,288	$57,406	$109,209
Overhead	Average annual cost of $25,000 SmartCycler Instrument based on 5- year warranty			$5000
Management	1 FTE ICP staff to monitor and implement	$78,000	$78,000	$78,000
	Educational materials	$500	$500	$500
	Yearly overhead and management costs	$78,500	$78,500	$83,500
Total costs of screening		$126,788	$135,906	$192,709

AST, antimicrobial susceptibility test; BAP, blood agar plate; FTE, full time equivalent; ICP, infection control practitioner.

Table 3. Costs of isolating MRSA patients

Expense category	Expense detail	Cost
Materials	Gown	$0.72
	Gloves	$0.10
	Mask	$0.04
	Cost/patient/day (average of 37 visits/day)	$31.82
Staff	Average time in minutes to don barriers	1
	Average number of visits/day	37
	Cost/patient/day at $30.00/hr	$18.50
	Average time daily to restock isolation carts	5
	Cost/patient/day at $20.00/hr	$1.67
Total materials and staff cost per patient day		$51.99
	Number of days per patient	5.9
Total materials and staff costs per patient		$306.74
Dedicated equipment per patient	Stethoscope	$3.22
	Thermometer	$4.68
Total costs per patient		$314.64
	Number of patients in the ICU annually	1762
	Colonizations per ICU patient	0.0981
	Total number of colonized ICU patients	173
Total annual cost		$54,433
Isolation carts	Isolation cart	$825.00
	Average number of new isolation carts needed	3
	Costs for new isolation carts	$2475
Yearly isolation costs		$56,908

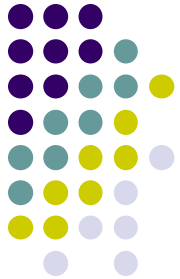
Table 4. Reductions in infections and costs from MRSA screening in the ICU

	New MRSA infections per hospital admission	Cost per hospital admission	Net savings per hospital admission
Model 1: Base case			
No intervention	0.0480	$18,051	
Intervention	0.0159		
Standard culture		$17,567	$484
Chromogenic agar		$17,568	$483
PCR		$17,575	$476
Model 2: No separate isolation costs for patients with MRSA infections			
No intervention	0.0480	$18,022	
Intervention	0.0159		
Standard culture		$17,550	$472
Chromogenic agar		$17,552	$470
PCR		$17,558	$463
Model 3: MRSA colonization probability of 2.58%			
No intervention	0.0351	$17,197	
Intervention	0.0116		
Standard culture		$16,743	$454
Chromogenic agar		$16,744	$453
PCR		$16,751	$447
Model 4: MRSA colonization probability of 7.73%			
No intervention	0.0610	$18,908	
Intervention	0.0203		
Standard culture		$18,401	$507
Chromogenic agar		$18,402	$506
PCR		$18,409	$499
Model 5: Infection reduction at 33%			
No intervention	0.0480	$18,051	
Intervention	0.0324		
Standard culture		$17,835	$216
Chromogenic agar		$17,836	$215
PCR		$17,843	$208

Infrastructure

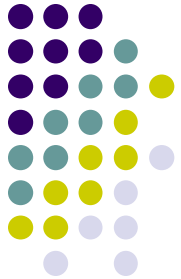
- Contact Precautions to be implemented upon identification of MRSA patients
  - Patient placement
  - Gloving
  - Gowning
  - Patient transport
  - Patient-care equipment and instruments/devices
  - Environmental measures
  - Discontinuation of Contact Precautions
    - No recommendation can be made regarding when to discontinue Contact Precautions

Other ‘difficult’ issues



- Should consent be taken for MRSA screening in universal surveillance?
- If patient is screened negative for MRSA but acquires MRSA during hospital stay, can he sue the hospital?
- Should all patients be informed of their MRSA status?
  - Inpatient
  - Outpatient

MRSA Action UK: civil claim for compensation



- *"In order to bring a civil claim for compensation, you must be able to prove that:-*
  - *The infection was acquired in the hospital/residential home*
  - *The treatment given by the healthcare provider was substandard (negligent)*
  - *If the treatment had not been substandard, you would not have acquired MRSA*
  - *The negligence caused you injury and loss*

- *It is not sufficient to show that you contracted MRSA in hospital, because the Courts accept that it is not always possible for hospitals to eliminate MRSA completely. The Court will consider whether the hospital has taken all reasonable precautions to reduce the risk of infection to the lowest possible level. Your solicitors will therefore ask the hospital to disclose documents about its MRSA policies and guidelines, so that they can consider whether there is evidence that the hospital should have done more to reduce the risk of infection."*

Decontamination

- Decolonization

- Environmental decontamination

Decolonization

- Rationale
  - MRSA carriers 3.9x more likely to develop bacteremia (Pujol et al. Am J Med 1996;100:509-16)
  - 20-30% MRSA carriers at risk of developing infection in 12-18 months (Davis et al. CID 2004; 39:776-82; Huang et al. CID 1003; 36:281-5)

- Objective
  - To prevent infection or transmission

- Methods
  - Nares – mupirocin 2% ointment (Bactroban)
  - Oropharynx and skin – chlorhexidine
  - Selective digestive decontamination – parenteral 3rd generation cephalosporin and aminoglycoside with/without antifungal

Table 2
Randomized controlled trials evaluating decolonization regimens for eradication of *Staphylococcus aureus* carriage in various patient populations

Reference (Number of Patients)	MSSA, MRSA, or Both	Follow-up (Weeks)	Treatment(s) versus Comparator	Eradication Rate (%)	Relative Risk (95% CI)
Wheat[25] (80)	Both	12	Rifampin	65	Rifampin
			Cloxacillin	0	0 (undefined)
			Rifampin + cloxacillin	60	Cloxacillin
			No treatment	0	0.96 (0.72–1.30)
Peterson[26] (21)	MRSA	24	Rifampin + ciprofloxacin	27	1.33 (0.39–4.6)
			Rifampin + TMP-SMX	40	
Walsh[27] (94)	MRSA	2	Rifampin + novobiocin	67	0.80 (0.57–1.11)
			Rifampin + TMP-SMX	53	
Muder[28] (35)	MRSA	12	Rifampin	70	Rifampin
			Minocycline	38	0.44 (0.18–1.11)
			Rifampin + minocycline	50	Minocycline
			No treatment	14	1.06 (0.52–2.18)
Parras[29] (84)	MRSA	12	Mupirocin	78	0.92 (0.71–1.20)
			Fusidic acid + TMP-SMX	71	
Watanakunokorn[30] (59)	Both	12	Chlorhexidine	76	0.89 (0.68–1.17)
			Chlorhexidine + mupirocin	85	
Harbarth[31] (102)	MRSA	4	Chlorhexidine + mupirocin	25	0.57 (0.31–1.04)
			Chlorhexidine + placebo	18	
Martin[32] (76)	Both	10	Mupirocin	29	0.09 (0.01–0.67)
			Placebo	3	
Chang[33] (23)	MRSA	2	Fusidic acid	33	3.5 (0.51–23.8)
			No treatment	50	
Mody[34] (127)	Both	12	Mupirocin	61	0.22 (0.07–0.67)
			Placebo	15	
Dryden[35] (224)	MRSA	2	Chlorhexidine + mupirocin + silver sulfadiazine	49	1.17 (0.88–1.57)
			Tea tree oil	41	
Simor[36] (146)	MRSA	12	Chlorhexidine + mupirocin + rifampin + doxycycline	74	0.44 (0.24–0.78)
			No treatment	32	

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *S aureus*; TMP-SMX, trimethoprim-sulfamethoxazole.

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JANUARY 7, 2010 VOL. 362 NO. 1

Preventing Surgical-Site Infections in Nasal Carriers of *Staphylococcus aureus*

Lonneke G.M. Bode, M.D., Jan A.J.W. Kluytmans, M.D., Ph.D., Heiman F.L. Wertheim, M.D., Ph.D., Diana Bogaers, I.C.P., Christina M.J.E. Vandenbroucke-Grauls, M.D., Ph.D., Robert Roosendaal, Ph.D., Annet Troelstra, M.D., Ph.D., Adrienne T.A. Box, B.A.Sc., Andreas Voss, M.D., Ph.D., Ingeborg van der Tweel, Ph.D., Alex van Belkum, Ph.D., Henri A. Verbrugh, M.D., Ph.D., and Margreet C. Vos, M.D., Ph.D.

- Randomized, double-blind, placebo-controlled clinical trial, conducted at three university hospitals and two general hospitals in the Netherlands
- October 2005 – June 2007
- 6771 patients
- 3.4% vs 7.7% *S aureus* infection

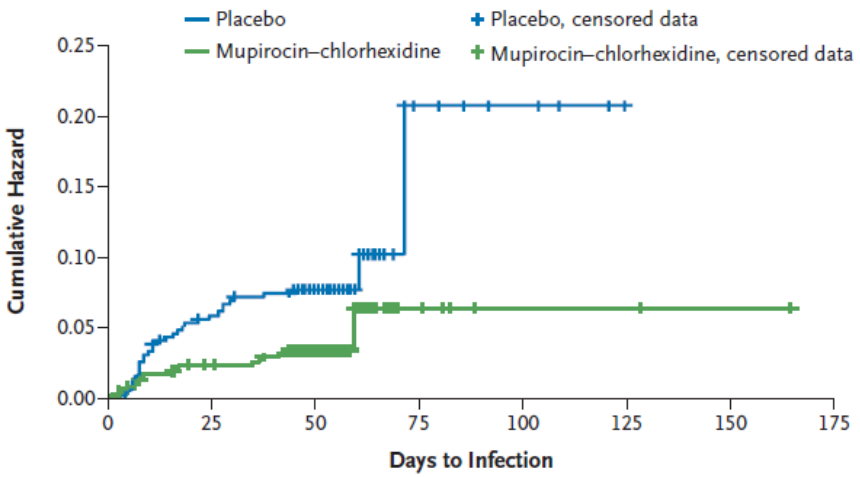
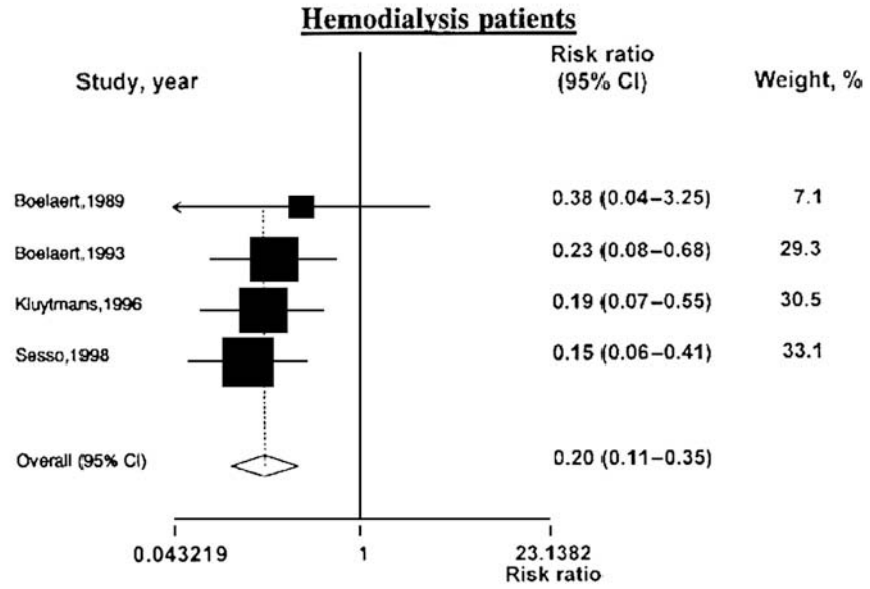
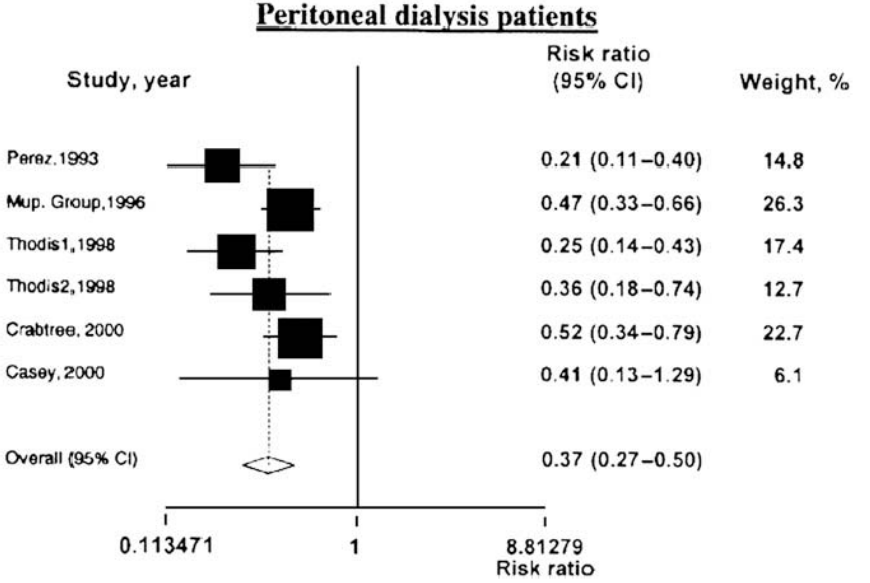


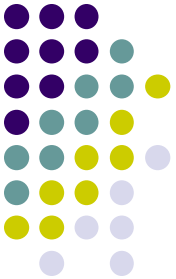
Figure 3. Kaplan–Meier Curves Showing Cumulative Hazard of Hospital-Acquired *Staphylococcus aureus* Infection in the Study Groups.

Data were censored at the end of the follow-up period or at the time of death.





Decolonization in high risk patient groups



- 3 RCTs
- *S aureus* infections: risk reduction
  - 80 in haemodialysis patients and 63% in PD patients
- *S aureus* bacteremia
  - 78% reduction in haemodialysis and 66% reduction in PD patients

ORIGINAL INVESTIGATION

Chlorhexidine Gluconate to Cleanse Patients in a Medical Intensive Care Unit

The Effectiveness of Source Control to Reduce the Bioburden of Vancomycin-Resistant Enterococci

Michael O. Vernon, DrPH; Mary K. Hayden, MD; William E. Trick, MD; Robert A. Hayes, BSc; Donald W. Blom, RN; Robert A. Weinstein, MD; for the Chicago Antimicrobial Resistance Project (CARP)

Background: Historically, methods of interrupting pathogen transmission have focused on improving health care workers' adherence to recommended infection control practices. An adjunctive approach may be to use source control (eg, to decontaminate patients' skin).

Methods: We performed a prospective sequential-group single-arm clinical trial in a teaching hospital's medical intensive care unit from October 2002 to December 2003. We bathed or cleansed 1787 patients and assessed them for acquisition of vancomycin-resistant enterococci (VRE). We performed a nested study of 86 patients with VRE colonization and obtained culture specimens from 758 environmental surfaces and 529 health care workers' hands. All patients were cleansed daily with the procedure specific to the study period as follows: period 1, soap and water baths; period 2, cleansing with cloths saturated with 2% chlorhexidine gluconate; and period 3, cloth cleansing without chlorhexidine. We measured colonization of patient skin by VRE, health care worker hand or environmental surface contamination by VRE, and patient acquisition of VRE rectal colonization.

Results: Compared with soap and water baths, cleansing patients with chlorhexidine-saturated cloths resulted in 2.5 $\log_{10}$ less colonies of VRE on patients' skin and less VRE contamination of health care workers' hands (risk ratio [RR], 0.6; 95% confidence interval [CI], 0.4-0.8) and environmental surfaces (RR, 0.3; 95% CI, 0.2-0.5). The incidence of VRE acquisition decreased from 26 colonizations per 1000 patient-days to 9 per 1000 patient-days (RR, 0.4; 95% CI, 0.1-0.9). For all measures, effectiveness of cleansing with nonmedicated cloths was similar to that of soap and water baths.

Conclusion: Cleansing patients with chlorhexidine-saturated cloths is a simple, effective strategy to reduce VRE contamination of patients' skin, the environment, and health care workers' hands and to decrease patient acquisition of VRE.

Arch Intern Med. 2006;166:306-312

- 413 bed trauma unit (Seattle)
- Daily CHG bath of 286 trauma patients for 6 months

Table 3. Outcome Variables Associated With Method of Bathing

Variable	Mean (SD) Without Chlorhexidine (n=253)	Mean (SD) With Chlorhexidine[a] (n=286)	*P* Value
Mechanical ventilation, d	10.3 (7.9)	9.5 (8.5)	.26
ICU length of stay, d	12.5 (12.7)	10.9 (15.2)	.19
Hospital length of stay, d	18.7 (14.3)	15.8 (11.8)	.01
Maximum MODS score	4.1 (3.5)	3.6 (3.1)	.08
Mortality, No. (%)	17 (6.7)	16 (5.6)	.72

Abbreviations: ICU, intensive care unit; MODS, multiple-organ dysfunction syndrome.
[a] Administered in a washcloth as 2% chlorhexidine gluconate.

Table 4. Comparison of Infection Incidence by Method of Bathing

Infection	No. (No. per 1000 Device-Days) Without Chlorhexidine	No. (No. per 1000 Device-Days) With Chlorhexidine[a]	Difference (95% CI)	*P* Value
CRBSI	15 (8.4)	4 (2.1)	6.2 (1.6 to 1.9)	.01
UTI	14 (7.1)	12 (6.5)	0.6 (–4.5 to 5.7)	.82
VAP	38 (21.6)	33 (16.9)	4.7 (–4.2 to 13.6)	.30
Secondary BSI	6 (3.0)	5 (2.5)	0.5 (–2.7 to 3.8)	.76

Abbreviations: BSI, bloodstream infection; CI, confidence interval; CRBSI, catheter-related bloodstream infection; UTI, urinary tract infection; VAP, ventilator-associated pneumonia.
[a] Administered in a washcloth as 2% chlorhexidine gluconate.

Table 5. Causative Microorganisms in Catheter-Related Bloodstream Infections

Microorganism	No. of Cases Without Chlorhexidine (n=15)	No. of Cases With Chlorhexidine[a] (n=4)
Gram-positive bacteria		
Coagulase-negative *Staphylococcus* species	6	3
Bacillus species	1	0
Enterococcus species	1	0
Staphylococcus aureus	4	0
Gram-negative bacteria		
Escherichia coli	1	1
Klebsiella pneumoniae	1	0
Pseudomonas aeruginosa	1	0

[a] Administered in a washcloth as 2% chlorhexidine gluconate.

Evans et al. Arch Surg 2010; 145(3):240-6

Table 7. MRSA and *Acinetobacter* Species Colonization Rate by Method of Bathing

Microorganism	No. (No. per 1000 Patient-Days) Without Chlorhexidine (n=253)	With Chlorhexidine[a] (n=286)	Difference (95% CI)	*P* Value
MRSA	137 (69.3)	47 (23.3)	46.0 (32.6-59.4)	<.001
Acinetobacter species	9 (4.6)	2 (1.0)	3.6 (0.2-6.8)	.36

Abbreviations: CI, confidence interval; MRSA, methicillin-resistant *Staphylococcus aureus*.
[a] Administered in a washcloth as 2% chlorhexidine gluconate.

Daily bathing of trauma patients with cloths impregnated with 2% CHG is associated with a decreased rate of colonization by MRSA and *Acinetobacter* and lower rates of catheter-related bloodstream infection and MRSA VAP.

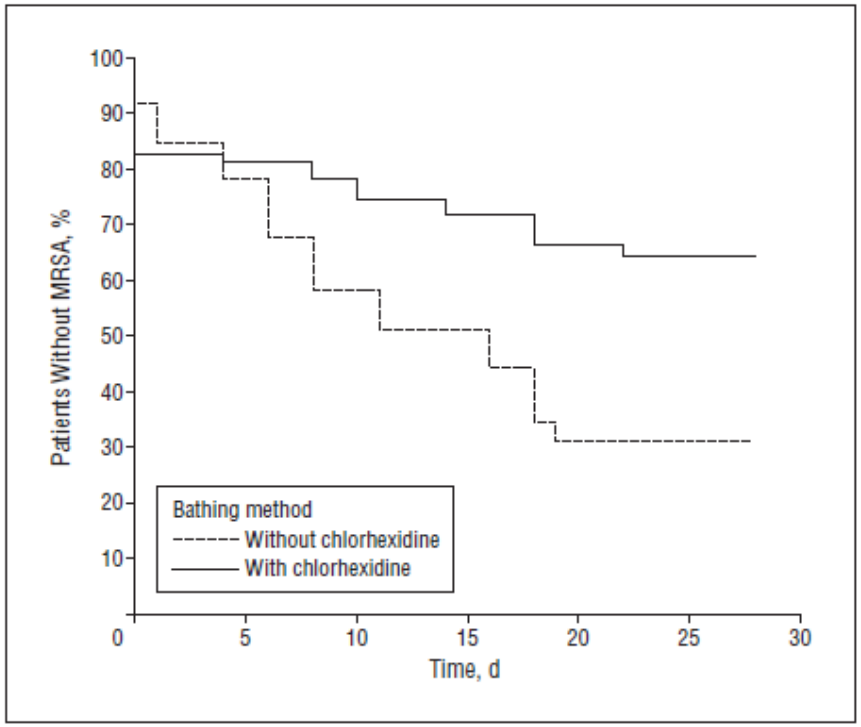


Figure. Proportion of patients with and without bathing with 2% chlorhexidine gluconate washcloths who did not have methicillin-resistant *Staphylococcus aureus* (MRSA) colonization during intensive care unit stay, *P*=.02.

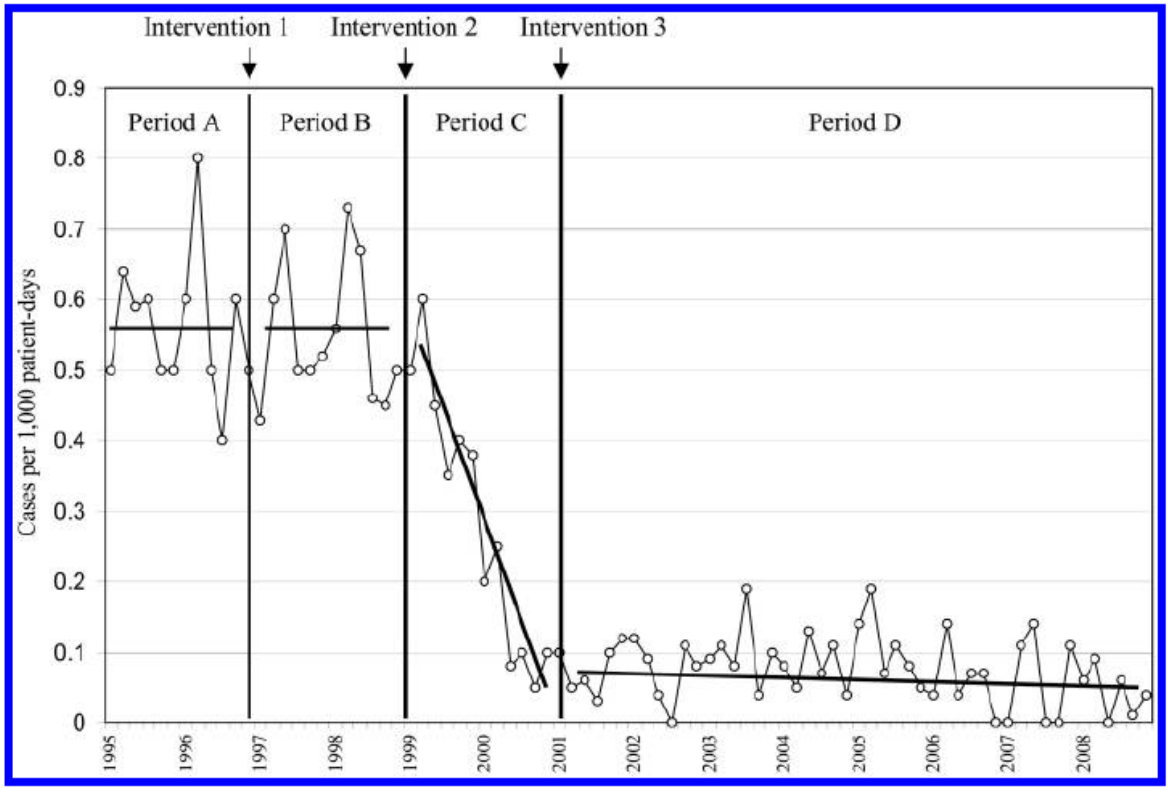
INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY AUGUST 2010, VOL. 31, NO. 8

ORIGINAL ARTICLE

Long-Term Control of Endemic Hospital-Wide Methicillin-Resistant *Staphylococcus aureus* (MRSA): The Impact of Targeted Active Surveillance for MRSA in Patients and Healthcare Workers

Jesús Rodríguez-Baño, MD, PhD; Lola García, RN; Encarnación Ramírez, MD, PhD; Carmen Lupión, RN; Miguel A. Muniain, MD, PhD; Carmen Velasco, PhD; Juan Gálvez, MD; M. Dolores del Toro, MD, PhD; Antonio B. Millán, MD, PhD; Lorena López-Cerero, MD, PhD; Alvaro Pascual, MD, PhD

- Quasi-experimental, interrupted time-series analysis
- Impact of the interventions analyzed by use of segmented regression
- 950-bed teaching hospital in Seville, Spain from 1995 through 2008.
- Long term control of endemic MRSA feasible in acute care setting
- Key elements
  - Targeted active surveillance in patients and HCWs
  - Decolonization



MRSA colonization and infection cases decreased from **0.56 to 0.07** per 1000 patient days

FIGURE 1. Bimonthly incidence rates of healthcare-associated methicillin-resistant *Staphylococcus aureus* colonization or infection during the 4 different study periods (from January 1995 to December 2008) at Hospital Universitario Virgen Macarena in Seville, Spain.

- A – baseline (1995 -1996)
- B - Contact precautions, with no active surveillance for MRSA (1997 – 1998)
- C - Targeted active surveillance for MRSA in patients and healthcare workers in specific wards, prioritized according to clinical epidemiology data (1999 – 2000)
- D - Targeted active surveillance for MRSA in patients admitted from other medical centers (2001 – 2008)

Selective digestive tract decontamination (SDD) and selective oropharyngeal decontamination (SOD)

- SDD – prevention of secondary colonization in oropharynx and GIT
  - Systemic cephalosporins in 1st 4 days in ICU and maintenance of anaerobes
- SOD – application of topical antibiotics in oropharynx only

Table 3. Cumulative Incidence of ICU-Acquired Bacteremia and Candidemia.*

Type of Infection	Study Group			Crude Odds Ratio (95% CI)		
	Standard Care (N=1990)	SOD (N=1904)	SDD (N=2045)	SDD vs. Standard Care	SOD vs. Standard Care	SDD vs. SOD
		no. (%)				
Staphylococcus aureus	22 (1.1)	9 (0.5)	9 (0.4)	0.40 (0.18–0.86)	0.43 (0.20–0.93)	0.93 (0.37–2.40)
Streptococcus pneumoniae	3 (0.2)	1 (0.1)	1 (0.0)	0.32 (0.03–3.12)	0.35 (0.04–3.35)	0.93 (0.06–14.90)
GNF-GNR species†	36 (1.8)	17 (0.9)	16 (0.8)	0.43 (0.24–0.77)	0.49 (0.27–0.87)	0.88 (0.44–1.74)
Enterobacteriaceae	87 (4.4)	59 (3.1)	18 (0.9)	0.19 (0.12–0.32)	0.70 (0.50–0.98)	0.28 (0.16–0.47)
Enterococcus species	55 (2.8)	49 (2.6)	48 (2.3)	0.85 (0.57–1.25)	0.93 (0.63–1.37)	0.91 (0.61–1.36)
Candida species	16 (0.8)	14 (0.7)	8 (0.4)	0.49 (0.21–1.11)	0.91 (0.45–1.85)	0.53 (0.23–1.24)
Patients with at least one episode of bacteremia or candidemia — no. (%)	186 (9.3)	124 (6.5)	88 (4.3)	0.44 (0.34–0.57)	0.68 (0.53–0.86)	0.65 (0.49–0.85)

* SDD denotes selective digestive tract decontamination, and SOD selective oropharyngeal decontamination.
† Glucose-nonfermenting gram-negative rods (GNF-GNR) are characteristic of *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, and acinetobacter species.

Environmental contamination

Rates of Surface Contamination with MRSA, VRE, and *C. difficile*

Surface	MRSA*	VRE†	*C. difficile*‡
Floors	55%	—	48%
Commode/Toilet	—	—	41%
Windowsill	—	—	33%
Bedsheets	53%	40%	21%
Patient Gown	51%	—	—
Overbed Table	40%	20%	—
Bedrail	29%	28%	19%
Blood Pressure Cuff	—	14%	—
Totals	29%	23%	27%

* Boyce J.M., et al.: Environmental contamination due to methicillin-resistant *Staphylococcus aureus*: Possible infection control implications. *Infect Control Hosp Epidemiol* 18:622–627, Sep. 1997.
† Slaughter S., 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* 125:448–456, Sep. 15, 1996.
‡ Samore M.H., et al.: Clinical and molecular epidemiology of sporadic and clustered cases of nosocomial *Clostridium difficile* diarrhea. *Am J Med* 100:32–40, Jan. 1996.

MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant *Enterococcus*; *C. difficile*, *Clostridium difficile*.

Reality

- Many high touch points in patient care area
  - Sink
  - Tray table
  - Toilet seat
  - Flush handle
  - Side rail
  - Bedside table
  - Call box
  - Chair
  - Telephone
  - Bathroom door knobs
  - Bathroom handhold
  - Bathroom light switch
  - Room door knobs
  - Bedpan cleaner

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How long do nosocomial pathogens persist on inanimate surfaces? A systematic review

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Published: 16 August 2006

BMC Infectious Diseases 2006, **6**:130 doi:10.1186/1471-2334-6-130

This article is available from: http://www.biomedcentral.com/1471-2334/6/130

Received: 26 April 2006

Accepted: 16 August 2006

Table 1: Persistence of clinically relevant bacteria on dry inanimate surfaces.

Type of bacterium	Duration of persistence (range)
Acinetobacter spp.	3 days to 5 months
Bordetella pertussis	3 – 5 days
Campylobacter jejuni	up to 6 days
Clostridium difficile (spores)	5 months
Chlamydia pneumoniae, *C. trachomatis*	≤ 30 hours
Chlamydia psittaci	15 days
Corynebacterium diphtheriae	7 days – 6 months
Corynebacterium pseudotuberculosis	1–8 days
Escherichia coli	1.5 hours – 16 months
Enterococcus spp. including VRE and VSE	5 days – 4 months
Haemophilus influenzae	12 days
Helicobacter pylori	≤ 90 minutes
Klebsiella spp.	2 hours to > 30 months
Listeria spp.	1 day – months
Mycobacterium bovis	> 2 months
Mycobacterium tuberculosis	1 day – 4 months
Neisseria gonorrhoeae	1 – 3 days
Proteus vulgaris	1 – 2 days
Pseudomonas aeruginosa	6 hours – 16 months; on dry floor: 5 weeks
Salmonella typhi	6 hours – 4 weeks
Salmonella typhimurium	10 days – 4.2 years
Salmonella spp.	1 day
Serratia marcescens	3 days – 2 months; on dry floor: 5 weeks
Shigella spp.	2 days – 5 months
Staphylococcus aureus, including MRSA	7 days – 7 months
Streptococcus pneumoniae	1 – 20 days
Streptococcus pyogenes	3 days – 6.5 months
Vibrio cholerae	1 – 7 days

ORIGINAL INVESTIGATION

Role of Environmental Contamination as a Risk Factor for Acquisition of Vancomycin-Resistant Enterococci in Patients Treated in a Medical Intensive Care Unit

José A. Martínez, MD; Robin Ruthazer, MPH; Karen Hansjosten, RN; Laurie Barefoot, RN; David R. Snydman, MD

Background: Colonization pressure, proximity to another case, exposure to a nurse who cares for another case, enteral feeding, and the use of sucralfate, vancomycin hydrochloride, cephalosporins, or antibiotics are among the defined risk factors for acquisition of vancomycin-resistant enterococci (VRE) in the intensive care unit (ICU) setting. However, the role of rooms with contaminated environmental surfaces has not been well delineated.

Methods: Retrospective case-control study conducted on patients admitted to the medical ICU (MICU) of a tertiary-care, university-affiliated medical center during a 9-month period. Patients who acquired VRE (cases) were matched with 2 randomly selected control subjects who did not acquire VRE and had been in the MICU for at least the same number of days.

Results: Thirty cases were matched with 60 appropriate controls. Cases were more likely to have been in the hospital for longer than 7 days before MICU admission ($P=.009$); to have occupied a specific room with persisting contaminated surfaces ($P=.06$); to have had a central venous catheter ($P=.05$); to have received vancomycin ($P=.02$), cephalosporins ($P=.03$), and quinolones ($P=.006$) before MICU admission; and to have received vancomycin ($P=.02$) and metronidazole sodium phosphate ($P=.03$) after MICU admission. Multivariate analysis showed that a hospital stay of longer than 1 week before MICU admission ($P=.04$), use of vancomycin before or after MICU admission ($P=.03$), use of quinolones before MICU admission ($P=.03$), and placement in a contaminated room ($P=.02$) were the best predictors of VRE acquisition.

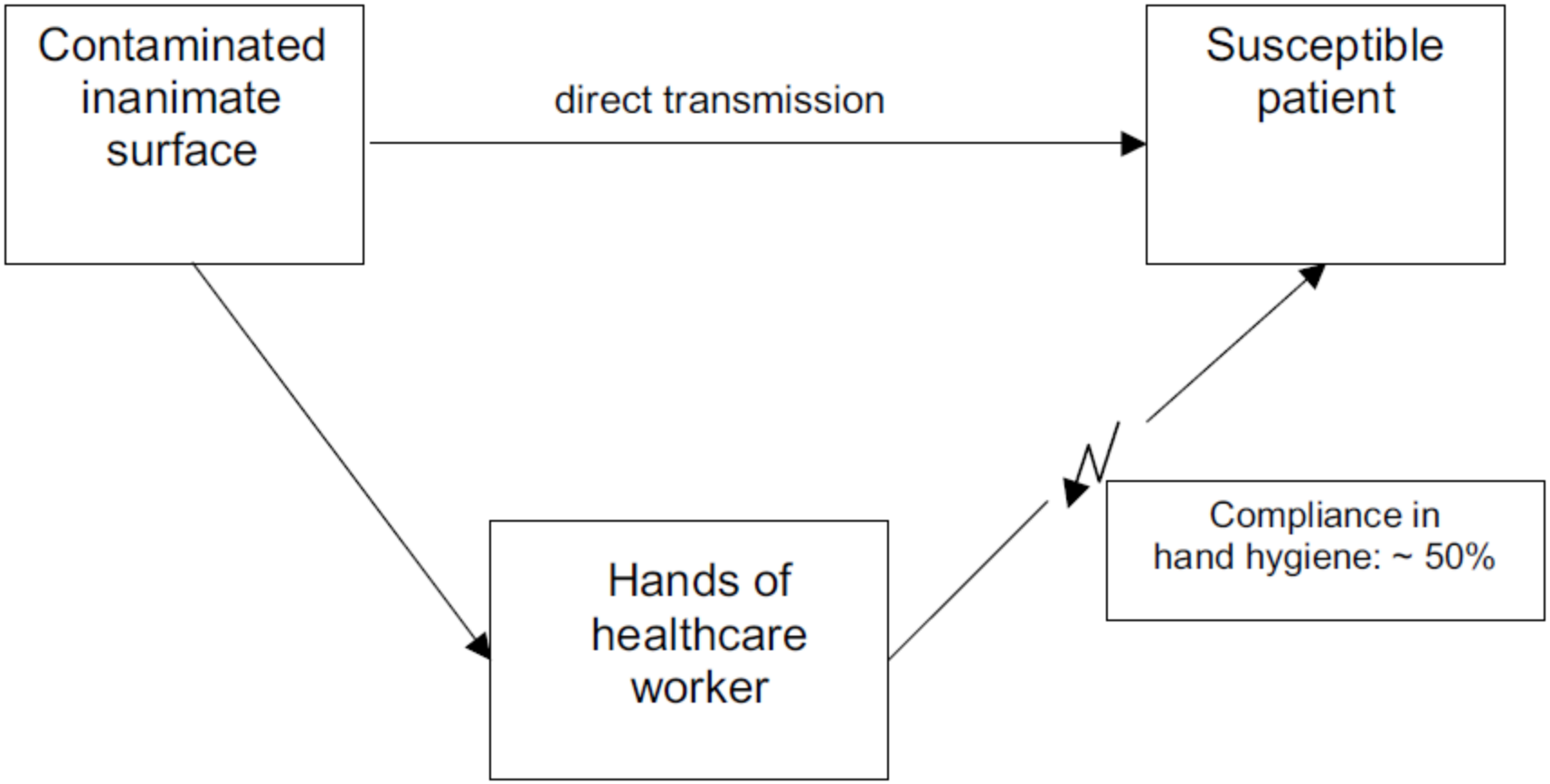
Conclusions: Among all other factors associated with VRE transmission, VRE acquisition may depend on room contamination, even after extensive cleaning. This study underscores the need for better cleaning and the role of the environment in transmission of VRE.

Arch Intern Med. 2003;163:1905-1912

- Heavy contamination of hospital surfaces—such as bed linens, bed rails, and tabletops—with MDROs such as MRSA, VRE, and C. difficile

- Many MDROs are able to live on inanimate surfaces for prolonged periods of time, and studies have shown that the hands of health care workers are just as likely to become contaminated with MDROs by touching surfaces in the rooms of colonized patients as they are touching the skin of those patients

- Patients who are admitted to rooms previously occupied by a patient colonized with an MDRO have a higher risk of acquiring an MDRO during their hospitalization


Contaminated inanimate surface
direct transmission
Susceptible patient
Hands of healthcare worker
Compliance in hand hygiene: ~ 50%

Journal of Hospital Infection (2004) 56, 101–105

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Investigation of an outbreak of multidrug-resistant *Acinetobacter baumannii* in trauma intensive care unit

S.S. El Shafie[a,*], M. Alishaq[b], M. Leni Garcia[b]

Table II Results of environmental cultures

Reservoir	Number of swabs	Number positive for *A. baumannii*
Bedrails	7	3
Mattresses	3	None
Walls	3	None
Curtains	3	1
Sinks	2	None
Faucets	2	None
Suction with vacuum	2	2
Medication box	3	None
Infusion pump	2	None
Ambu bags	3	3
Ventilation filter	3	3
Total	33	12 (36%)

Evaluation of patient area cleaning

- 157 rooms and 1404 targ
- 45%, 42%, and 56% of ta terminal cleaning/disinfec

Carling et al, AJIC 2006

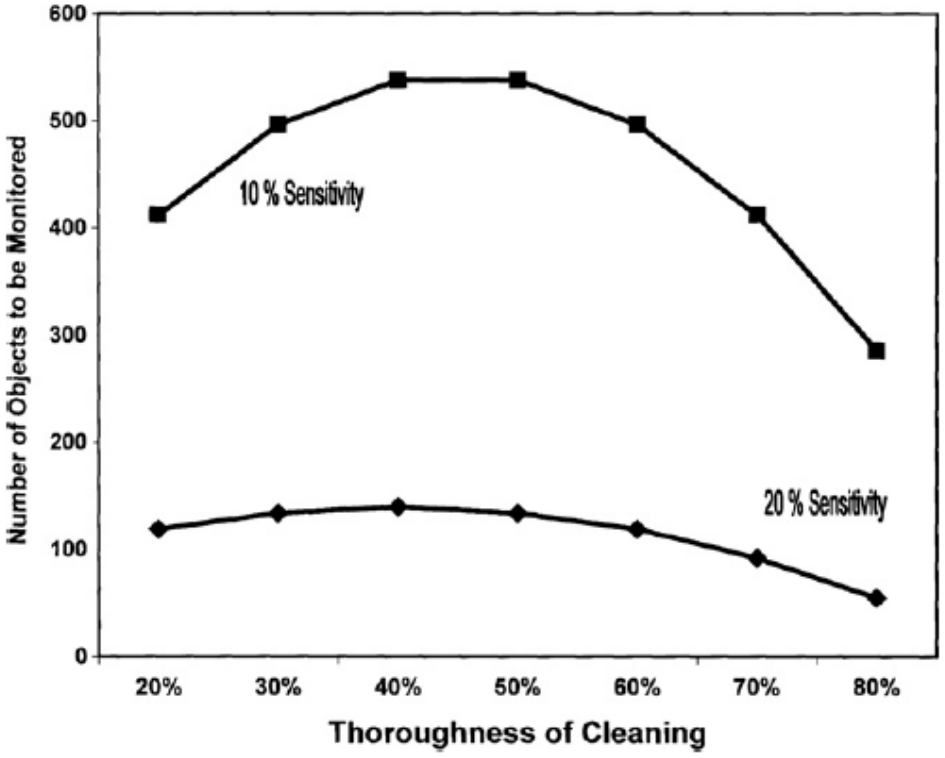
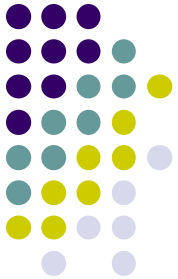


Fig 5. The relationship between the number of high-risk objects evaluated and the ability to detect significant change in the thoroughness of cleaning.

Carling and Bartley AJIC June 2010

Evaluating environmental hygiene



Method	Easy to use	Identifies pathogens	Useful for teaching	Directly evaluates cleaning	Published use for improvement
Observation	Low	No	Yes	Yes	1
Swab cultures	High	Yes	Not studied	Potential	1
Agar slide cultures	Good	Limited	Not studied	Potential	1
Fluorescent gel	High	No	Yes	Yes	49
ATP system	High	No	Yes	Potential	2

Carling and Bartley AJIC June 2010

The use of adenosine triphosphate bioluminescence to assess the efficacy of a modified cleaning program implemented within an intensive care setting

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London, United Kingdom

Background: A total environmental cleaning system based on microfiber technology was implemented within 2 intensive care units (ICUs). The efficacy of this modified cleaning program was assessed using adenosine triphosphate (ATP) bioluminescence.
Methods: A team of trained hygiene technicians cleaned all near-patient furniture and equipment twice a day using ultramicrofiber cloths. Every week for 40 weeks, 10 surfaces within a randomly selected bed area were sampled using the 3M Clean-Trace Clinical Hygiene Monitoring System (3M Health Care Ltd, Loughborough, United Kingdom). The ability of the modified cleaning program to reduce surface contamination to "acceptable" levels was measured against previously proposed benchmark ATP values.
Results: In comparison with normal cleaning procedures routinely carried out by the nurses, the modified cleaning program significantly reduced ($P < .001$) the ATP readings obtained from surfaces within the near-patient environment. In both ICUs, 95% of surfaces sampled after modified cleaning had relative light unit values of <500 and were deemed "clean." Almost 90% of the surfaces could also be "passed" using the more stringent benchmark value of 250 relative light units. However, regardless of benchmark value used, the majority of surfaces sampled could also be considered adequately clean prior to them being cleaned by the hygiene technicians.
Conclusion: The use of ATP bioluminescence has been proposed as a means to improve the management of hospital cleaning. Use of benchmark values can help continually monitor the efficacy of existing cleaning programs. However, when evaluating novel or new cleaning practices, baseline cleanliness (ie, the level of cleanliness routinely achieved using normal cleaning procedures) must also be taken into consideration, or the efficacy of modified cleaning will be overestimated.
Key Words: Adenosine triphosphate bioluminescence; ATP bioluminescence; intensive care unit; cleaning.

Conclusion

- Active surveillance
  - Screening alone is not effective
  - Follow-up interventions needed to reduce risk of transmission and infection

- Decontamination
  - Decolonization – effective infection control strategy for hemodialysis catheter-associated infections and in cardiac and orthopaedic surgery patients
  - Environmental hygiene – need for enhanced programs

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THANK YOU