**INSTITUTE FOR HEALTHCARE IMPROVEMENT**
**TECHNICAL BRIEF**

# Methicillin-resistant *Staphylococcus aureus* (MRSA) Reduction
(Last updated October 26, 2006)

**IHI Research and Development Team for this Technical Brief:**

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**Intent:** A reduction in methicillin-resistant *Staphylococcus aureus* (MRSA) is needed in U.S. hospitals.

**Background:** According to the Centers for Disease Control and Prevention, current estimates in U.S. hospitals each year are as follows:

- At least 126,000 persons are infected by MRSA, and at least 5,000 die as a result of these infections. These infections result in at least $4 billion in excess health care costs.
- At least 211,000 persons are infected by *Clostridium difficile*, and at least 6,000 die as a result of these infections. These infections result in at least $1 billion in excess health care costs.
- At least 21,000 persons are infected by vancomycin-resistant *Enterococcus* (VRE), and at least 1,000 die as a result of these infections. These infections result in at least $268 million in excess health care costs.
- Overall, MRSA, *C. difficile*, and VRE infections combined infect at least 350,000 persons, cause the death of at least 12,000, and result in at least $5 billion in excess health care costs (see attached documents CDC MRSA estimate, CDC VRE estimate, and CDC C. diff estimate).

Worldwide, we see a significant variation in MRSA percentages from close to 0% of isolates to as high as 60% (Appendix A and B).

**Current Landscape:** Over 31,000 articles have been written about aureus or MRSA since 1966 (simple Medline search 8/18/2006). In a published editorial written in 2003 by William R. Jarvis, MD, and Belinda Ostrowsky, MD, MPH, it was stated that over 20,000 articles had been written on the subject at that time [Jarvis WR, Ostrowsky B. Dinosaurs, methicillin-resistant Staphylococcus aureus, and infection control personnel: Survival through translating science into prevention. *Infect Control Hosp Epidemiol*. 2003 Jun;24:392-396]. Over 10,000 articles have been written in the intervening period, and yet MRSA infection rates have remained steady or risen during this time interval. It is important for us to gain the skill to control the current resistant

organisms because more resistant bacteria such as vancomycin-resistant *Staphylococcus aureus* (VRSA) may present additional challenges in the future.

There is debate on what are the best change ideas to reduce MRSA. However, we do know that some countries have been able to control this problem because of the types of prevention and treatment they have deployed(appendix A). According to the literature,(2,3,5,6,9,10) it clearly appears that all hospitals should support improved hand hygiene and contact isolation to reduce MRSA. These two items alone will not eliminate MRSA however, they should be a foundation for the work to identify other change ideas to reduce MRSA. Not only will hand hygiene and contact isolation help reduce infections from MRSA, but they will also decrease the spread of VRE, C. diff, and other infectious agents. In addition, selective screening cultures, patient isolation, closing hospital wards, and "search and destroy" are all methods that have been used in the work to decrease MRSA; some, if not all, of these tools are needed if we are to dramatically decrease MRSA infections in U.S. hospitals.

**Aim:** Decrease the MRSA rate in U.S. hospitals. The goal is to decrease levels of resistance and the numbers of infections related with these organisms.

**Measures:**

1. Percent of bacteremia cases related to health-care-associated MRSA
2. Percent of isolates of *Staphylococcus aureus* that are MRSA

**Table 1** *Evolution of important epidemiological MRSA indicators, University of Geneva Hospitals, 1989–1997*

| Year | Number of screening cultures | MRSA laboratory isolates* | Prevalence of MRSA patients | New cases/100 admissions | New cases/1,000 patient-days | Relative risk of MRSA acquisition [95% CI] | No. of patients with MRSA bacteraemia | No. of patients with MSSA bacteraemia |
|---|---|---|---|---|---|---|---|---|
| 1989 | 0 | 3% | 0.07% | 0.05 | 0.04 | Reference | 1 | 94 |
| 1990 | 0 | 6% | 0.23% | 0.16 | 0.12 | 3.1 [1.9–5.3] | 8 | 78 |
| 1991 | 0 | 11% | 0.38% | 0.28 | 0.23 | 5.7 [3.5–9.3] | 13 | 83 |
| 1992 | 0 | 17% | 0.84% | 0.57 | 0.49 | 11.5 [7.2–18.4] | 34 | 96 |
| 1993 | 1,863 | 19% | 0.93% | 0.49 | 0.44 | 9.8 [6.1–15.8] | 26 | 95 |
| 1994 | 7,600 | 20% | 1.42% | 0.60 | 0.54 | 11.9 [7.4–18.9] | 31 | 102 |
| 1995 | 9,186 | 24% | 1.35% | 0.47 | 0.43 | 9.4 [5.9–15.2] | 23 | 97 |
| 1996 | 9,918 | 21% | 1.02% | 0.32 | 0.30 | 6.5 [4.0–10.6] | 12 | 98 |
| 1997 | 10,566 | 19% | 0.59% | 0.24 | 0.21 | 4.4 [2.6–7.2] | 10 | 98 |

*Methicillin resistance among all isolated *S. aureus* isolates; one isolate per patient per year (including screening cultures).
MRSA, methicillin-resistant *S. aureus*; MSSA, methicillin-sensitive *S. aureus*.

The table above shows a decrease in bacteremia for MRSA over time, as well as a variety of measures that could be used to track improvement over time

[Source: 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 Sep;46(1):43-49.]

**Key Deliverables:**
**I. Literature Review**
**II. Examples of Ongoing Work in Reduction of MRSA**
**III. Changes/Design Concepts**
**IV. Roadmap Forward**

**I. Literature Review:**

- Descriptive Theory

1. Vriens M, Blok H, Fluit A, Troelstra A, Van Der Werken C, Verhoef J. Costs associated with a strict policy to eradicate methicillin-resistant Staphylococcus aureus in a Dutch university medical center: A 10-year survey. *Eur J Clin Microbiol Infect Dis*. 2002 Nov;21:782-786.

   This is a cost analysis of "search and destroy" versus not doing it. The authors are arguing that a strict policy is cost-effective.

- Normative Theory

2. Boyce J, Havill NL, Kohan C, Dumigan DG, Ligi CE. Do infection control measures work for methicillin-resistant Staphylococcus aureus. *Infection Control and Hospital Epidemiology*. 2004 May;25(5):395-401.

   This study discusses the challenges of various control measures. It is normative theory of what will impact the outcomes for controlling resistance rates.

3. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *The Lancet*. 2000;356(9238):1307-1312. [http://www.hopisaffe.ch/next.html]

   There are two main theories in this article on hand hygiene. One is that hand hygiene will decrease health-care-associated infection from MRSA. The second is that a sustained campaign is needed to increase hand washing compliance. The authors did not feel that an intervention without reinforcement could work. When considering this work we will need to address national cultural differences when transferring ideas across countries.

4. Jarvis WR, Ostrowsky B. Dinosaurs, methicillin-resistant Staphylococcus aureus, and infection control personnel: Survival through translating science into prevention. *Infect Control Hosp Epidemiol*. 2003 Jun;24:392-396.

   This editorial reviews several articles and makes the following point: "We have the science, now we need the will to implement the science into clinical practice for prevention."

5. Jarvis WR. Controlling antimicrobial-resistant pathogens. *Infection Control and Hospital Epidemiology*. 2004 May;25(5):369-372.

This editorial makes the case for the use of active surveillance cultures and contact isolation in addition to hand hygiene.

6. 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 Sep;46(1):43-49.

This study takes a series of interventions and applies them to a hospital with an outbreak of methicillin-resistant Staph. Over a period of time, the hospital's MRSA rates decrease. The seven major interventions that were used are listed below (see "III. Changes/Design Concepts"). The authors argue for multiple means of measures to assess the effectiveness of MRSA interventions.

7. Verhoef J, Beaujean D, Blok H, Baars A, Meyler A, van der Werken C, et al. A Dutch approach to methicillin-resistant Staphylococcus aureus. *Eur J Clin Microbiol Infect Dis*. 1999;18: 461-466.

An editorial that outlines the Dutch approach to MRSA elimination. The concept of "search and destroy" is outlined below.

- "Why did MRSA not become endemic in our hospital despite its introduction at regular intervals? Control of the emergence of resistant microorganisms is generally achieved by strict control of the use of antimicrobial agents and by stringent hospital infection control practices. Our hospital has a strict antibiotic prescription policy; most parenteral antibiotics are given only after consultation with the clinical microbiologist or infectious disease specialist. However, this stringent policy could hardly be the major factor in limiting the emergence of resistance, since the incidence of methicillin-resistant *Staphylococcus epidermidis* (MRSE) varies between 50% and 65% in Dutch centers. This rate is not much different from that found in hospitals in other countries where the incidences of both MRSA and MRSE are high. If a relationship exists between antibiotic consumption and the incidence of MRSA, the incidence of MRSE should not be similar to that seen."

- "A key element in the elimination of MRSA from the hospital is the isolation of patients."

- "In our opinion, however, the early closure of wards and ICUs may help restrict the spread of MRSA."

- "An interesting phenomenon is the universal use of masks for strict isolation of MRSA positive patients in the Netherlands to prevent airborne transmission."

- "Screening for carriers among patients and health care workers, along with subsequent treatment of carriers. While patients hospitalized abroad are always screened in the Netherlands and in the UK, screening is performed only if there is a first encounter with MRSA or a new encounter after previous successful control. Furthermore, health care workers who have been in contact with a new MRSA-positive patient are screened, irrespective of the epidemic behavior of the MRSA strain. In addition, staff caring for a known MRSA-positive patient are screened daily, despite isolation precautions. If a ward is closed, all staff and all consultants of the ward are screened. It is our experience that health care workers become colonized with the outbreak strain during every outbreak. In this way they become part of the chain of events: they may spread MRSA."

- "Treatments with mupirocin ointment with oral rifampicin-minocycline and antiseptic detergents for washing skin and hair are now being used successfully for the eradication of the carrier state Very rarely, the carrier state becomes chronic and untreatable despite extensive effort to recognize and treat risk factors (e.g., eczema) for chronic MRSA carriage in the health care worker. Family members and the home situation must be carefully investigated for the presence of MRSA to exclude potential sources of re-infection of the health care worker. In the Netherlands, however, persistence of MRSA carriage may force the health care worker or member of hospital management to seek other employment for which contact with patients is unnecessary. This is an undesirable consequence of a very stringent but successful MRSA policy."

8. Larson E, Aiello AE. Systematic risk assessment methods for the infection control professional. *Am J Infect Control*. 2006 Jun;34:323-326.

   This article discusses hazards analysis.

9. 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 Sep 4;329(7465):533.

   A review of the literature on isolation concludes the following:

   "Conclusion: Major methodological weaknesses and inadequate reporting in published research mean that many plausible alternative explanations for reductions in MRSA acquisition associated with interventions cannot be excluded. No well designed studies exist that allow the role of isolation measures alone to be assessed. Nonetheless, there is

evidence that concerted efforts that include isolation can reduce MRSA even in endemic settings. Current isolation measures recommended in national guidelines should continue to be applied until further research establishes otherwise."

10. 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 May;24:362-386

This article is a comprehensive view of the literature on two resistant bacteria, MRSA and VRE. It concludes with five major recommendations:

1. Active surveillance cultures to identify the reservoir for spread
2. Hand hygiene
3. Barrier precautions for patients known or suspected to be colonized or infected with epidemiologically important antibiotic-resistant pathogens such as MRSA or VRE
4. Antibiotic stewardship
5. Decolonization or suppression of colonized patients

. **Literature about Financial Implications done by the CDC**

11.Stone PW, Larson E, Kawar LN. A systematic audit or economic evidence linking nosocomial infections and infection control interventions: 1990-2000. *Am J Infect Control.* 2002;30:145-152.

The costs attributable to bloodstream (mean = $38,703) and methicillin-resistant *Staphylococcus aureus* infections (mean = $35,367) were the largest.

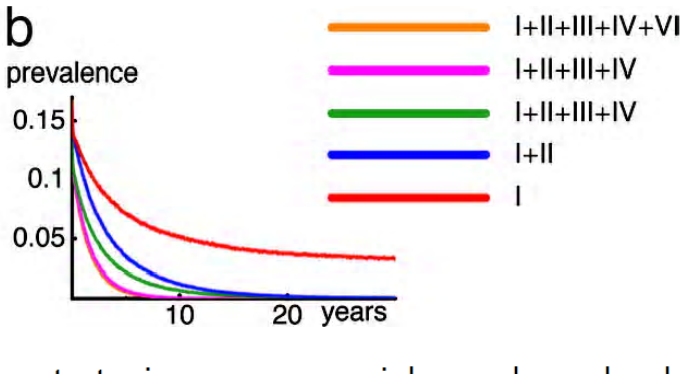
12.Muto CA, Blank MK, Pokrywka M, Posey K, Roberts T, Voth J, Clair J. University of Pittsburgh School of Medicine, UPMC - Presbyterian, Pittsburgh, PA
Cost avoidance associated with control (C) of methicillin-resistant *Staphylococcus aureus* (MRSA)

Results:
Annual MRSA initiative cost (MIC) was $35,281 and MIC/admission was $34.58. Model 1 projected an E 204 HAIs From 2002 to 2004, there were 33 A HAIs. The 171 E-A HAIs were valued at $6,047,757 or $2.0M annually. Model 2 projected an E 101 HAIs. The 68 E-A HAIs were valued at $2,404,956 or $800K annually. MIC of $35,281 was subtracted from Models' 1 and 2 avoided costs (E-A) yielding annual overall savings of $1.98 million (Model 1) or $766,371 (Model 2).

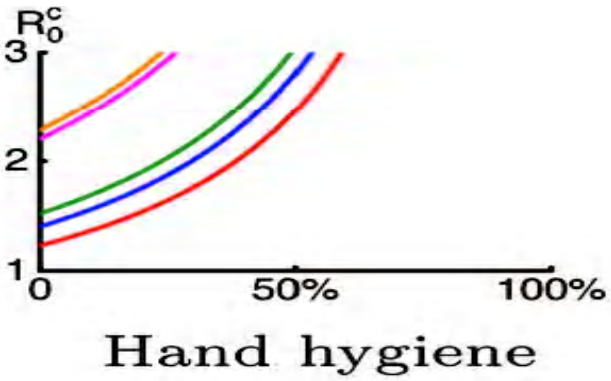
- Literature about Simulation of Potential Changes

  13.Bootsma MC, Diekmann O, Bonten MJ. Controlling methicillin-resistant Staphylococcus aureus: Quantifying the effects of interventions and rapid diagnostic testing. *Proc Natl Acad Sci USA*. 2006 Apr 4;103(14):5620-5625.

  This study is a simulation of potential interventions. See the article for details of the simulation model.




- **Measure I:** The isolation of identified carriers as a single control measure
- **Measure II:** Screening and precautionary isolation of high-risk patients
- **Measure III:** Screening of contact patients in case of the identification of an unexpected index patient
- **Measure IV:** Screening of Health Care Workers in case of the identification of an unexpected index patient
- **Measure V:** Temporary closing of wards
- **Measure VI:** Eradication of carriage




**The higher $R_0^c$ the faster the reduction of MRSA**

## II. Synopsis of Ongoing Work in Reduction of MRSA

NOTE: These results from facilities are meant to illustrate what has been tried recently in some organizations and what challenges they face.

**Example 1: MRSA Reduction Work from UK Safer Patients Initiative (SPI)**
[This is multipronged project to improve safety in the UK see http://www.ihi.org/IHI/Programs/SaferPatientsInitiative/]

Systemic focus:

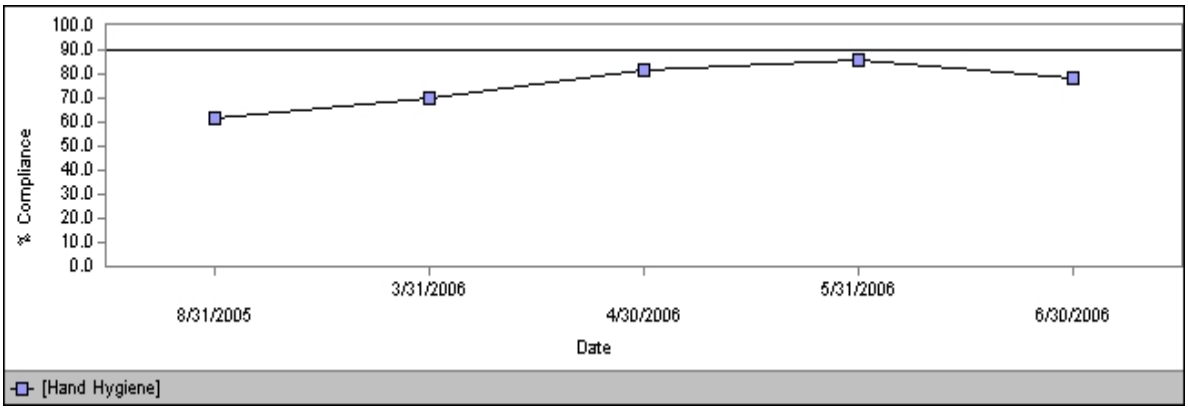
- They have real time review of cases, including review of where in the hospital (i.e., what unit) the infection was acquired and whether or not the antibiotic treatment was adequate. This helps them update their strategy on a weekly basis.
- They have many patients with MRSA in the community that interact with multiple providers. They keep track of their "old" MRSA cases to minimize the impact on the health care system—they are flagged the minute they contact a provider for special precautions.
- They have very limited single room capacity so they are careful what they do with patients. Most patients are in 6 bed bays on a 24- or 30-bed ward. They have considered but do not generally use cohort nursing (one set of nurses on a shift are designated to care for all the colonized or infected patients) because they have small numbers of cases on any unit. They do use cohort nursing when there is an outbreak.
- They have standard screening in high risk areas—ICUs and special baby units. They screen on admission, during the stay, and at discharge, then isolate and treat appropriately. If MRSA is found during stay or at discharge, they work to identify the source.

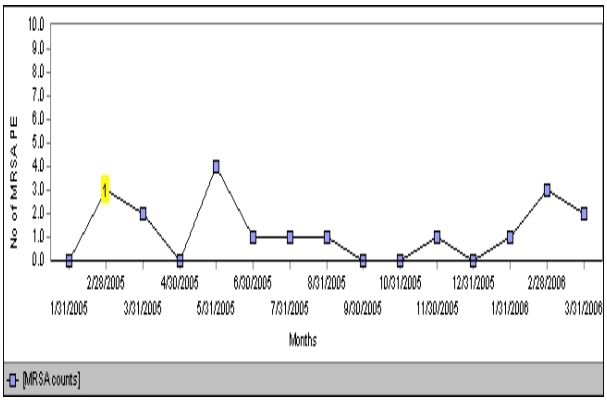
Improvement plan:

- They are developing a three-part approach, including a simple risk assessment, a change in barrier isolation, and color coding the aprons of the nurses that are caring for MRSA/resistant organism patients. Three things are too much to do at once, so they are starting with risk assessment.
- They are well into testing the risk assessment:
    - They have developed a three question checklist about location of colonization and features of the case.
    - The nurses use this checklist on admission and with any new identification.
    - Each question has a certain number of points for a "yes" answer, and when patients reach a certain threshold, they are considered high risk.
    - At high risk, patients are given a single room and additional precautions are used. Below that threshold, they use different precautions and manage the patient in a "bay."
- They are working on the education piece as well. They were struck with how little their staff knew about appropriate precautions, even after training, so they are putting isolation

checklists by the bedside and outside the door of each room with an isolation patient—7-8 key items are included.

Results:




**Example 2: UK Safer Patients Initiative** Hand Hygiene Compliance **Efforts**

"We have trained nurses in each of our clinical areas to perform 'hand hygiene audits' using an assessment tool developed by the Infection Control Nurses Association (UK) that identifies each 'opportunity' for handwashing and then records whether or not the individual disinfected their hands at that opportunity. We now regularly publish and review the results of these audits, and rates of compliance are beginning to increase. I am keen to spread the 'burden' of performing the audits so that all staff take turns in performing them, to avoid those who do being characterised as 'spies'; and also to include medical staff in this training."

Another facility provides patients with education about hand hygiene on admission. Patients are encouraged to ask clinicians to wash hands if they don't. After discharge, they are given a survey to rate how well the clinicians did with regard to hand hygiene. The patients rate the clinicians over 90% for hand hygiene compliance. Another facility gives cards to patients when they come to the ER. A patients gives the card back to care providers when the providers wash their hands. If

the patient observes a problem with hand hygiene, he/she is encouraged to call the phone number of the ER manager listed on the card.

**III. Changes/Design Concepts:**

1. Barrier precautions

2. Hand hygiene (see IHI Improving Hand Hygiene How-to Guide at http://www.ihi.org/IHI/Topics/CriticalCare/IntensiveCare/Tools/HowtoGuideImprovingHandHygiene.htm)
    - Poster promotion (Pittet D, et al *Lancet* article)
    - Alcohol/antiseptic use
    - Provide training for appropriate use of alcohol-based hand hygiene products
    - Stress competency in handwashing (i.e., yearly competency assessment)
    - Provide adequate handwashing facilities (e.g., sinks must be convenient for patient; include caregivers in the consideration of architectural standards that govern where sinks should be located
    - Involve patients in hand hygiene efforts by encouraging them to ask health care providers if they have washed their hands

3. Selective screening for MRSA
    - Culture
    - Rapid screening technology

4. Isolate infected and colonized patients
    - Prioritize clinical areas that require the use of isolation rooms
    - Develop criteria by active infection, clinical area
    - All infected or colonized patients should be cohorted either geographically or by care providers(it is recognized that not all hospitals will have facilities for this)
    - Assure adequate staffing to provide designated staff to care for infected and colonized patients
    - Appropriate contact precautions with the use of gloves and gowns with infected or colonized patients and the potentially contaminated environments of these patients

5. Decolonization
    - Decolonization for infected/colonized patients and staff members
    - Decolonization or treatment for infected/colonized staff, as appropriate

6. “Search and destroy” for MRSA (which is really the application of the above principles)
    - All patients with MRSA isolated in private rooms
    - Patients from foreign hospitals who are suspected MRSA carriers are screened (nose, throat, perineum, sputum, urine, wound) and quarantined:
    - MRSA-positive patients, health care workers, and roommates are screened

- Positive patients, health care workers are decolonized with mupirocin and cholorhexidine (90% success, but 25%-50% recolonized 3-6 months)
- 1 patient or health care worker colonized with same strain as index patient, ward closed, positive health care workers sent home, patients isolated/cohorted
- Advance warning if colonized patient transferred to another hospital

7. The capacity of MRSA to survive in the environment and on fomites
    - Thorough cleansing of rooms between patients
    - Cleansing of equipment such as stethoscopes, blood pressure cuffs, otoscope handles, etc. after use with MRSA patients or equipment dedicated to their use

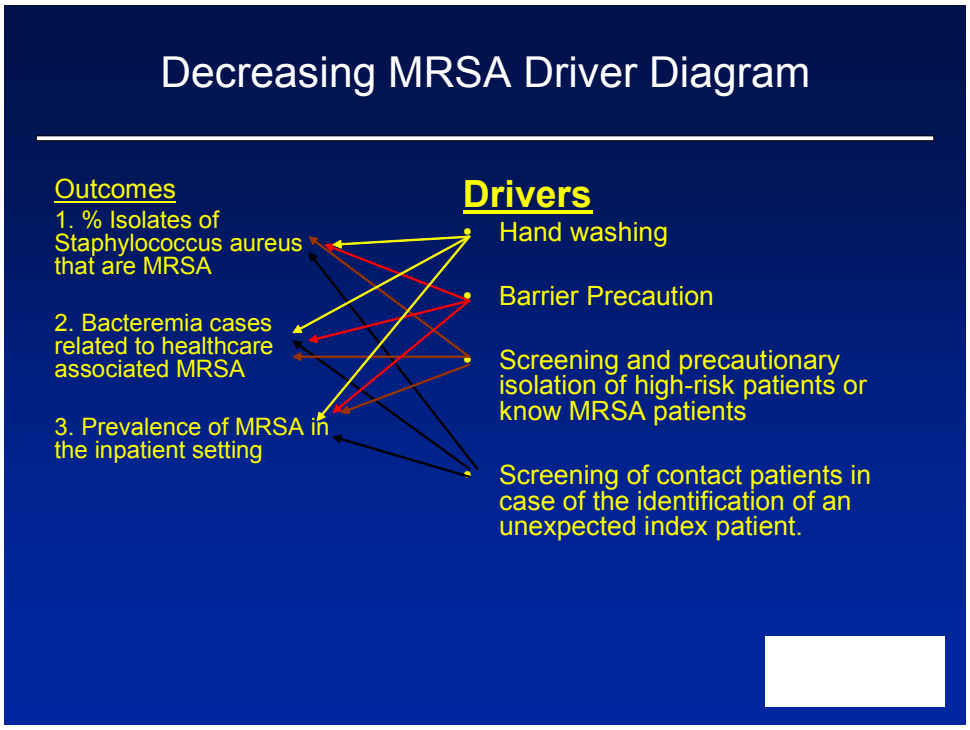
**Open Questions about Changes/Design Concepts**

- How applicable is the "search and destroy" approach once MRSA is highly endemic?
- How much value will we achieve with rigorous hand hygiene and barrier precaution alone?
- What is the core bundle of ideas that should be implemented by all facilities?
- What would a tiered approach look like?

**IV. Roadmap Forward:**

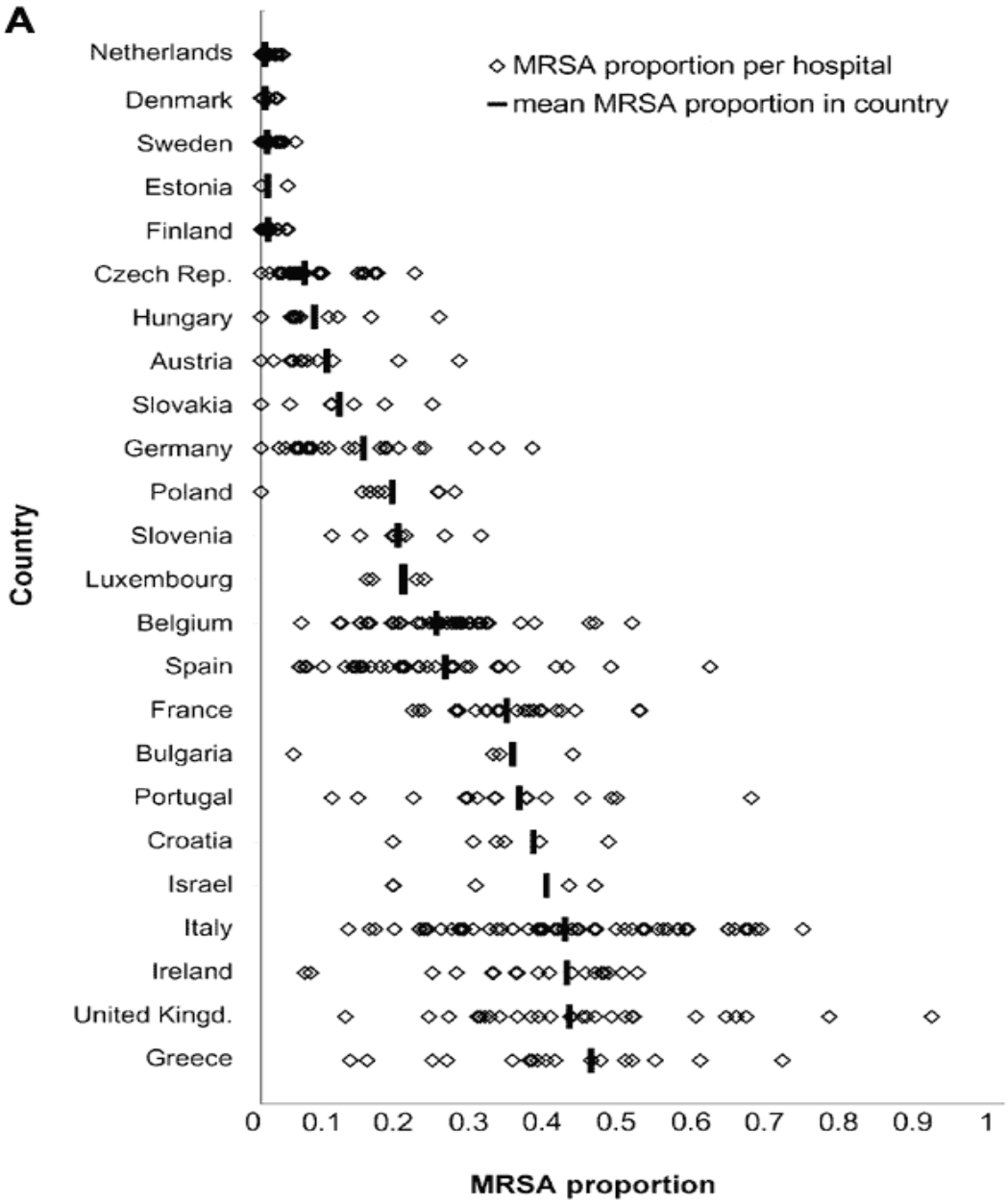
There are four key drivers for resistant bacteria such as MRSA. To create an effective program all four steps listed below should be addressed. The present prevalence of MRSA will determine the speed at which it can be decreased.

1. Improved rates of hand hygiene compliance
2. Barrier precaution
3. Screening and precautionary isolation of high-risk patients or known MRSA patients
4. Screening of contact patients in case of the identification of an unexpected index patient


Decreasing MRSA Driver Diagram
Outcomes
1. % Isolates of Staphylococcus aureus that are MRSA
2. Bacteremia cases related to healthcare associated MRSA
3. Prevalence of MRSA in the inpatient setting
Drivers
Hand washing
Barrier Precaution
Screening and precautionary isolation of high-risk patients or know MRSA patients
Screening of contact patients in case of the identification of an unexpected index patient.

## Appendixes

Appendix A. Methicillin-resistant *Staphylococcus aureus* in Europe, 1999–2002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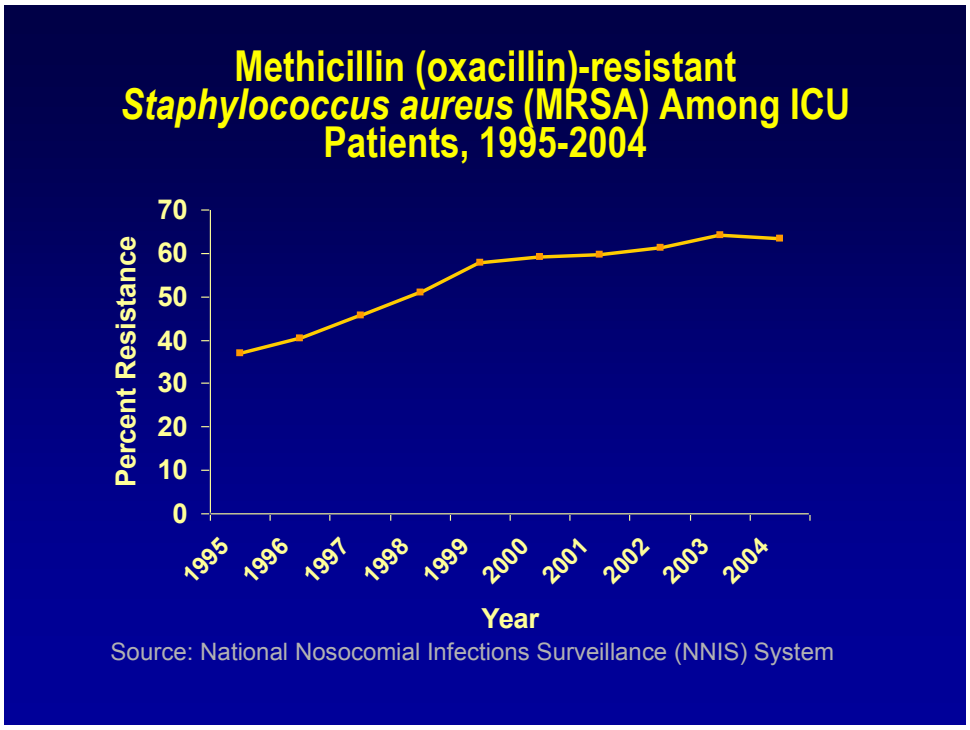
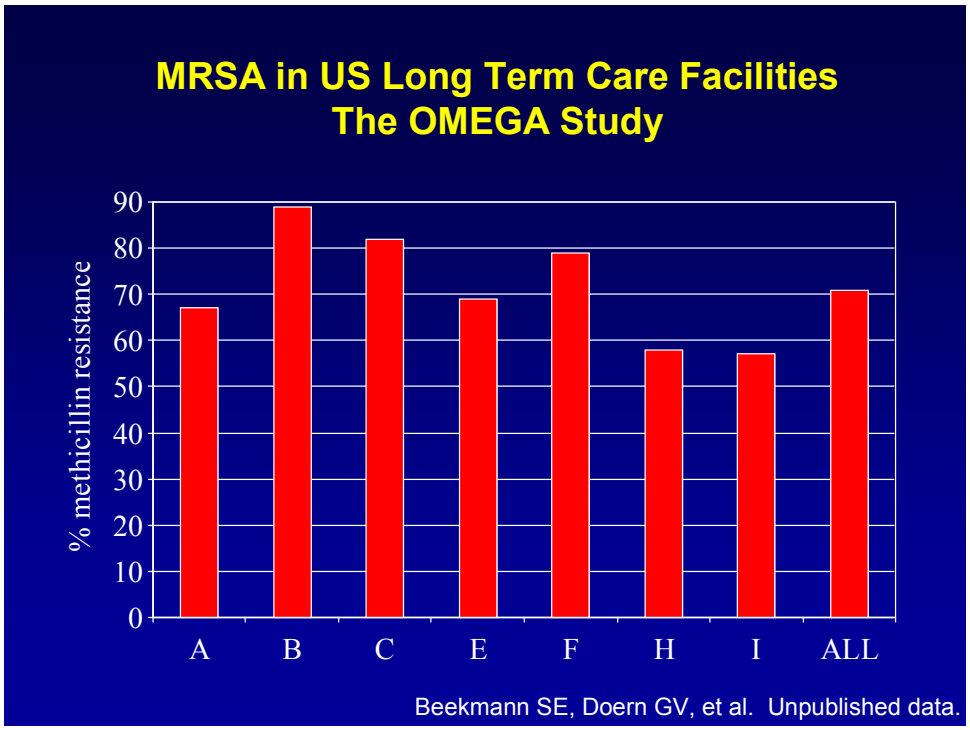
MRSA proportion

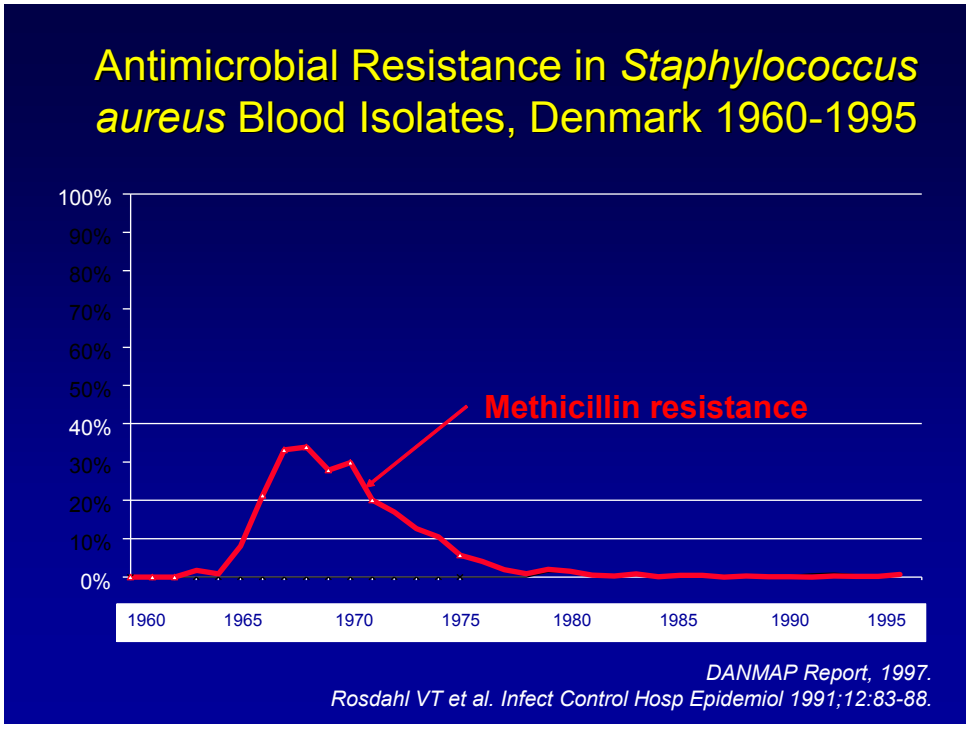
Appendix B. Methicillin (oxacillin)-resistant *Staphylococcus aureus* (MRSA) among ICU patients, 1995-2004 US




Appendix C. MRSA in U.S. Long-term Care Facilities: The OMEGA Study



Appendix D. Antimicrobial Resistance in *Staphylococcus aureus* Blood Isolates, Denmark 1960-1995




Appendix E. National Estimates of U.S. Short Stay Hospital Discharges with *C. difficile* Listed as First-listed or Any Diagnosis