

# “All-Time Top” Infection Control Literature part 1

---

Robert A. Weinstein, MD

June 8, 2015

Rush University Medical Center  
Cook County Health & Hospitals System  
Chicago IL

# Study Categories: Slide Icons

- Practice-changing Studies:



- “New Concept” Studies:



- Confirmatory Studies:



# Topics

---

1. Antimicrobial Resistance
2. Key Epidemiologic Risk Factors
3. Five General Control Measures
4. Surgical Site Infection Control
5. Device-associated Infection Control
6. Major Outbreaks
7. Quality Improvement
8. Statistics and Modeling
9. Molecular Advances
10. The Microbiome

# In the “Beginning”...

## Survival of the Fittest (Most Adapted)

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE  
FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNEAN, ETC., SOCIETIES;  
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE  
ROUND THE WORLD.'

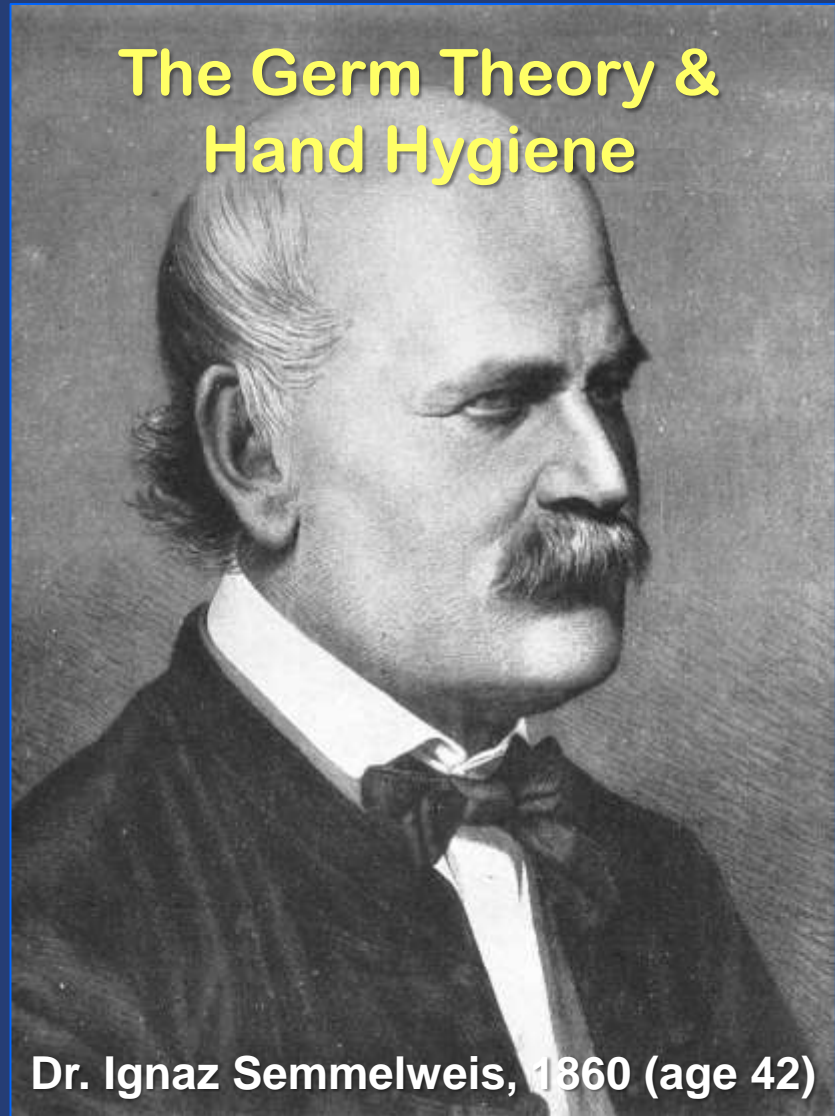
LONDON:

JOHN MURRAY, ALBEMARLE STREET.

1859.

*The right of Translation is reserved.*

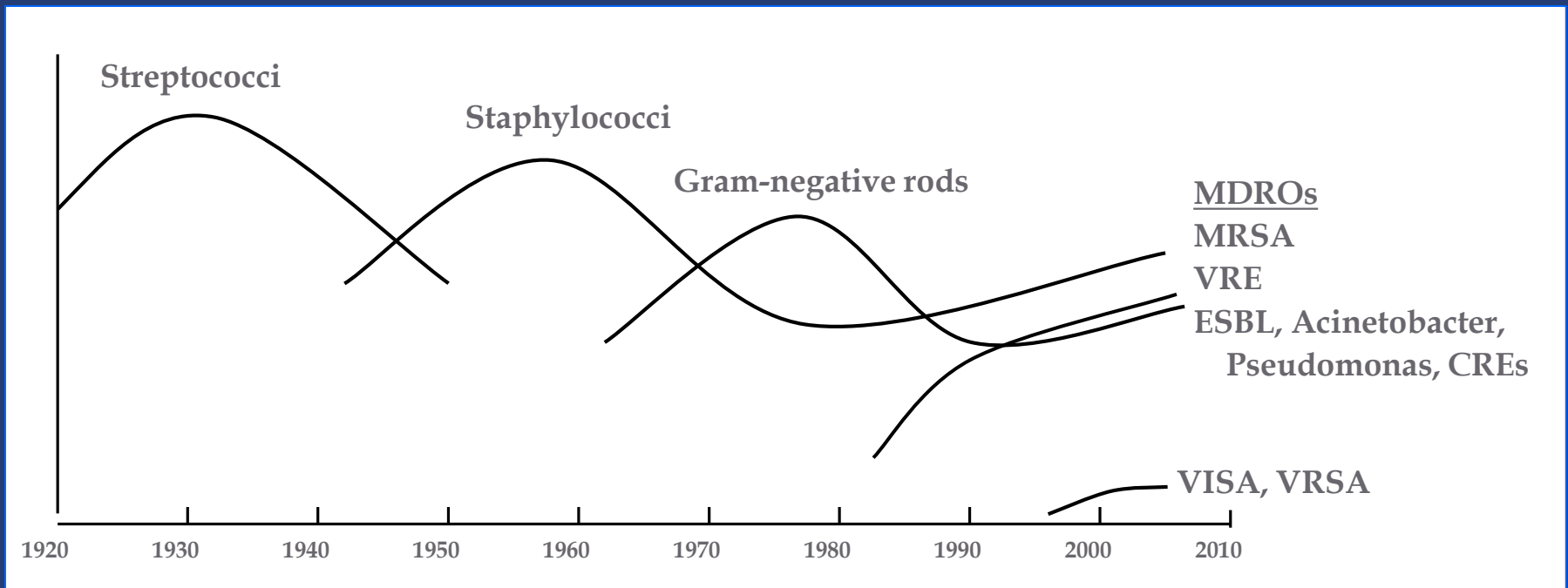
## The Germ Theory & Hand Hygiene



Dr. Ignaz Semmelweis, 1860 (age 42)



# Major Nosocomial Pathogens of the 20th Century and Beyond – Four Eras



MDROs, multi-drug resistant organisms





# Community-Acquired Methicillin-Resistant *Staphylococcus aureus* in Children With No Identified Predisposing Risk

Betsy C. Herold, MD; Lilly C. Immergluck, MD; Melinda C. Maranan, MD; Diane S. Lauderdale, PhD; Ryan E. Gaskin; Susan Boyle-Vavra, PhD; Cindy D. Leitch; Robert S. Daum, MD

**Context.**—Community-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) infections in children have occurred primarily in individuals with recognized predisposing risks. Community-acquired MRSA infections in the absence of identified risk factors have been reported infrequently.

**Objectives.**—To determine whether community-acquired MRSA infections in children with no identified predisposing risks are increasing and to define the spectrum of disease associated with MRSA isolation.

**Design.**—Retrospective review of medical records.

**Patients.**—Hospitalized children with *S aureus* isolated between August 1988 and July 1990 (1988-1990) and between August 1993 and July 1995 (1993-1995).

**Setting.**—The University of Chicago Children's Hospital.

**Main Outcome Measures.**—Prevalence of community-acquired MRSA over time, infecting vs colonizing isolates, and risk factors for disease.

**Results.**—The number of children hospitalized with community-acquired MRSA disease increased from 8 in 1988-1990 to 35 in 1993-1995. Moreover, the prevalence of community-acquired MRSA without identified risk increased from 10 per 100 000 admissions in 1988-1990 to 259 per 100 000 admissions in 1993-1995 ( $P < .001$ ), and a greater proportion of isolates produced clinical infection. The clinical syndromes associated with MRSA in children without identified risk were similar to those associated with community-acquired methicillin-susceptible *S aureus*. Notably, 7 (70%) of 10 community-acquired MRSA isolates obtained from children with an identified risk were nonsusceptible to at least 2 drugs, compared with only 6 (24%) of 25 isolates obtained from children without an identified risk ( $P = .02$ ).

**Conclusions.**—These findings demonstrate that the prevalence of community-acquired MRSA among children without identified risk factors is increasing.

JAMA. 1998;279:593-598

The epidemiology of MRSA infections is complex. Acquisition of the organism in a hospital or a long-term care facility is well documented in adults and children.<sup>9</sup> In adults, other risk factors identified for MRSA infection include chronic liver, lung, or vascular disease, dialysis, malignancy, or prolonged exposure to antimicrobial agents.<sup>4,9</sup> Despite fewer descriptive data, predisposing risk factors for MRSA infections in pediatric populations include prolonged hospitalization, invasive or surgical procedures, indwelling catheters, endotracheal tubes, and prolonged or recurrent exposure to antibiotics, factors similar to those documented in adults.<sup>10,12</sup>

---

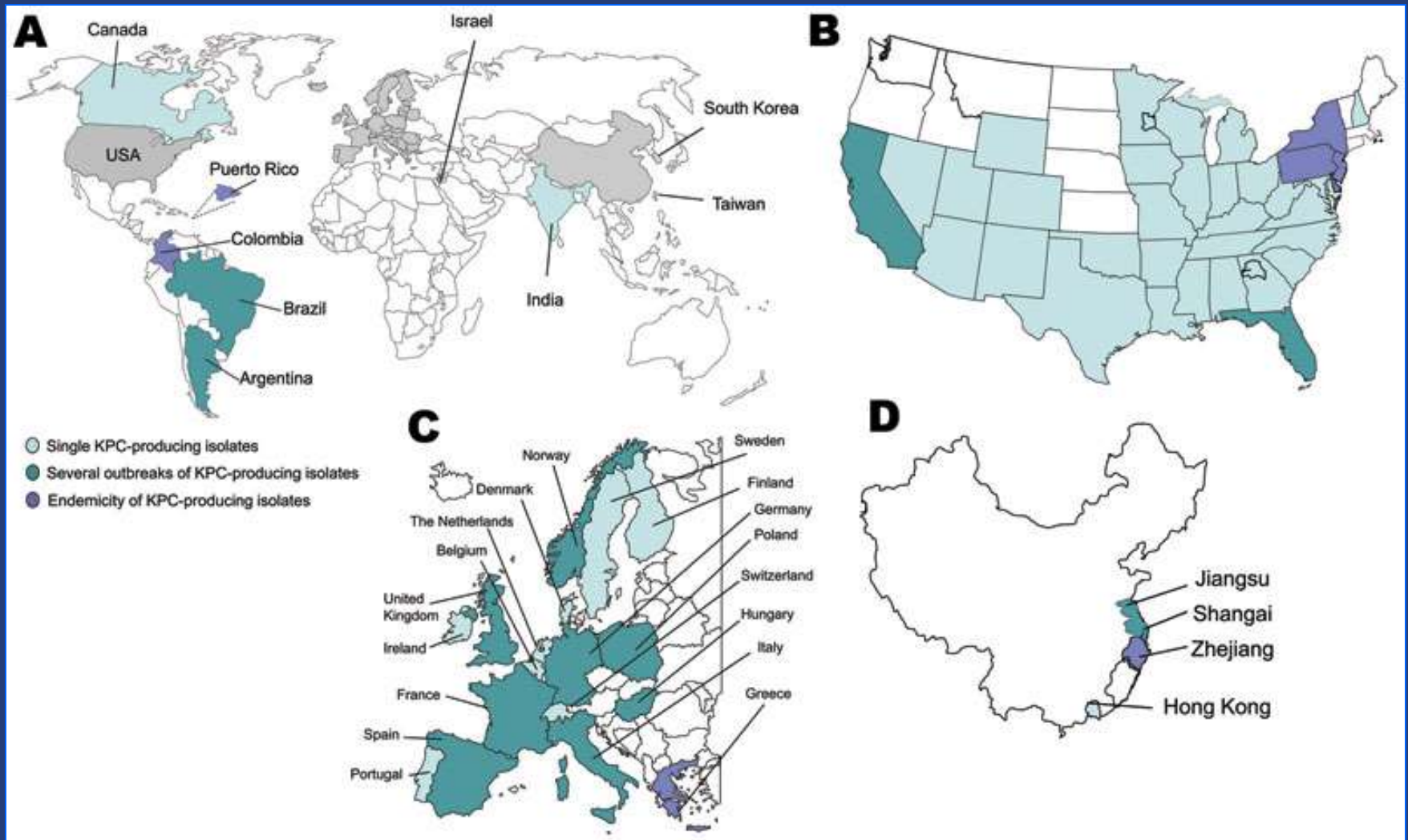
For editorial comment see p 623.

---

Community-acquired MRSA infections among hospital inpatients, ie, isolates obtained within 72 hours of hospitalization, have been described among adults. The majority of these, however, have occurred in individuals with a recognized predisposing risk factor, such as



# Worldwide Geographic Distribution of *Klebsiella pneumoniae* Carbapenemase (KPC) Producers





# *Clostridium difficile* — Associated Disease

## ANTIBIOTIC-ASSOCIATED PSEUDOMEMBRANOUS COLITIS DUE TO TOXIN-PRODUCING CLOSTRIDIA

JOHN G. BARTLETT, M.D., TE WEN CHANG, M.D., MARC GURWITH, M.D.,  
SHERWOOD L. GORBACH, M.D., AND ANDREW B. ONDERDONK, PH.D.

**Abstract** A substance producing cytotoxicity in tissue culture was detected in stool specimens from all of four patients with pseudomembranous colitis due to antibiotics and in one of 54 with antibiotic-associated diarrhea. These stools also caused enterocolitis when injected intracecally into hamsters. On each occasion, cytotoxicity in tissue culture and enterocolitis in hamsters were neutralized by pretreat-

ment with gas-gangrene antitoxin. The toxicity in both tissue cultures and hamsters could be reproduced with broth cultures of clostridia strains isolated from four of the five stools. These results suggest that toxin-producing clostridia are responsible for antibiotic-associated pseudomembranous colitis. (N Engl J Med 298:531-534, 1978)





# Causative Pathogens, According to Type of Infection, NHSN, 2011, USA

Pathogen	All Health Care-Associated Infections (N=504)		Pneumonia (N=110)	Surgical-Site Infections (N=110)	GI Infections (N=86)	UTIs (N=65)	Bloodstream Infections (N=50)
	no. (%)	rank	number (percent)				
<i>Clostridium difficile</i>	61 (12.1)	1	0	0	61 (70.9)	0	0
<i>Staphylococcus aureus</i>	54 (10.7)	2	18 (16.4)	17 (15.5)	1 (1.2)	2 (3.1)	7 (14.0)
<i>Klebsiella pneumoniae</i> or <i>K. oxytoca</i>	50 (9.9)	3	13 (11.8)	15 (13.6)	1 (1.2)	15 (23.1)	4 (8.0)
<i>Escherichia coli</i>	47 (9.3)	4	3 (2.7)	14 (12.7)	1 (1.2)	18 (27.7)	5 (10.0)
Enterococcus species	44 (8.7)	5	2 (1.8)	16 (14.5)	5 (5.8)	11 (16.9)	6 (12.0)
<i>Pseudomonas aeruginosa</i>	36 (7.1)	6	14 (12.7)	7 (6.4)	1 (1.2)	7 (10.8)	2 (4.0)
<i>Candida</i> species	32 (6.3)	7	4 (3.6)	3 (2.7)	3 (3.5)	3 (4.6)	11 (22.0)
Streptococcus species	25 (5.0)	8	7 (6.4)	8 (7.3)	2 (2.3)	2 (3.1)	2 (4.0)
Coagulase-negative staphylococcus species	24 (4.8)	9	0	7 (6.4)	0	1 (1.5)	9 (18.0)
Enterobacter species	16 (3.2)	10	3 (2.7)	5 (4.5)	0	2 (3.1)	2 (4.0)

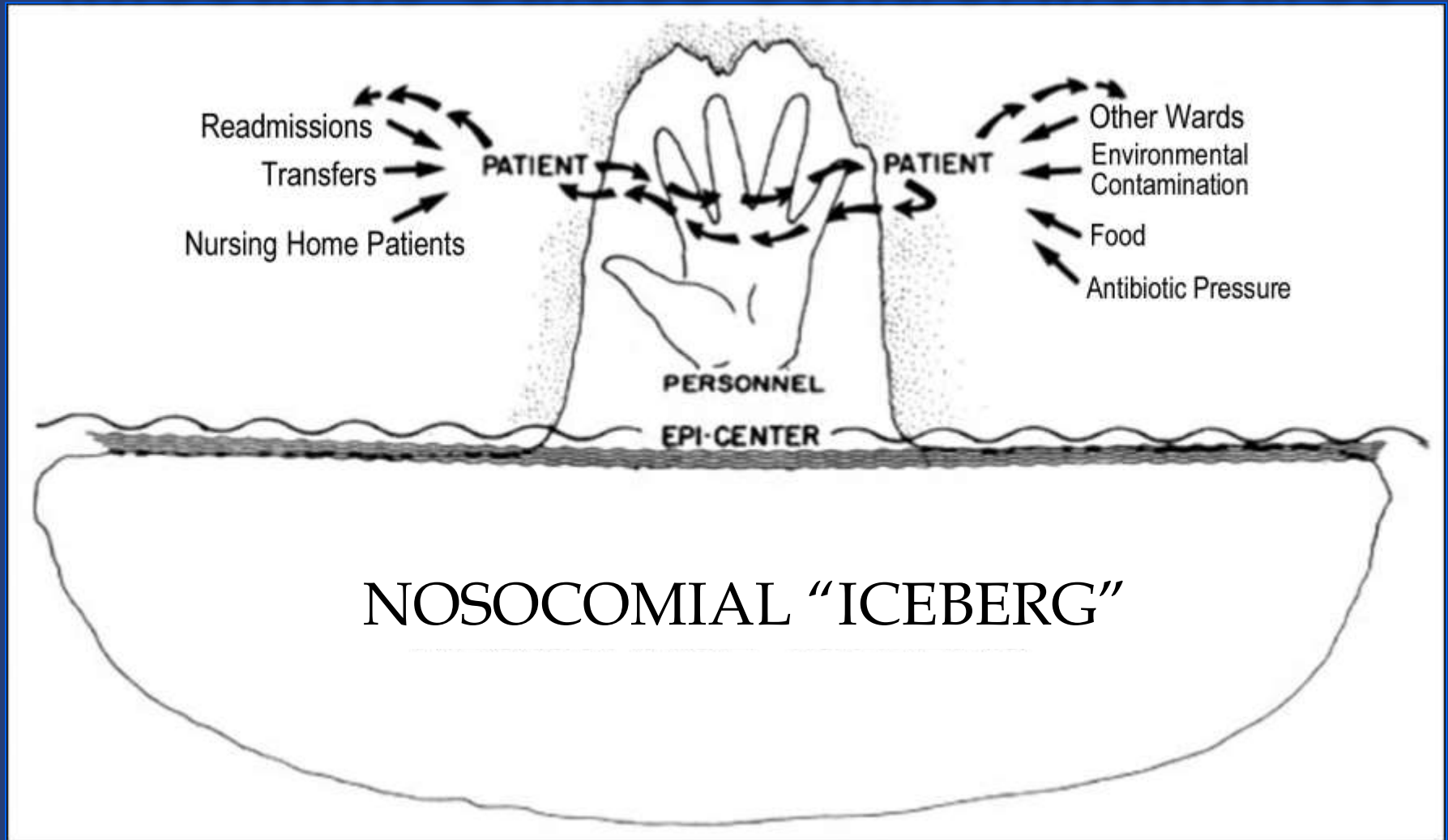


# Topics

---

1. Antimicrobial Resistance
2. Key Epidemiologic Risk Factors
3. Five General Control Measures
4. Surgical Site Infection Control
5. Device-associated Infection Control
6. Major Outbreaks
7. Quality Improvement
8. Statistics and Modeling
9. Molecular Advances
10. The Microbiome

# Epidemiology of Healthcare-associated Infections Guides Control Measures



NOSOCOMIAL "ICEBERG"



# Nosocomial Klebsiella Infections: Intestinal Colonization as a Reservoir

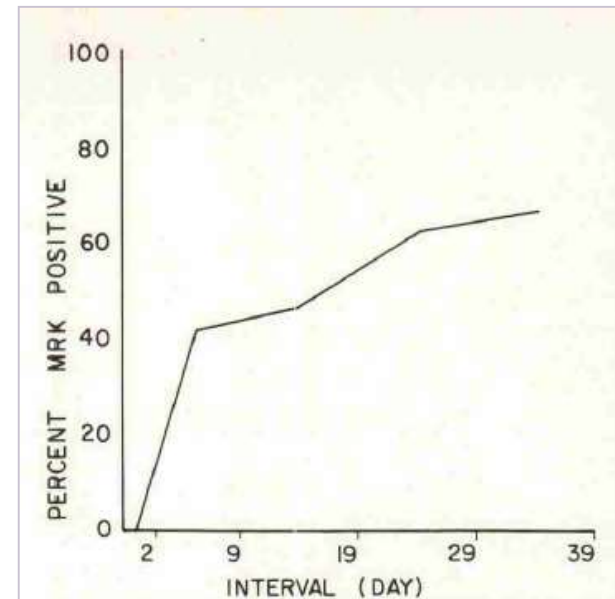
RICHARD SELDEN, M.D., SHARON LEE, B.A., WEN LAN LOU WANG, PH.D.,

JOHN V. BENNETT, M.D., and THEODORE C. EICKHOFF, M.D.,

Atlanta, Georgia; and Denver, Colorado

A prospective study of patients admitted to a hospital where there was endemic nosocomial infection with multidrug-resistant klebsiella was undertaken to evaluate the role of intestinal colonization of patients. Among 31 patients who became intestinal carriers of klebsiella during hospitalization, 14 subsequently became infected by the same serotype. Of 101 patients who did not become intestinal carriers of klebsiella, only 11 were infected by that organism. Antibiotic therapy was shown to be predisposing to intestinal colonization with klebsiella and to exert a selective pressure in favor of multidrug-resistant klebsiella. Gastrointestinal acquisition and carriage of klebsiella by patients may be an important intermediate step in the development of nosocomial klebsiella infection and may also serve to perpetuate a significant reservoir of organisms within the hospital.

Percent of 138 patients positive for multidrug-resistant klebsiella on rectal culture, by interval from admission to culture, June 1968





# The Role of “Colonization Pressure” in the Spread of Vancomycin-Resistant Enterococci

## *An Important Infection Control Variable*

Marc J. M. Bonten, MD; Sarah Slaughter, MD; Anton W. Ambergen; Mary K. Hayden, MD;  
Jean van Voorhis, RN, MS; Catherine Nathan, MS; Robert A. Weinstein, MD

**Objective:** The spread of nosocomial multiresistant microorganisms is affected by compliance with infection control measures and antibiotic use. We hypothesized that “colonization pressure” (ie, the proportion of other patients colonized) also is an important variable. We studied the effect of colonization pressure, compliance with infection control measures, antibiotic use, and other previously identified risk factors on acquisition of colonization with vancomycin-resistant enterococci (VRE).

**Methods:** Rectal colonization was studied daily for 19 weeks in 181 consecutive patients who were admitted to a single medical intensive care unit. A statistical model was created using a Cox proportional hazards regression model including length of stay in the medical intensive care unit until acquisition of VRE, colonization pressure, personnel compliance with infection control measures (hand washing and glove use), APACHE (Acute Physiology and Chronic Health Evaluation) II scores, and the proportion of days that a patient received vancomycin or third-generation cephalosporins, sucralfate, and enteral feeding.

**Results:** With survival until colonization with VRE as the end point, colonization pressure was the most important variable affecting acquisition of VRE (hazard ratio [HR], 1.032; 95% confidence interval [CI], 1.012-1.052;  $P=.002$ ). In addition, enteral feeding was associated with acquisition of VRE (HR, 1.009; 95% CI, 1.000-1.017;  $P=.05$ ), and there was a trend toward association of third-generation cephalosporin use with acquisition (HR, 1.007; 95% CI, 0.999-1.015;  $P=.11$ ). The effects of enteral feeding and third-generation cephalosporin use were more important when colonization pressure was less than 50%. Once colonization pressure was 50% or higher, these other variables hardly affected acquisition of VRE.

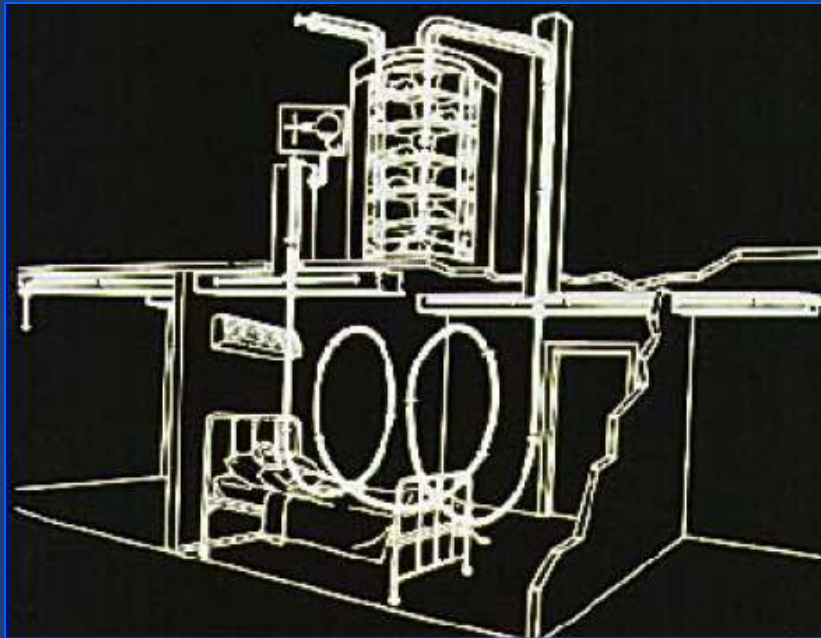
**Conclusions:** Acquisition of VRE was affected by colonization pressure, the use of antibiotics, and the use of enteral feeding. However, once colonization pressure was high, it became the major variable affecting acquisition of VRE.

*Arch Intern Med.* 1998;158:1127-1132



# Proving Tuberculosis (TB) is Airborne

Wells and Riley Experimental TB Ward, 1956-62



Quantitative air sampling for TB



Riley et al, Aerial dissemination of tuberculosis – a two year study of contagion on a tuberculosis ward, *Am J Hyg* 1959; 70:185-196 (reprinted as a “Classic” in *Am J Epidemiol* 1995; 142:3-14)



# Topics

---

1. Antimicrobial Resistance
2. Key Epidemiologic Risk Factors
3. Five General Control Measures
4. Surgical Site Infection Control
5. Device-associated Infection Control
6. Major Outbreaks
7. Quality Improvement
8. Statistics and Modeling
9. Molecular Advances
10. The Microbiome



# 1. Infection Control Programs

## THE EFFICACY OF INFECTION SURVEILLANCE AND CONTROL PROGRAMS IN PREVENTING NOSOCOMIAL INFECTIONS IN US HOSPITALS

ROBERT W. HALEY,<sup>1,2</sup> DAVID H. CULVER,<sup>1</sup> JOHN W. WHITE,<sup>1</sup> W. MEADE MORGAN,<sup>1</sup>  
T. GRACE EMORI,<sup>1</sup> VAN P. MUNN<sup>1</sup> AND THOMAS M. HOOTON<sup>1,3</sup>

### Essential components included

- Surveillance and control activities
- A trained, effective infection control physician
- An infection control nurse per 250 beds
- A system for reporting infection rates to practicing surgeons

Programs with these four components reduced their hospitals' infection rates by 32%

without effective programs, the overall infection rate increased by 18% from 1970 to 1976.





## 2. Hand Hygiene — A Controlled Trial!

*The formula for clear interpretation of results here is to supply one constant avenue of transmission and try to block all the rest, truly a sound experimental approach missing in many nursery studies.*

### Transmission of Staphylococci Between Newborns

*Importance of the Hands of Personnel*

EDWARD A. MORTIMER, JR., M.D.

PHILIP J. LIPSITZ, M.B.

(CAPETOWN)

M.R.C.P. (EDIN.), D.C.H.

EMANUEL WOLINSKY, M.D.

ANTONIO J. GONZAGA, M.D.

AND

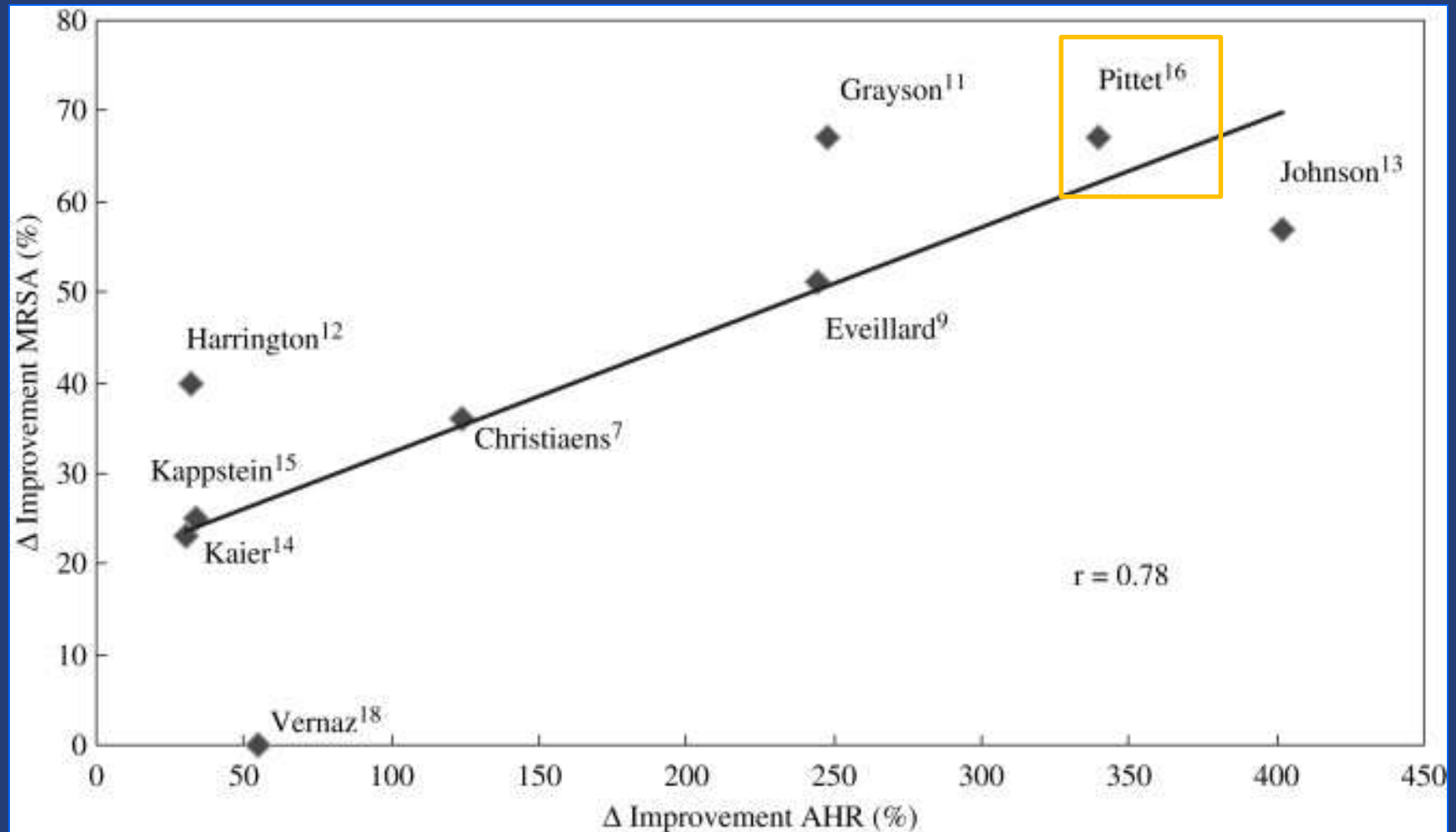
CHARLES H. RAMMELKAMP, JR.,  
M.D.

CLEVELAND



# Impact of Alcohol Hand-rub Use on Methicillin-Resistant *S. aureus* (MRSA): An Analysis of the Literature

Difference (%) in Improvement of Alcohol Hand-rub (AHR) Use & Change in MRSA Rates (%)



# 3. Chlorhexidine Bathing to Control the Fecal Patina

## 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.

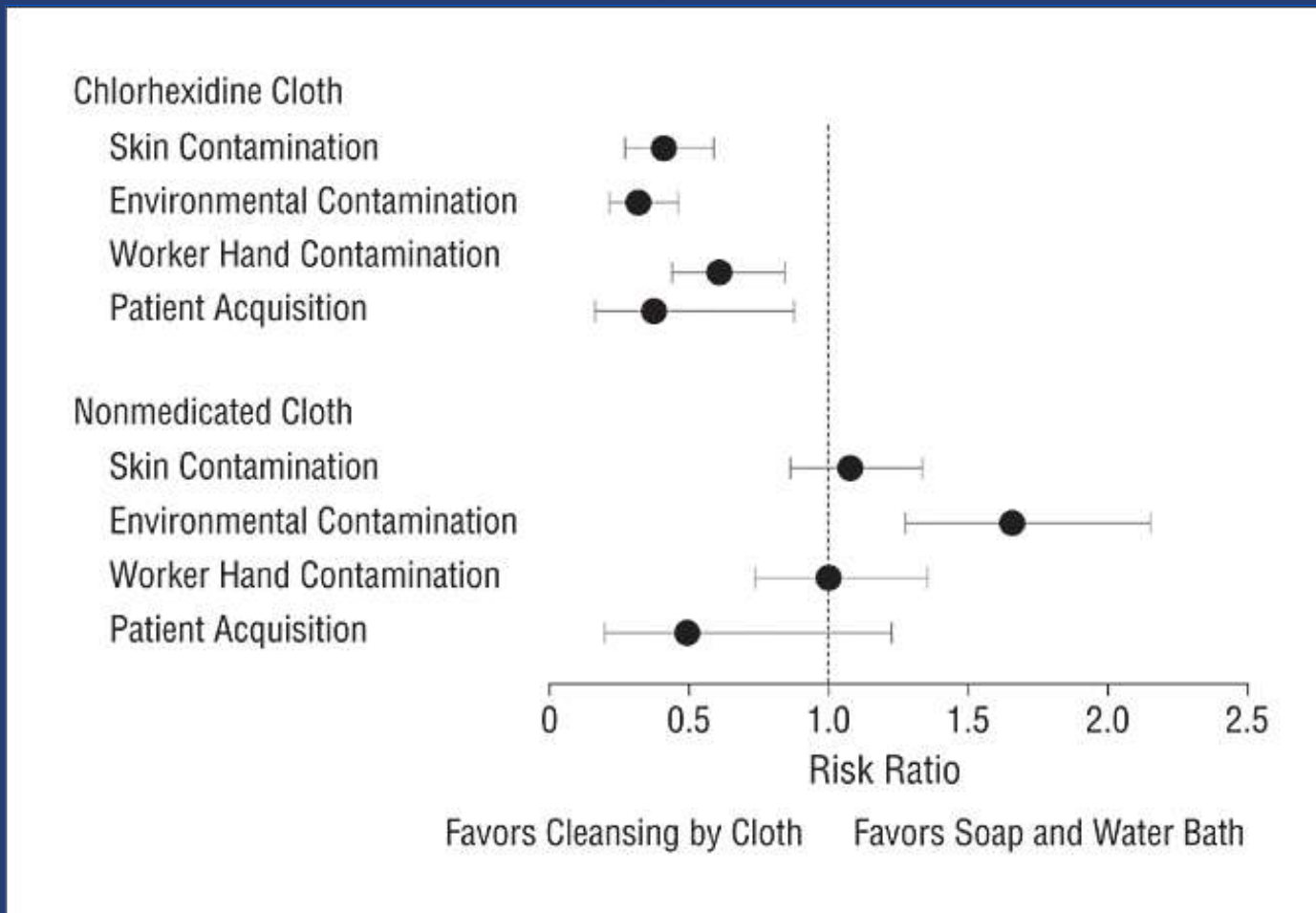
**Results:** Compared with soap and water baths, cleansing patients with chlorhexidine-saturated cloths resulted in 2.5 log<sub>10</sub> less colonies of VRE on patients' skin and less VRE contamination of health care workers' hands (risk ratio [RR], 0.6; 95% confidence interval [CI], 0.4-0.8) and environmental 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



# Risk Ratios for Patient Skin, Environmental, or Health Care Worker Contamination by VRE or Patient Acquisition of VRE





# 4. Gown & Garb?

## Effects of 'bare below the elbows' policy on hand contamination of 92 hospital doctors in a district general hospital

C.A. Willis-Owen<sup>a,\*</sup>, P. Subramanian<sup>a</sup>, P. Kumari<sup>b</sup>, D. Houlihan-Burne<sup>a</sup>

<sup>a</sup>Trauma & Orthopaedics Department, Hillingdon Hospital, London, UK

<sup>b</sup>Microbiology Department, Hillingdon Hospital, London, UK

---

### ARTICLE INFO

#### Article history:

Received 10 October 2009

Accepted 11 December 2009

Available online 29 March 2010

#### Keywords:

Hand hygiene

Hand washing

Bare below the elbows

Hospital-acquired infection

### SUMMARY

Despite a lack of evidence the UK's Department of Health introduced a policy of 'bare below the elbows' attire in order to try to reduce the incidence of nosocomial infection. This study investigates the link between this state of dress and hand contamination. A prospective observational study of doctors working in a district general hospital was carried out. The fingertips of each hand were imprinted onto culture medium, and resultant growth assessed for number of colony-forming units and presence of clinically significant pathogens or multiply resistant organisms. These findings were correlated with attire, grade, sex and specialty. Ninety-two doctors were recruited of whom 49 were 'bare below the elbows' compliant and 43 were not. There was no statistically significant difference between those doctors who were 'bare below the elbows' and those that were not, either for the number of colony-forming units or for the presence of clinically significant organisms. No multiply resistant organisms were cultured from doctors' hands. 'Bare below the elbows' attire is not related to the degree of contamination on doctors' fingertips or the presence of clinically significant pathogens. Further studies are required to establish whether investment in doctors' uniforms and patient education campaigns are worthwhile.

© 2009 The Hospital Infection Society. Published by Elsevier Ltd. All rights reserved.



## 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

Sarah Slaughter, MD; Mary K. Hayden, MD; Catherine Nathan, MS; Tzyy-Chyn Hu, RN, MSPH; Thomas Rice, PhD; Jean Van Voorhis, RN, MS; Marian Matushek, MS; Cory Franklin, MD; and Robert A. Weinstein, MD

**Conclusions:** Universal use of gloves and gowns was no better than universal use of gloves only in preventing rectal colonization by vancomycin-resistant enterococci in a medical intensive care unit of a hospital in which vancomycin-resistant enterococci are endemic. Because the use of gowns and gloves together may be associated with better compliance and may help prevent transmission of other infectious agents, this finding may not be applicable to outbreaks caused by single strains or hospitals in which the prevalence of vancomycin-resistant enterococci is low.

epidemiologic typing of vancomycin-resistant enterococci.

**Measurements:** The number of patients becoming colonized by vancomycin-resistant enterococci; the number of days to acquisition of vancomycin-resistant enterococci; and other measurements, including nosocomial infections, length of hospital stay, and mortality rates.

great enterococcal infections—ampicillin, vancomycin, and gentamicin—and that are frequently resistant to all commercially available agents (3). Vancomycin-resistant enterococci are cause for alarm not only because effective antibiotics are lacking, but also because vancomycin resistance may spread to other bacteria, particularly *Staphylococcus aureus*.





# So, What to Wear?

## Good For You (continued)

An Occasional Newsletter produced by Dr. Norman Simmons, CBE,  
Number 36, Special Edition, September 2007  
[e-mail nasimmons@doctors.org.uk](mailto:enasimmons@doctors.org.uk)

---

**Robert Blowers** showed that the perineal dispersal of bacteria could be prevented if the ladies as well as gentlemen wore impermeable underpants. Trousers alone were not effective; the bacteria on skin squames simply fell out of the trouser legs. So in some operating theatres doctors and nurses were provided with bicycle clips and in others they were clad in impermeable underwear - until they rebelled - theatres are hot places, you know - and it didn't really seem to make any difference. Will our new masters compel doctors and nurses to wear plastic underwear?



# 5. The Key Environmental Intervention – Indoor Plumbing – and Evidence Hierarchy for Evaluating Cleaning & Disinfecting

