



# Emerging Infectious Diseases: Potential Wastes Impact

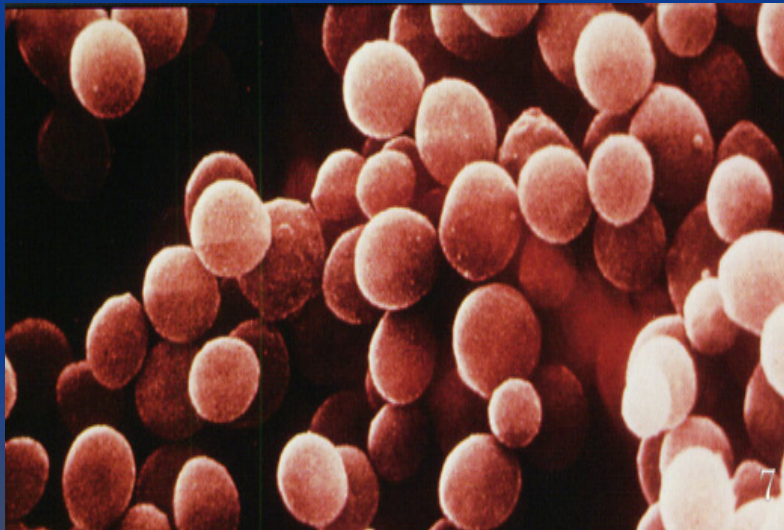
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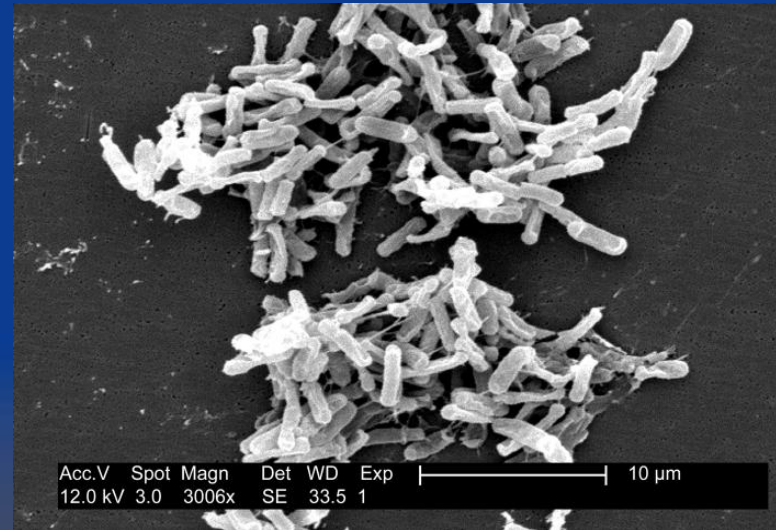


# EID and Potential Wastes Impact

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*Staphylococcus aureus*



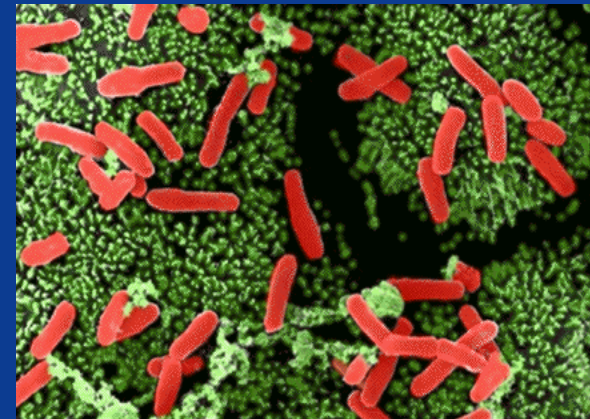
*Clostridium difficile* - CDC Public Health Image Library (L. Wiggs, J. Carr)



# Objectives for Today's Presentation



- Methicillin-resistant *Staphylococcus aureus* (MRSA)
  - Epidemiology
  - CA-MRSA, HA-MRSA
  - Mode of transmission
  - Control measures
- *Clostridium difficile*:
  - Epidemiology and surveillance
  - Epidemic strains
  - Mode of transmission
  - Environmental contamination
  - Control measures
- General assessment of impact on medical wastes





# *Staphylococcus aureus*



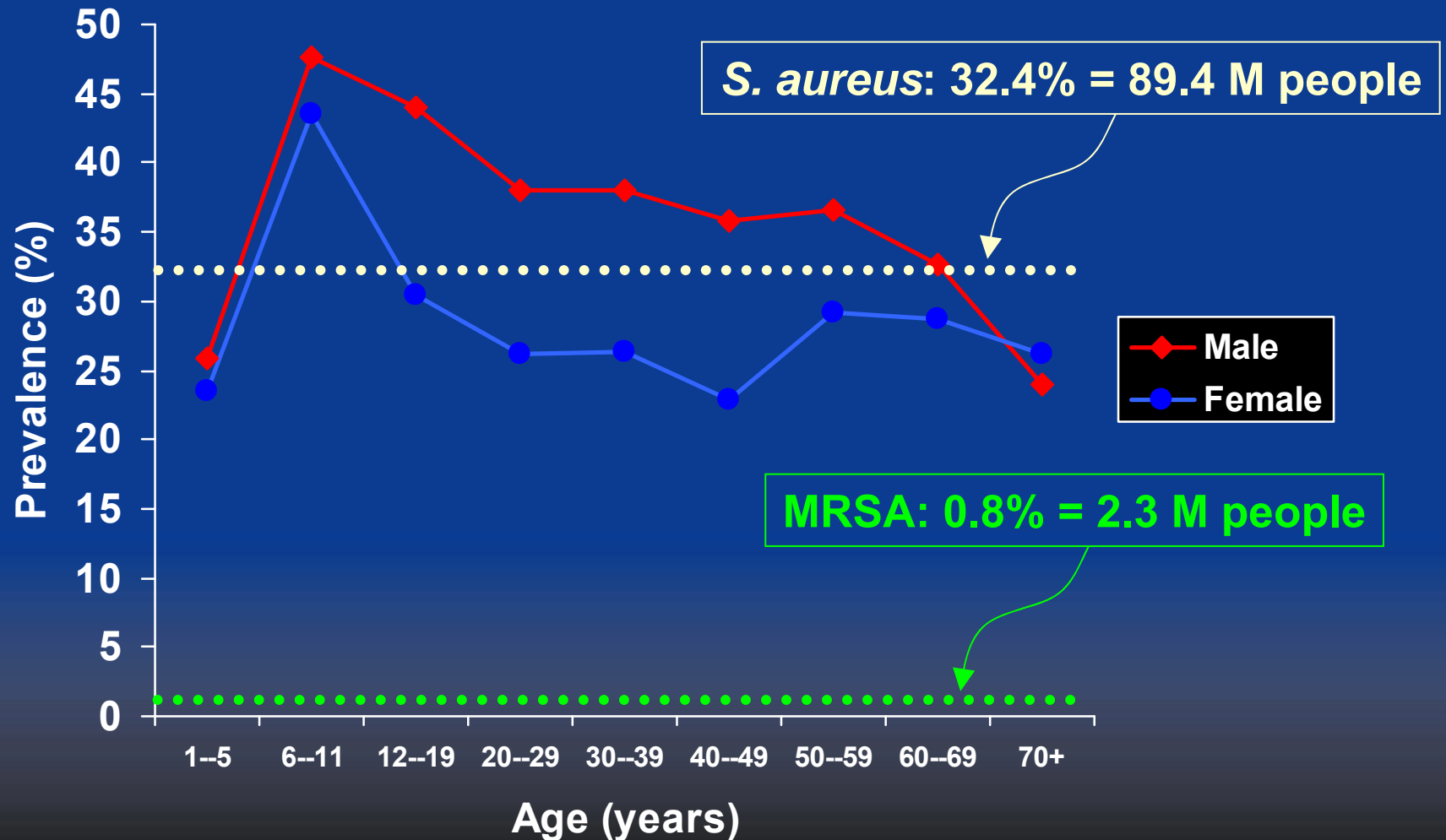
- ***Staphylococcus aureus*: common human colonizer and pathogen in the community and in health care**
  - Colonization
  - Infection: skin, variety of other syndromes
  - Transmission: direct contact
- **Methicillin-resistant *Staphylococcus aureus* (MRSA):**
  - Resistant to all currently available  $\beta$ -lactam agents (penicillins, cephalosporins)
  - Increasingly important cause of healthcare-associated infections since 1960s/1970s
  - In 1990s, emerged as cause of infection in the community



# *S. aureus* Nasal Colonization



National Health and Nutrition Examination Survey 2001-02



MRSA colonization associated with age  $\geq$  60 years & being female

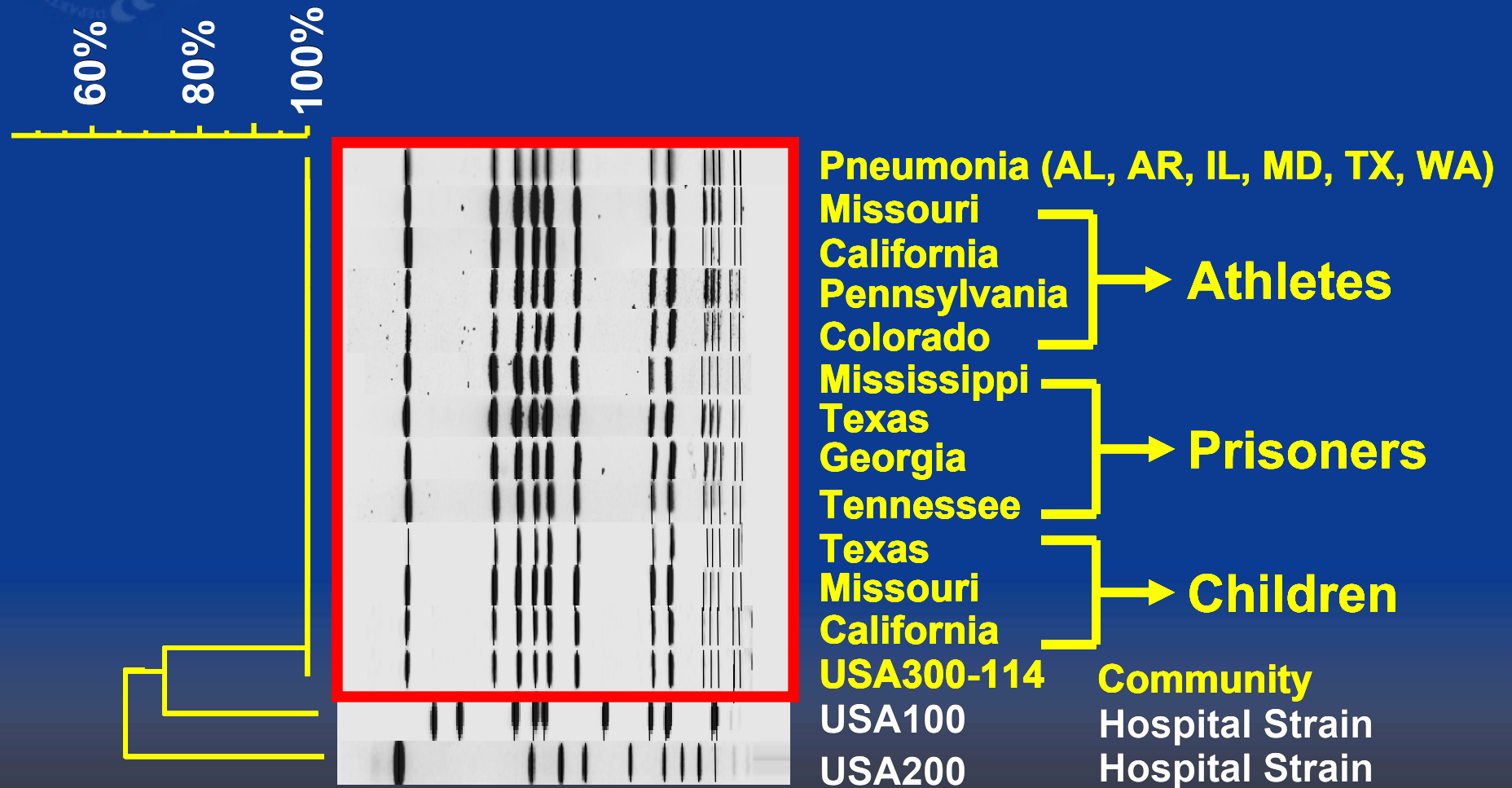


# MRSA Strain Characteristics Were *Initially* Distinct



	<b>MRSA in Healthcare</b>	<b>MRSA in the Community</b>
<b>Prevalent genotypes (U.S.)</b>	<b>USA100, USA200</b>	<b>USA300, USA400</b>
<b>Antimicrobial resistance</b>	<b>Multiple agents</b>	<b>Few agents</b>
<b>SCC<i>mec</i> (genetic element carrying <i>mecA</i> resistance gene)</b>	<b>Types I-III</b>	<b>Types IV, V</b>
<b>PVL toxin gene</b>	<b>Rare</b>	<b>Common</b>

# A Single Pulsed-Field Type (USA300) has Accounted for Most Community-Associated MRSA Infections in the U.S.



# CA-MRSA Infections are Mainly Skin Infections



Disease Syndrome	(%)
Skin/soft tissue	1,266 (77%)
Wound (traumatic)	157 (10%)
Urinary tract infection	64 (4%)
Sinusitis	61 (4%)
Bacteremia	43 (3%)
Pneumonia	31 (2%)



*Fridkin et al NEJM 2005;352:1436-44*



# CA-MRSA Incidence Varies by Age and Race

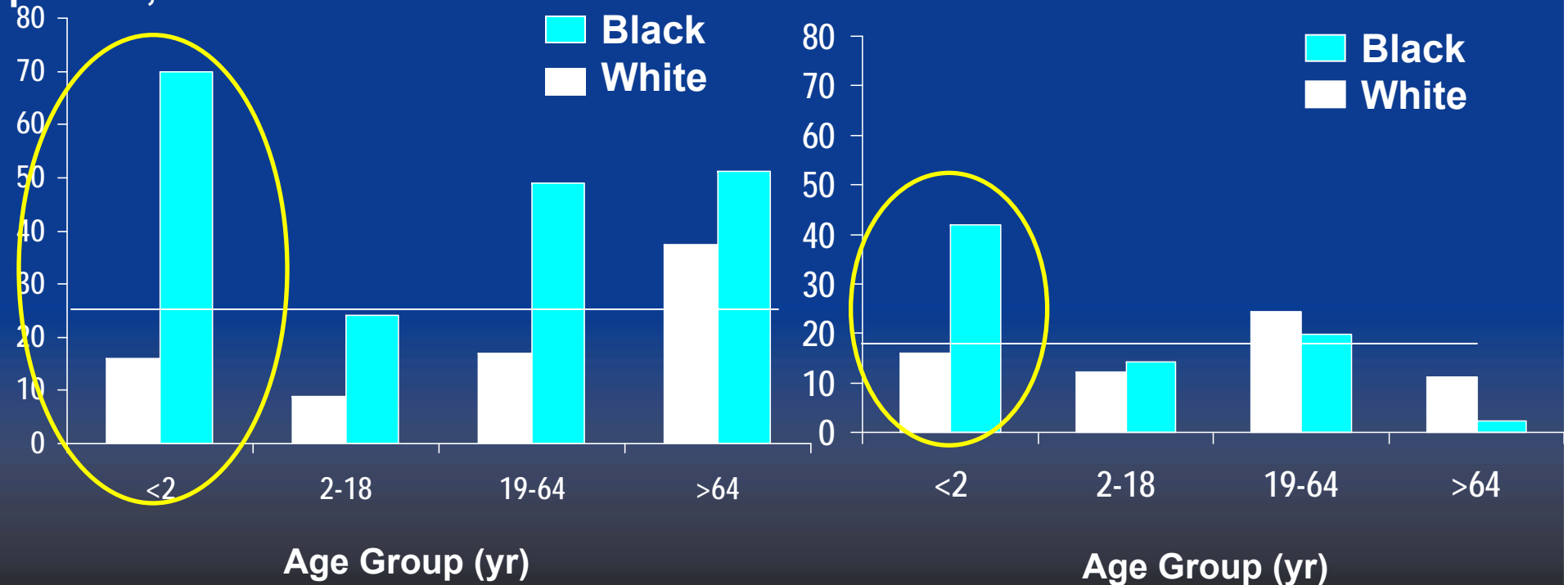
Atlanta, 2001-2002

26 per 100,000

Baltimore, 2002

18 per 100,000

Incidence, Cases  
per 100,000

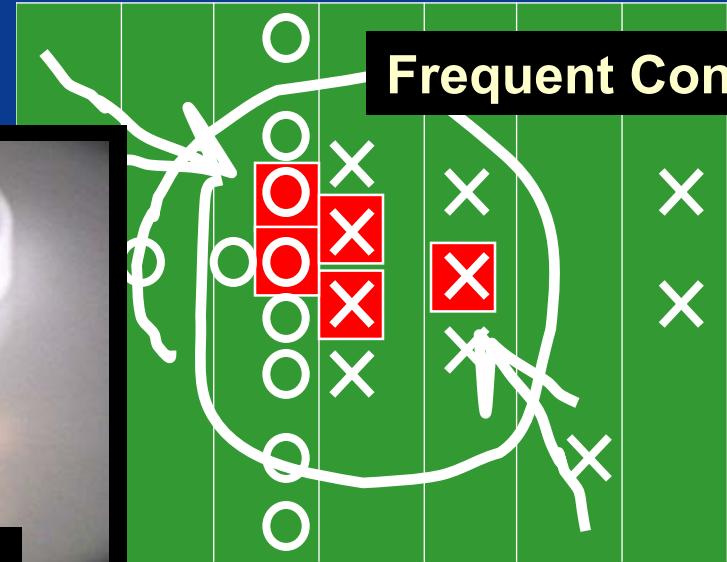


Fridkin et al *NEJM* 2005; 352:1436-44

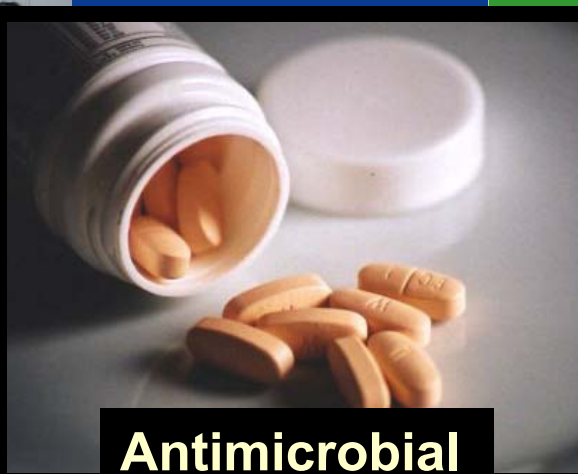
# Factors that Facilitate Transmission



**Crowding**



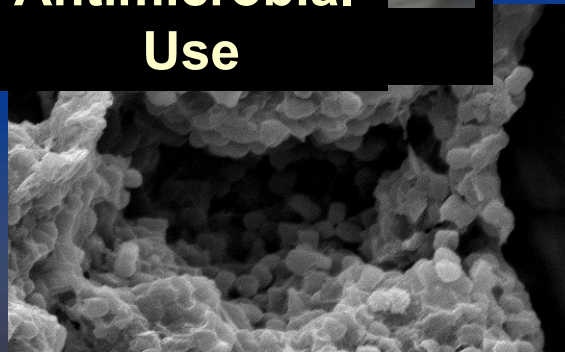
**Frequent Contact**



**Antimicrobial Use**



**Compromised Skin**



**Contaminated Surfaces and Shared Items**



**Cleanliness**



# Preventing Transmission



- **Persons with skin infections should keep wounds covered, wash hands frequently (always after touching infected skin or changing dressings), dispose of used bandages in trash, avoid sharing personal items.**
- **Uninfected persons can minimize risk of infection by keeping cuts and scrapes clean and covered, avoiding contact with other persons' infected skin, washing hands frequently, avoiding sharing personal items.**



# Preventing Transmission



- **Exclusion of patients from school, work, sports activities, etc should be reserved for those that are unable to keep the infected skin covered with a clean, dry bandage and maintain good personal hygiene.**
- **In general, it is not necessary to close schools to “disinfect” them when MRSA infections occur.**
- **In ambulatory care settings, use standard precautions for all patients (hand hygiene before and after contact, barriers such as gloves, gowns as appropriate for contact with wound drainage and other body fluids).**

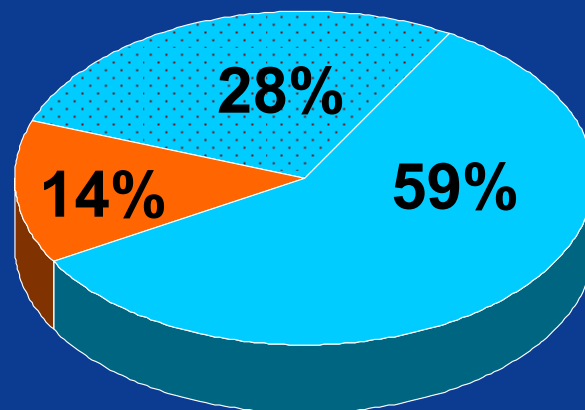


# Conclusions: CA-MRSA



- **New strains of MRSA have emerged in the community, with implications for management of skin infections and other staphylococcal infections.**
- **Incision and drainage remains a primary therapy for purulent skin infections.**
- **Oral treatment options are available for patients with skin infections that require ancillary antibiotic therapy.**
- **Patient education on proper wound care is a critical component of case management for patients with skin infections.**
- **Strategies focusing on increased awareness, early detection and appropriate management, enhanced hygiene, and maintenance of a clean environment have been successful in controlling clusters / outbreaks of infection.**

# Most Healthcare-Associated Invasive MRSA Infections Have Their Onset Outside of the Hospital



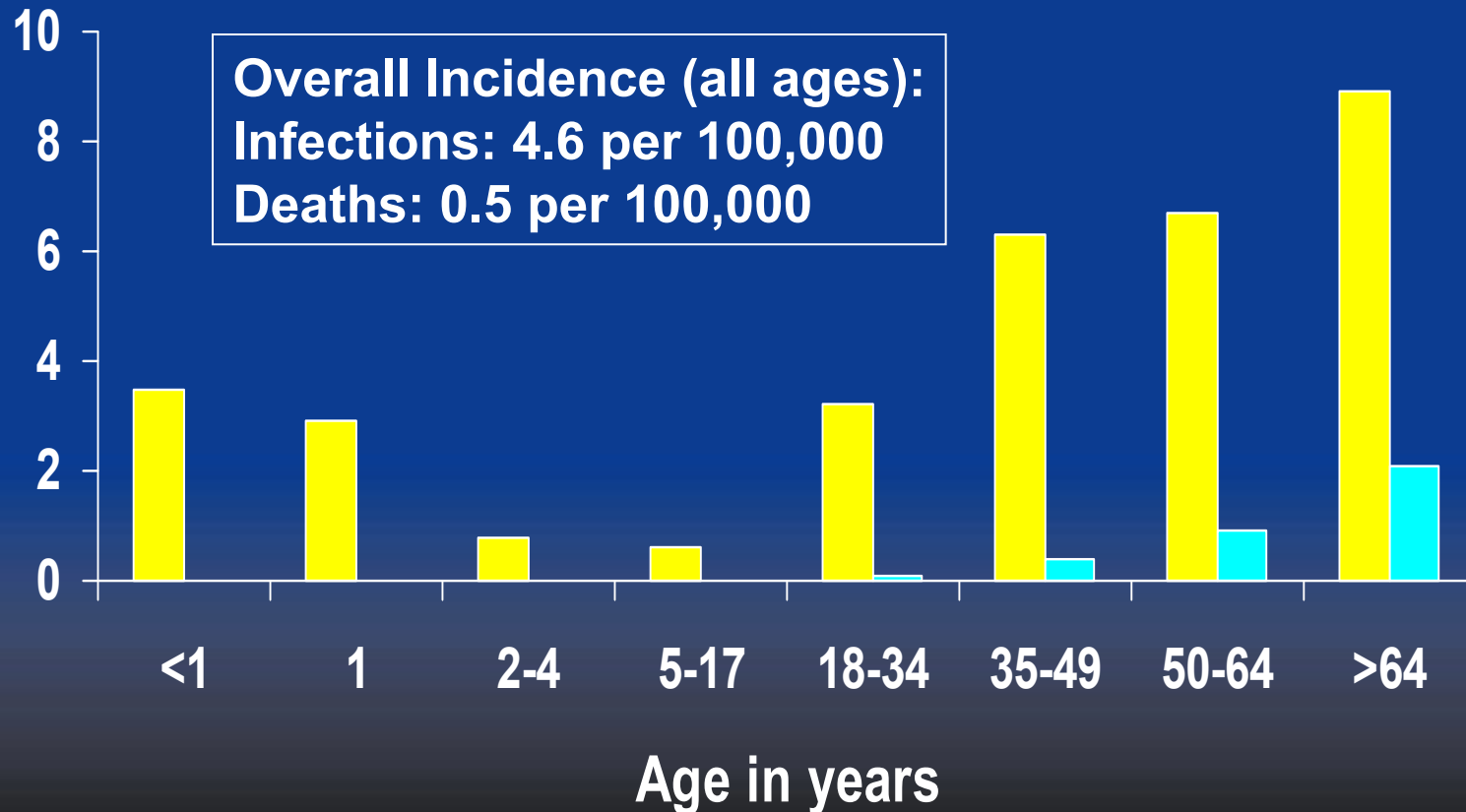
- Community-Associated
- Healthcare-Associated (community-onset)
- Healthcare-Associated (hospital-onset)

# Incidence of Invasive CA-MRSA Infections and Deaths by Age

Active Bacterial Core surveillance (ABCS), 2005

Incidence per  
100,000 persons

■ Infections ■ Deaths



**Table 1. Distribution of top ranking pathogens associated with NHSN reportable HAIs; January 2006 - October 2007**

Pathogen (n= 33,848) (25,502 infections)	CLABSI		CAUTI		VAP		SSI		Total *	
	N	%	N	%	N	%	N	%	N	%
<i>A. baumannii</i>	252	2.21	109	1.16	498	8.36	42	0.60	902	2.66
CoNS	3900	34.13	234	2.50	79	1.33	965	13.74	5178	15.30
<i>Candida</i> spp.	1342	11.74	1974	21.05	160	2.69	145	2.07	3628	10.72
<i>E. coli</i>	310	2.71	2009	21.42	271	4.55	671	9.55	3264	9.64
<i>Enterococcus</i> spp.	1834	16.05	1393	14.85	77	1.29	788	11.21	4093	12.10
<i>Enterobacter</i> spp.	443	3.88	384	4.10	498	8.36	293	4.17	1624	4.80
<i>P. aeruginosa</i>	357	3.12	938	10.00	972	16.31	390	5.55	2664	7.87
<i>S. aureus</i>	1127	9.86	208	2.22	1456	24.43	2108	30.01	4913	14.51

\* Total reflects post procedure pneumonia event as well (not included in this table)

Source: Hidron et al., abstract presentation, SHEA 2008



# Management of Severe / Invasive Infections



- Vancomycin remains a 1<sup>st</sup>-line therapy for severe infections possibly caused by MRSA
- Other IV agents may be appropriate **Consult an infectious disease specialist.**
- Final therapy decisions should be based on results of culture and susceptibility testing
- Severe community-acquired pneumonia: Vancomycin or linezolid if MRSA is a consideration\*

\*IDSA/ATS Guidelines for treatment of CAP in adults: Mandell et al. CID 2007;44:S27-72



## Why is the Emergence of MRSA as a Healthcare Pathogen Important?

- Has emerged as one of the predominant pathogens in healthcare-associated infections
- Treatment options are limited and less effective
  - higher morbidity and mortality
- High prevalence major influence on unfavorable antibiotic prescribing, which contributes to further spread of resistance
  - prevalent MRSA → more glycopeptide use → more glycopeptide resistance (VRE VRSA) → more linezolid/daptomycin use → more resistance



## Why is the Emergence of MRSA as a Healthcare Pathogen Important?

- Adds to overall *S. aureus* infection burden
- Represents a failure to contain transmission of drug-resistant bacteria
  - A marker for our ability to contain transmission of important pathogens in the healthcare setting
  - Learning how to successfully control of MRSA is likely to have benefits that extend to other pathogens



# How Best to Prevent MRSA Transmission in Healthcare Settings?

- Controversial subject
  - standard precautions versus standard plus barrier (i.e. contact precautions)?
  - Should contact precautions be used only on those identified by clinical cultures?
    - Due to “iceberg effect”, many colonized patients unrecognized base on clinical cultures alone
    - Should active surveillance be used to identify carriers?
      - If so, in what settings?



# HICPAC Guidance on Management of Multidrug-Resistant Organisms (MDROs) in Healthcare Settings

**First Tier: General Recommendations  
For All Acute Care Settings**

If endemic rates not decreasing, or  
if first case of important organism

**Second Tier: Intensified Interventions**



# HICPAC MDRO Guidance (Acute Care)

- Indications for moving to second tier
  - First case or outbreak of an epidemiologically important MDRO
  - When endemic rates of a target MDRO *are not decreasing* despite implementation of and correct adherence to the first tier measures



# Conclusions: HA-MRSA and CA-MRSA

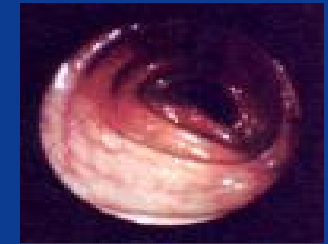
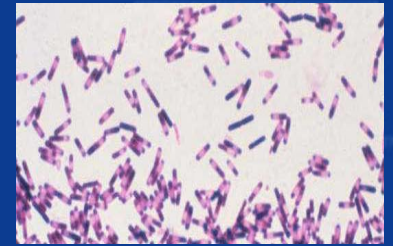


- The burden of MRSA remains high in US healthcare settings
- Community-associated MRSA (CA-MRSA) infections are emerging rapidly in many areas, but population-based estimates suggest that most MRSA infections are healthcare-associated
- Epidemic strains of MRSA originally associated with the community have emerged as important causes of hospital-acquired infections
- MRSA infections and transmission can be prevented, even in endemic settings in the US
- Effective control programs must be multifaceted, and broad institutional commitment, including measurement of impact, is required for successful implementation



# *Clostridium difficile*

- Anaerobic spore-forming bacillus
- *Clostridium difficile*-associated disease (CDAD)
  - Diarrhea
  - Pseudomembranous colitis, toxic megacolon, sepsis, and death
- Fecal-oral transmission
  - Fecal contamination
  - Environment, devices, and hands of healthcare personnel
- Antimicrobial exposure is major risk factor for disease
  - Acquisition and growth of *C. difficile*
  - Suppression of normal flora of the colon
- Clindamycin, penicillins, and cephalosporins



Healthy colon



Pseudo-membranous colitis

# Pathogenesis of *C. difficile* Diarrhea and Colitis

Antibiotic therapy



Alteration of colonic microflora



*C. difficile* exposure and colonization



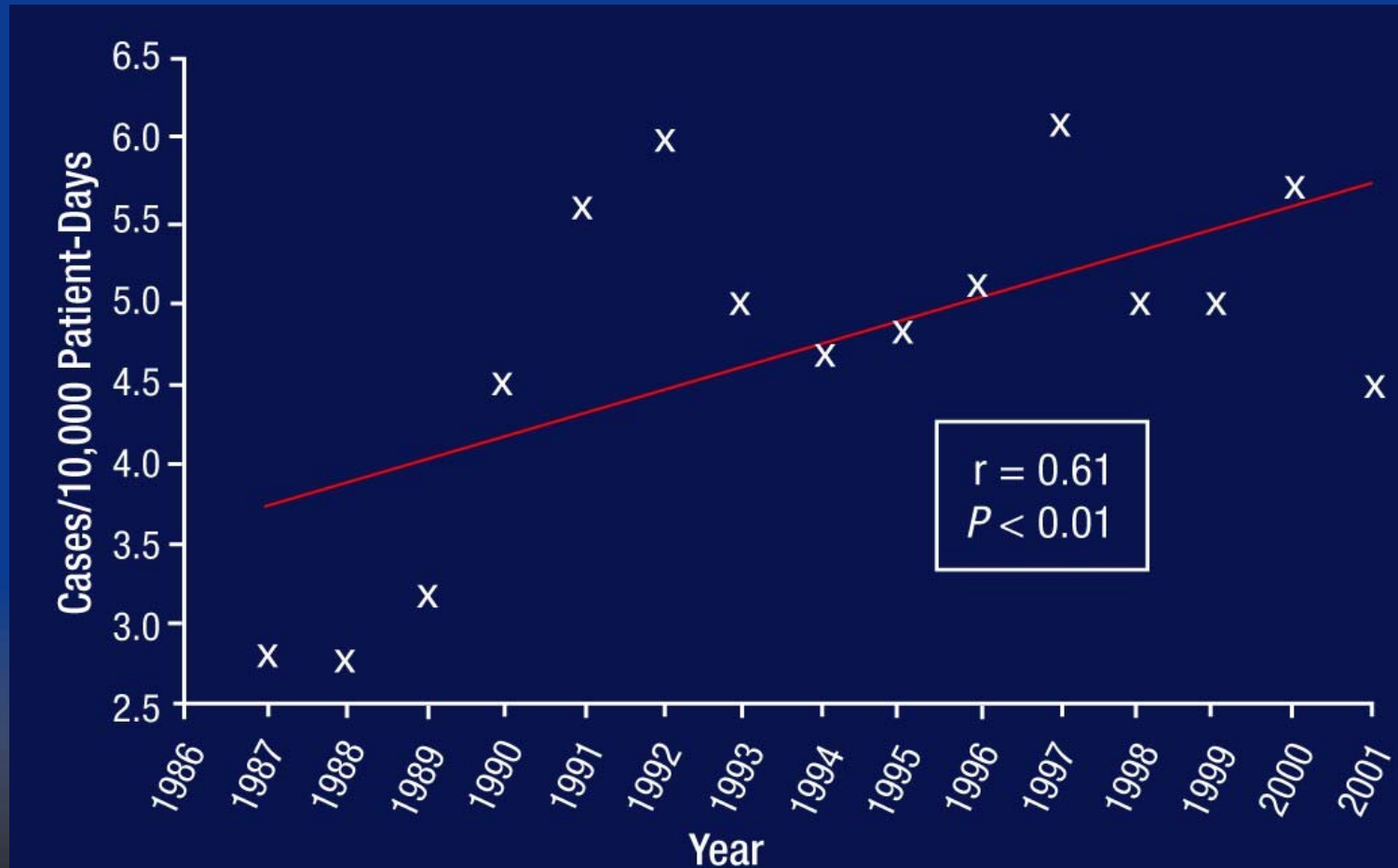
Release of toxin A and toxin B (and binary toxin CDT?)



Colonic mucosal injury and inflammation

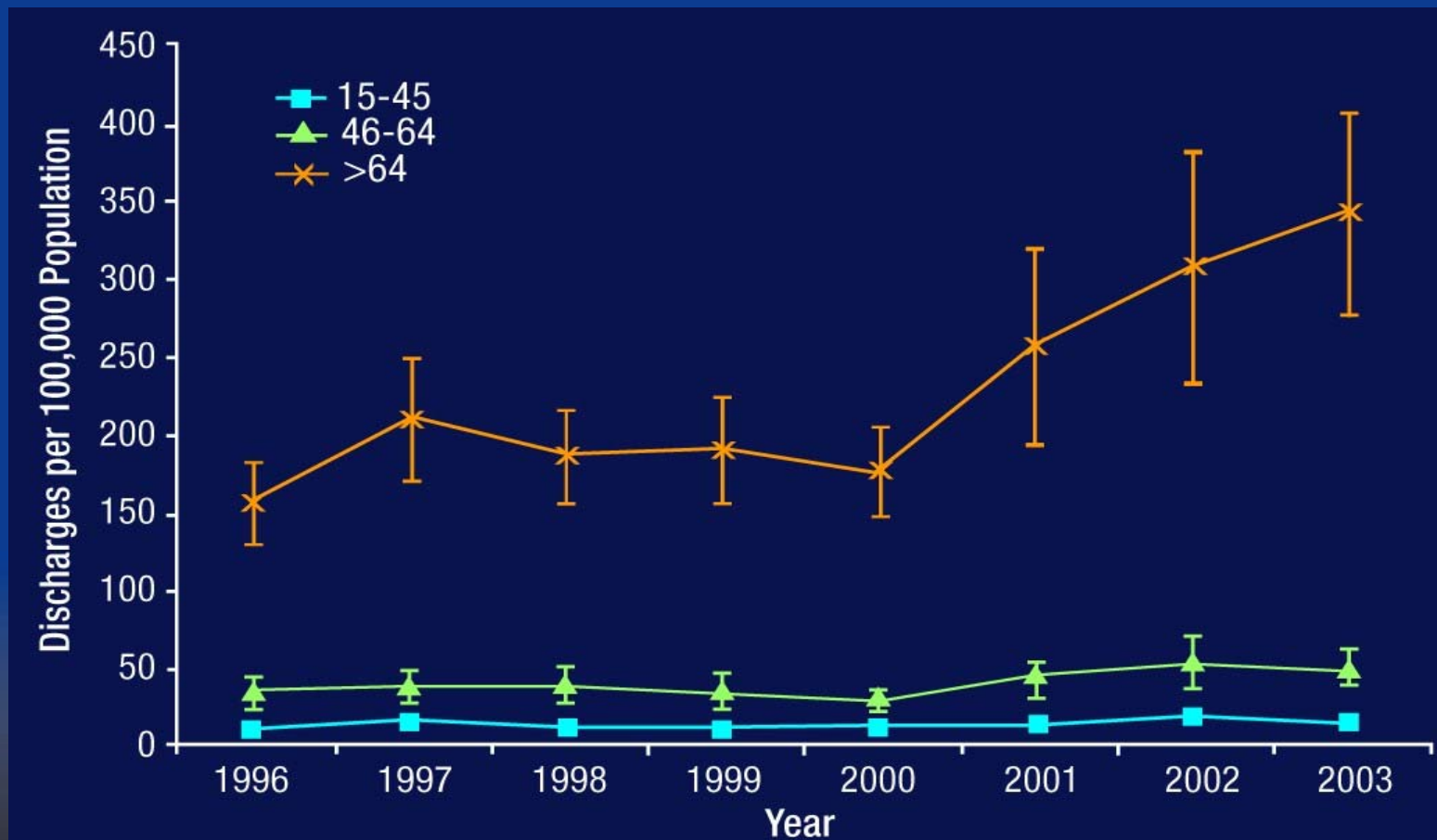
Adapted from: Kelly CP, LaMont JT. *Ann Rev Med* 1998; 49: 375-90.

# Annual CDAD Rates, US Hospitals with >500 Beds, Intensive Care Unit Surveillance Component, NNIS



From: Archibald LK, Banerjee SN, Jarvis WR. *J Infect Dis* 2004; 189: 1585–9.

# Rates of US Short-Stay Hospital Discharges with *C. difficile* Listed as Any Diagnosis by Age



From: McDonald LC, et al. *Emerg Infect Dis.* 2006; 12(3): 409-15.

# Challenges Posed by Emerging Epidemic Strains of *C. difficile*



- Emergence of a new epidemic strain
  - Toxinotype III or “BI” by REA
    - Distinct from “J” strain of 1989-1992<sup>1</sup>
  - Binary toxin as a possible virulence factor
    - In addition to toxins A and B containing
  - 18 bp deletion in *tcdC* gene
    - Could lead to increased toxin production (18-fold for toxin A, 23-fold for toxin B) observed by Warny et al.<sup>2</sup>
  - Increased resistance to fluoroquinolones
- Appears responsible for increase in cases
- May be responsible for increase in disease severity

1. Warny M, et al. *Lancet* 2005; 366: 1079-84.

2. Johnson S, et al. *N Engl J Med* 1999; 341: 1645-51.



# Comparison of Molecular Characteristics of 2 *C. difficile* Isolates with Historical Standard-Type Strains and a Recently Recognized Epidemic Strain, by Selected Characteristics, OH and PA, 2005

Characteristic	Standard Strain	Epidemic Strain	Ohio Strain	Pennsylvania Strain
Toxinotype	0	III	IX	XIV/XV
PFGE* pattern	< 80% related to NAP1†	NAP1	85% related to NAP1	64% related to NAP1
Binary toxin	-	+	+	+
18 bp deletion in <i>tcdC</i>	-	+	-	+

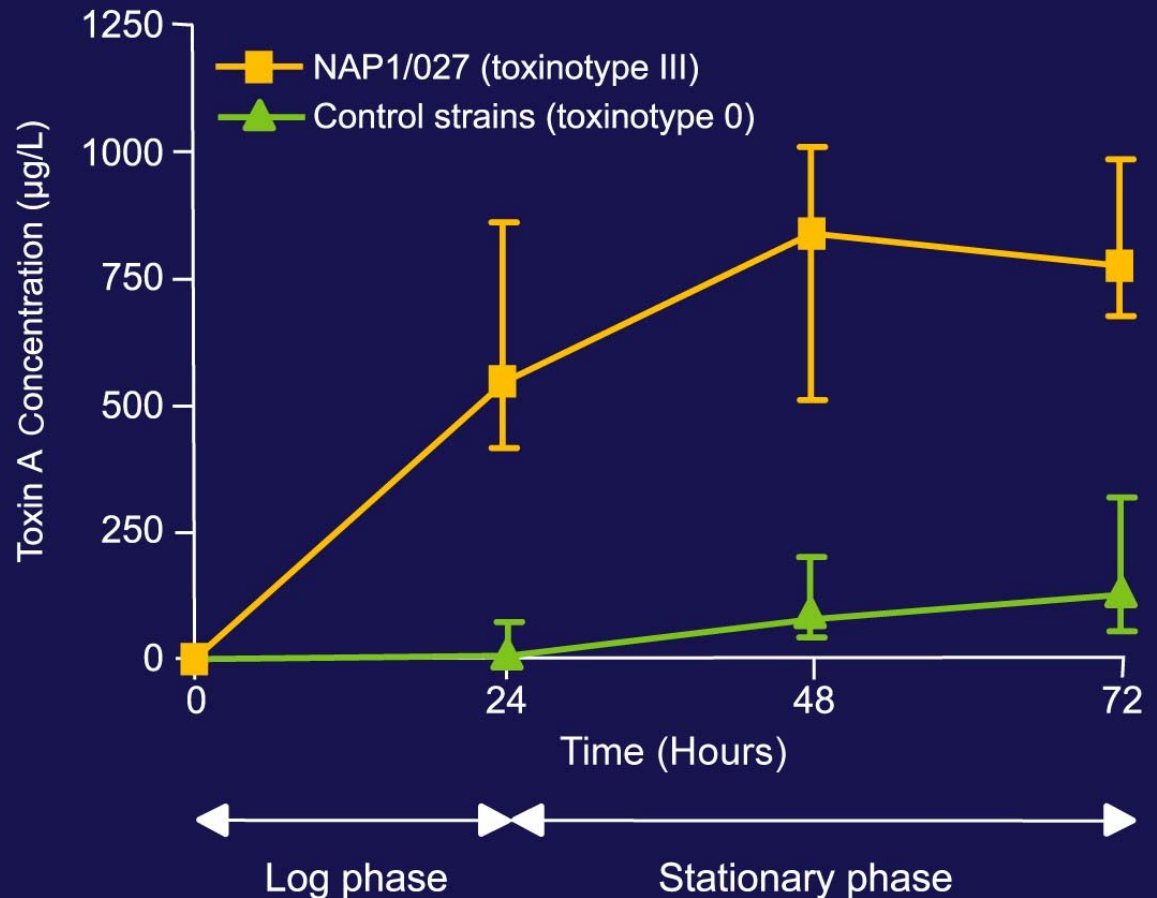
\*Pulsed-field gel electrophoresis.

† North American pulsed-field type 1.

From: McDonald LC, et al. *N Engl J Med* 2005; 353: 2433-41. See also CDC. *MMWR*. 2005;54:1201-5.

# Increased Toxin A Production *in vitro*

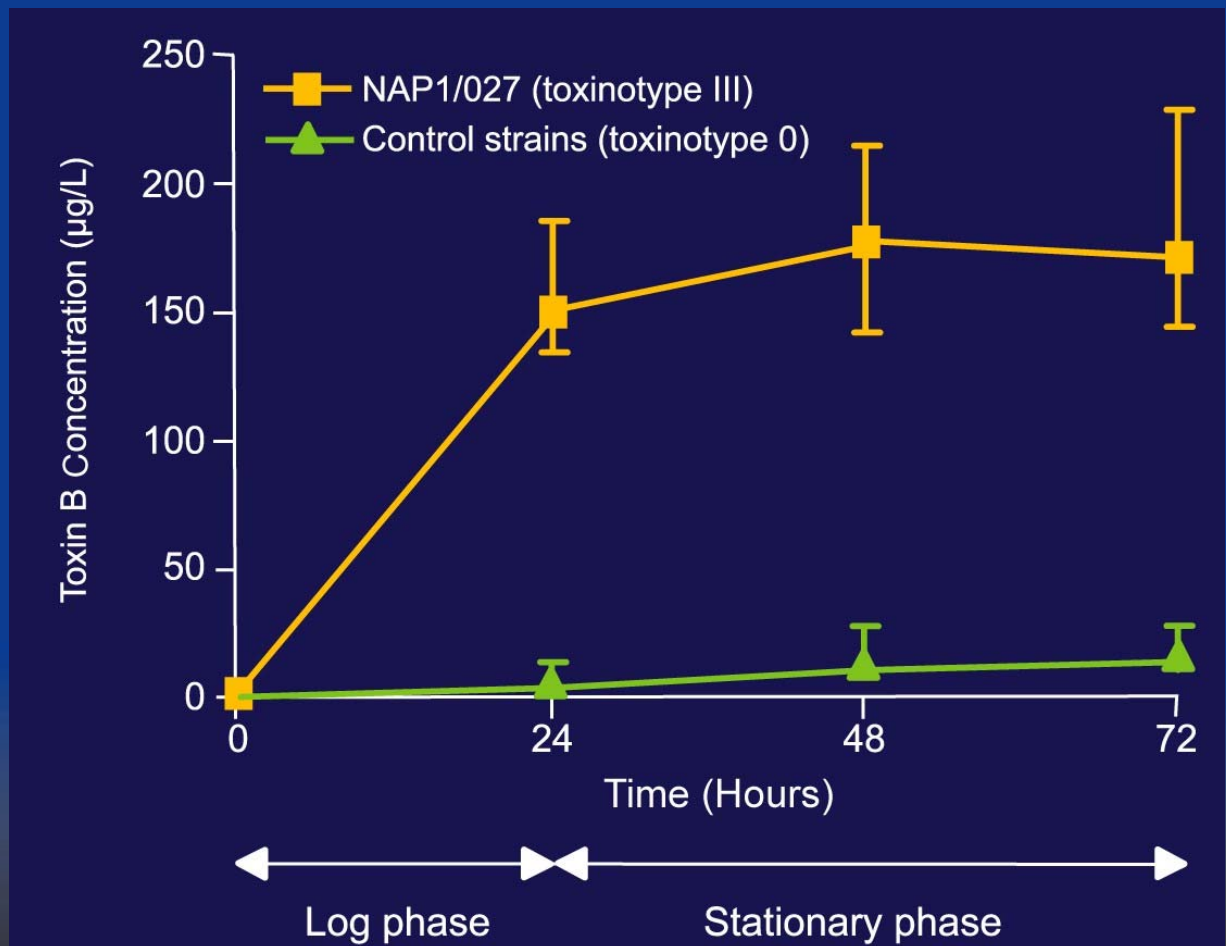
*In vitro* production of toxin A by *C. difficile* isolates. Median concentration and IQRs are shown. *C. difficile* strains included 25 toxinotype 0 and 15 NAP1/027 strains (toxinotype III) from various locations.



From: Warny M, et al. *Lancet* 2005; 366: 1079-84.

# Increased Toxin B Production *in vitro*

*In vitro* production of toxin B by *C. difficile* isolates. Median concentration and IQRs are shown. *C. difficile* strains included 25 toxinotype 0 and 15 NAP1/027 strains (toxinotype III) from various locations.



From: Warny M, et al. *Lancet* 2005; 366: 1079-84.



# Potential Reasons for Increased CDAD Incidence and Severity

- Changes in underlying host susceptibility
- Changes in antimicrobial prescribing
- New strain with increased virulence
- Changes in infection control practices



# Where Has *C. difficile* Contamination Been Found?

- Nath SK, et al. *Infect Control Hosp Epidemiol* 1994; 15: 382-9.
  - Patient Care Areas (ICU, hematologic oncology, medical units):
    - Toilet seat and bowl, floor by beds, pt. washroom floor, paper towel dispenser, table top
  - Dirty Utility Rooms:
    - Bedpan hopper, steam flusher, floor, waste container
  - Healthcare Workers:
    - Shoes
- 29% (7/24) environmental isolates matched the predominant toxigenic epidemic type from cases.

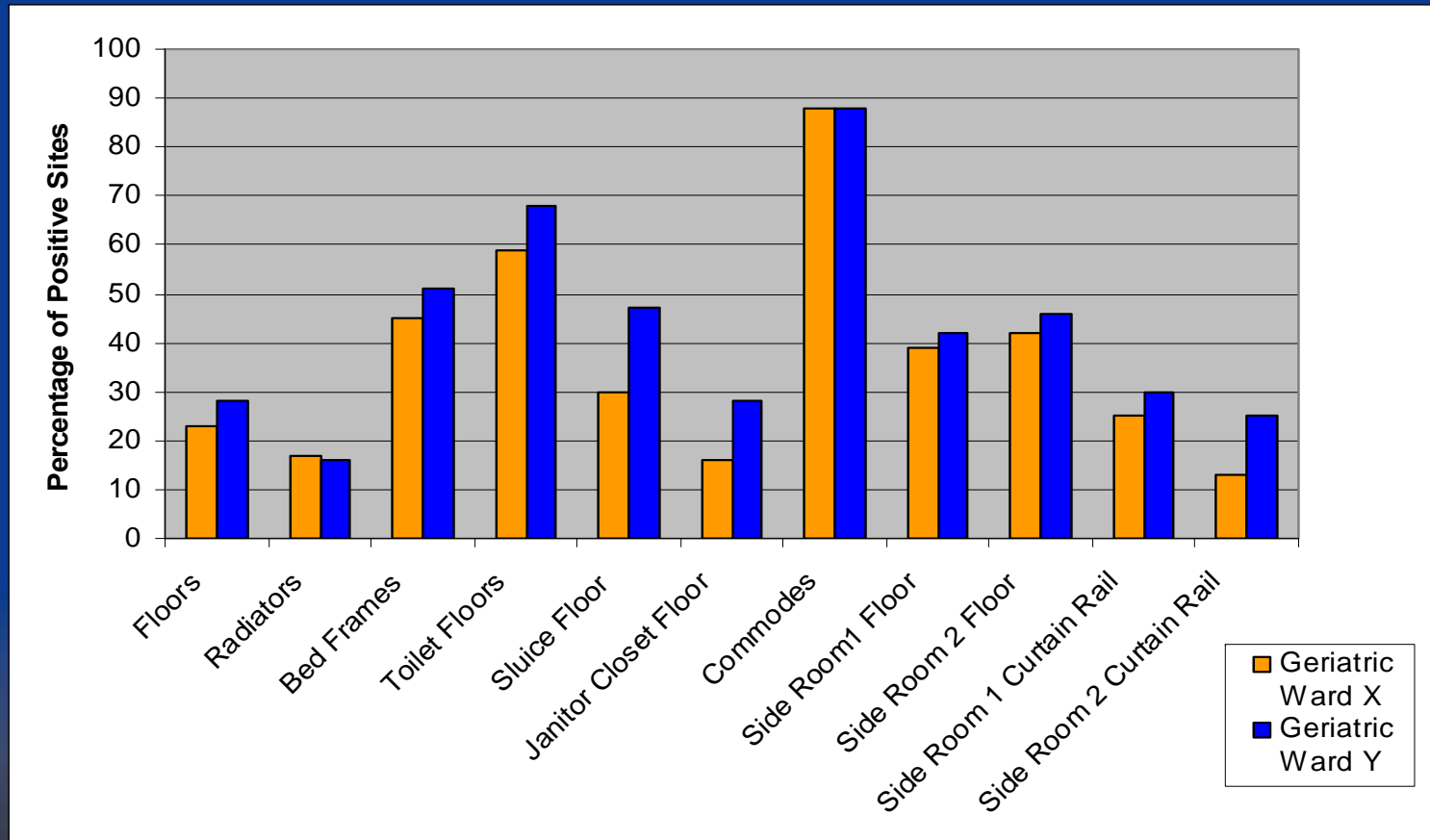


# Where Has *C. difficile* Contamination Been Found?

- Pulvirenti JJ, et al. *Infect Control Hosp Epidemiol* 2002; 23: 641-7.
  - Patient-Care Areas (HIV unit, ID unit):
    - Floors, bed rails, common toilets, portable toilets, communal blood pressure cuff
    - Positive environmental cultures:
      - Cook County Hospital: 14.7% (24/286)
      - Rush Presbyterian St. Luke's Med Center: 2.9% (3/104)
  - Outbreak strain (CD1A) at Cook County Hospital was detected in the environment 1 month after index outbreak patient was identified



# Frequency of *C. difficile* Culture Positive Sites in Study Areas

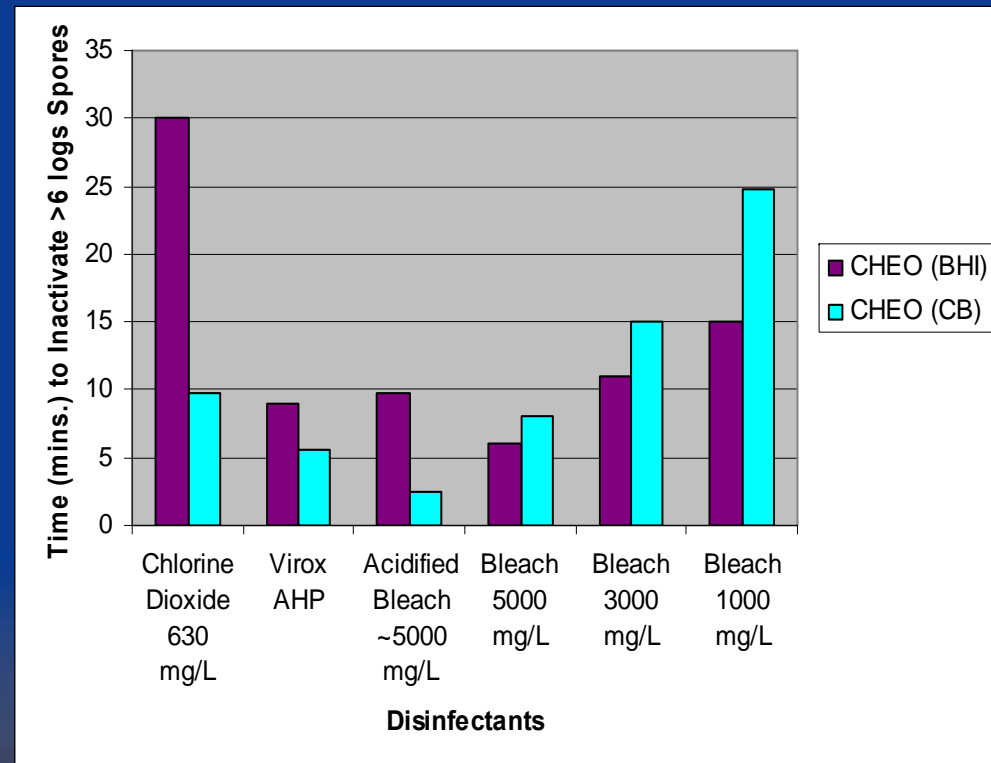


From: Wilcox MH, et al. J Hosp Infect 2003; 54: 109-14

# Activity of Selected Oxidative Germicides Against *C. difficile* Spores



- Strong oxidative disinfectants can inactivate high numbers of spores
- Contact time 10-15 mins.
- Occupational hazards with acidified bleach and 5000 mg/L FC bleach (chlorine gas)
- Can be used to manage an identified problem, but should not be used on a routine basis because of corrosiveness and hazards to workers and patients
- Clean to minimize organic soil amounts before disinfecting



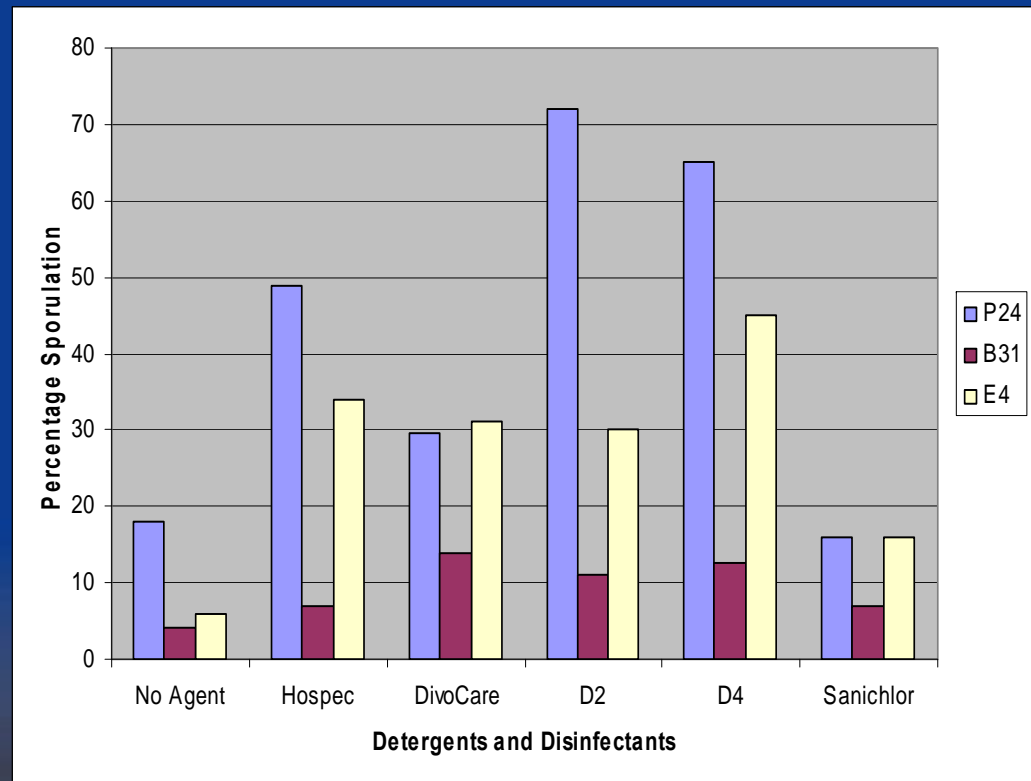
From: Perez J, et al. *Am J Infect Control* 2005; 33: 320-5.



# Cleaning Agents and Their Impact on *C. difficile*



- Epidemic (P24), clinical (B31), and environmental (E4) strains; fecal emulsions
- Sub-inhibitory concentrations of chemicals
- Chlorine-containing products: DivoCare, Sanichlor
- Non-chlorine containing products: Hospec, D2, D4
- Increased levels of sporulation in the presence of sub-inhibitory concentrations of cleaning agents
- P24 produced more spores in the presence of the non-chlorinated products



From: Wilcox MH, Fawley WN. Lancet 2000; 356: 1324



# Indications for Hand Hygiene

- When hands are visibly dirty, contaminated, or soiled, wash with non-antimicrobial or antimicrobial soap and water.
- If hands are not visibly soiled, use an alcohol-based handrub for routinely decontaminating hands.
- After glove removal during outbreaks of CDAD, hands should be washed with non-antimicrobial or antimicrobial soap and water

Guideline for Hand Hygiene in Health-care Settings. *MMWR* 2002; vol. 51, no. RR-16.

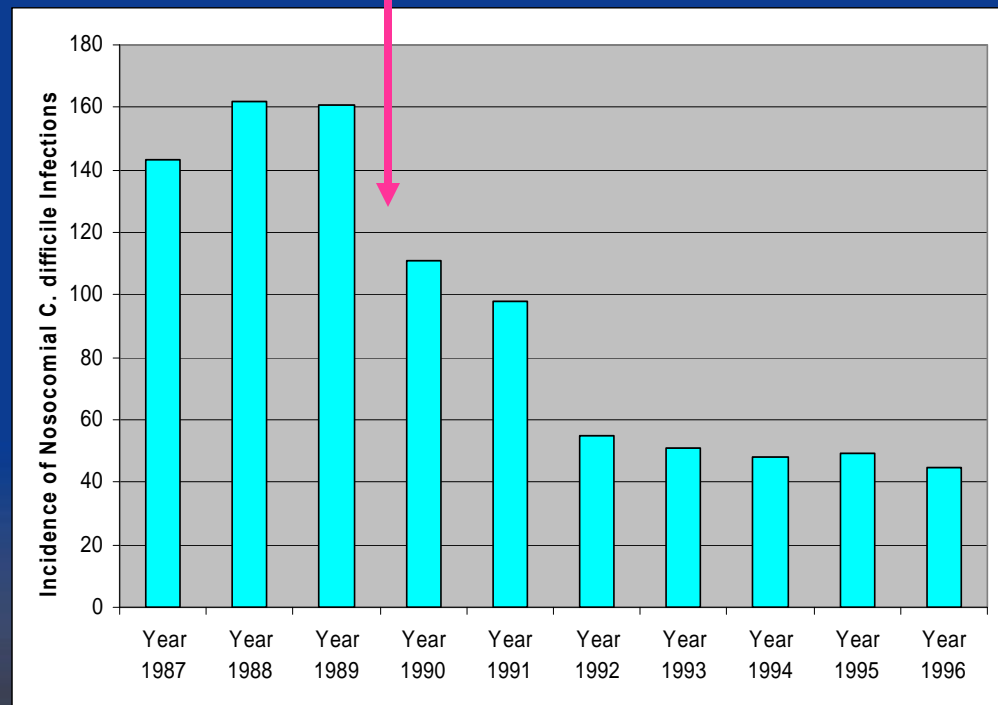


# Effect of Multiple Intervention Measures: *C. difficile*



- Isolation policy
- Monthly education program for all healthcare workers
- Phenolic disinfectant
- Antimicrobial soap for handwashing
- Centralized sterilization department
- Cart washer installation
- Active surveillance program

Intervention Started



From: Zafar AB, et al. *Am J Infect Control* 1998; 26: 588-93



# Recommendations for Hospitals

- Hospitals should conduct surveillance for CDAD
  - Recently proposed surveillance recommendations<sup>1</sup>
- Early diagnosis and treatment important for reducing severe outcomes and should be emphasized
  - Subset of epidemic isolates tested: metronidazole susceptible
- Strict infection control: CDC Fact Sheet<sup>2</sup>
  - Contact precautions for CDAD patients
  - An environmental cleaning and disinfection strategy
  - Hand-washing with CDAD patients in outbreak
- Further research needed
  - Role for antimicrobial controls in stemming this epidemic

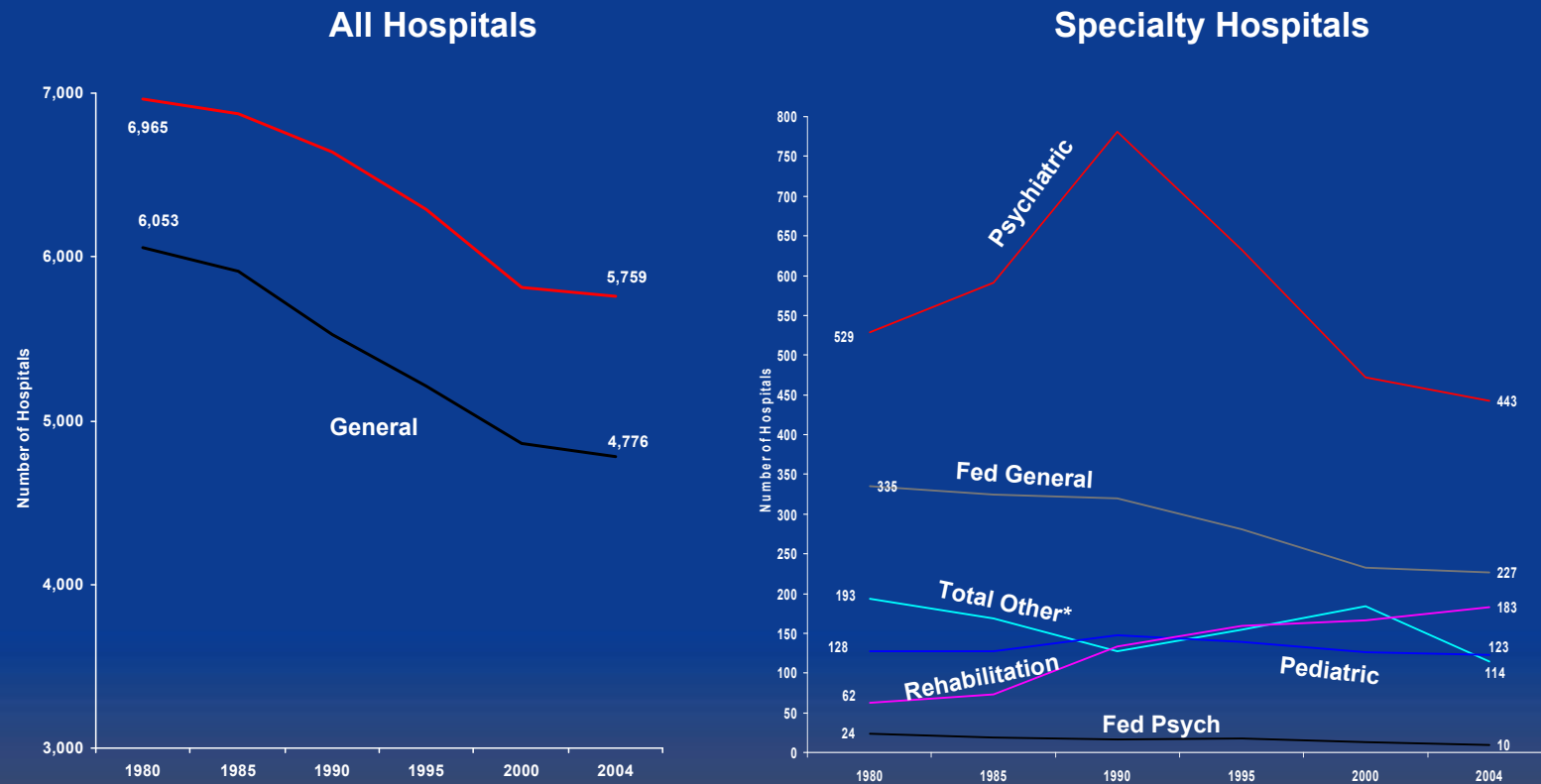
<sup>1</sup>McDonald et al. *Infect Control Hosp Epidemiol* 2007; 28:140-145

<sup>2</sup>See CDC *C. difficile* Fact Sheets: <http://www.cdc.gov/ncidod/dhqp/>.



## Table 3.1 Number of Hospitals by Type, 1980-2004

*The number of hospitals has declined with the exception of rehabilitation hospitals.*



\*Includes specialty hospitals such as TB, Ob-Gyn; eye, ear, nose and throat; orthopedic and chronic disease.

Source: American Hospital Association, personal communication, 2006.



# Impacts on Medical Waste



- No extraordinary challenge anticipated re: microbial inactivation
- Wastes generated while patients are in isolation required no special management compared to what is done now
- No major changes expected in state medical waste rules
- Changes for antibiotic usage:
  - Antibiotics to treat MRSA infections
  - Minimize antibiotic use to help prevent *C. difficile* infection
  - Excretion of antibiotics, discharge to the environment



# Acknowledgments

## Thanks to:

- **L. Clifford McDonald, MD, FACP, FSHEA in the Division of Healthcare Quality Promotion, CDC for slides and summary of emerging epidemic strains of *C. difficile***
- **Rachel Gorwitz, MD, John Jernigan, MD and numerous other DHQP colleagues engaged in MRSA epidemiologic research**



# Thank You!

Division of Healthcare Quality Promotion  
Centers for Disease Control and Prevention

“Protect patients, protect health-care personnel, and promote safety, quality, and value in the health-care delivery system”