VAP & CAUTI: Practical Functionality of Microbiology-Specific Microbes (….or how I spent my summer writing a lecture few would ever consider)

A Lecture for APIC DFW, Dallas, TX
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Disclosure

- The lecture by Robert Garcia is funded by Sage Products, Inc.

Today's Objectives

- Review Classifications of Pneumonia
- Review new definitions for VAE & Microbiology
- Review CAUTI & Microbiology

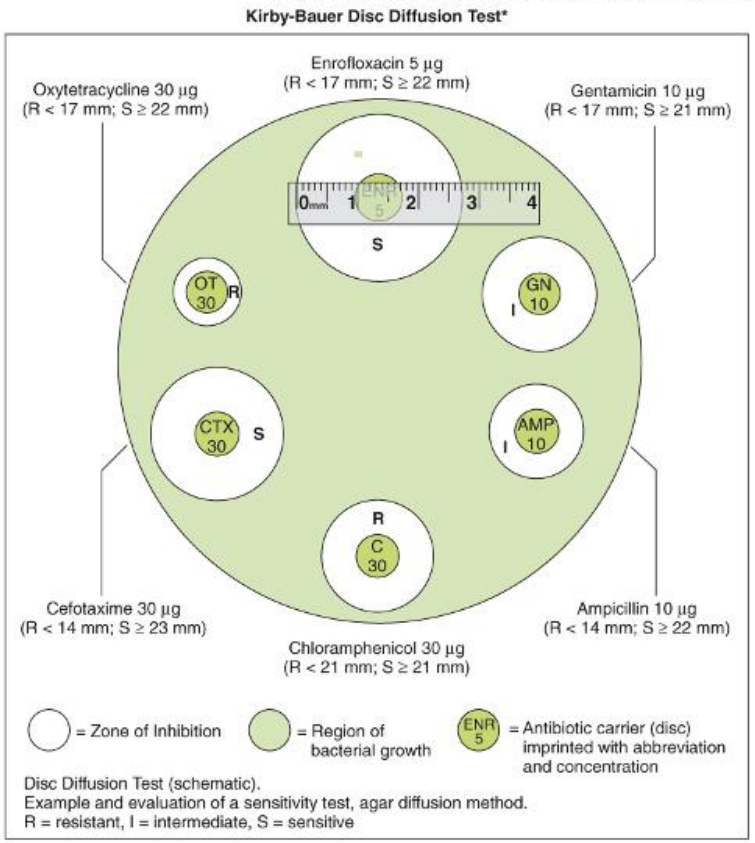
A Few Points on Clinical Microbiology & HAIs

General Guidelines for Specimen Collection

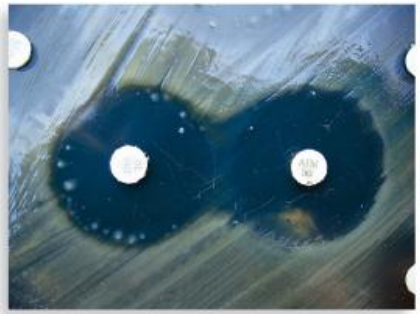
- Poor collection = poor results
- Educate, educate on proper *aseptic* collection (e.g., samples from urinary catheters)
- Adequate volumes, adequate containers
- Defensive approach in the reimbursement world = collect samples *on day of admission* to the hospital when a patient has a medical device, e.g., urinary catheter, ETT, tracheostomy
- Collect urine sample for bacteriology and urinalysis when catheter is inserted
- After collection, how long does it take to transport the sample to the lab? Refrigerated?

Example: Urine Transport Device

Bacterial Resistance: Zone of Inhibition

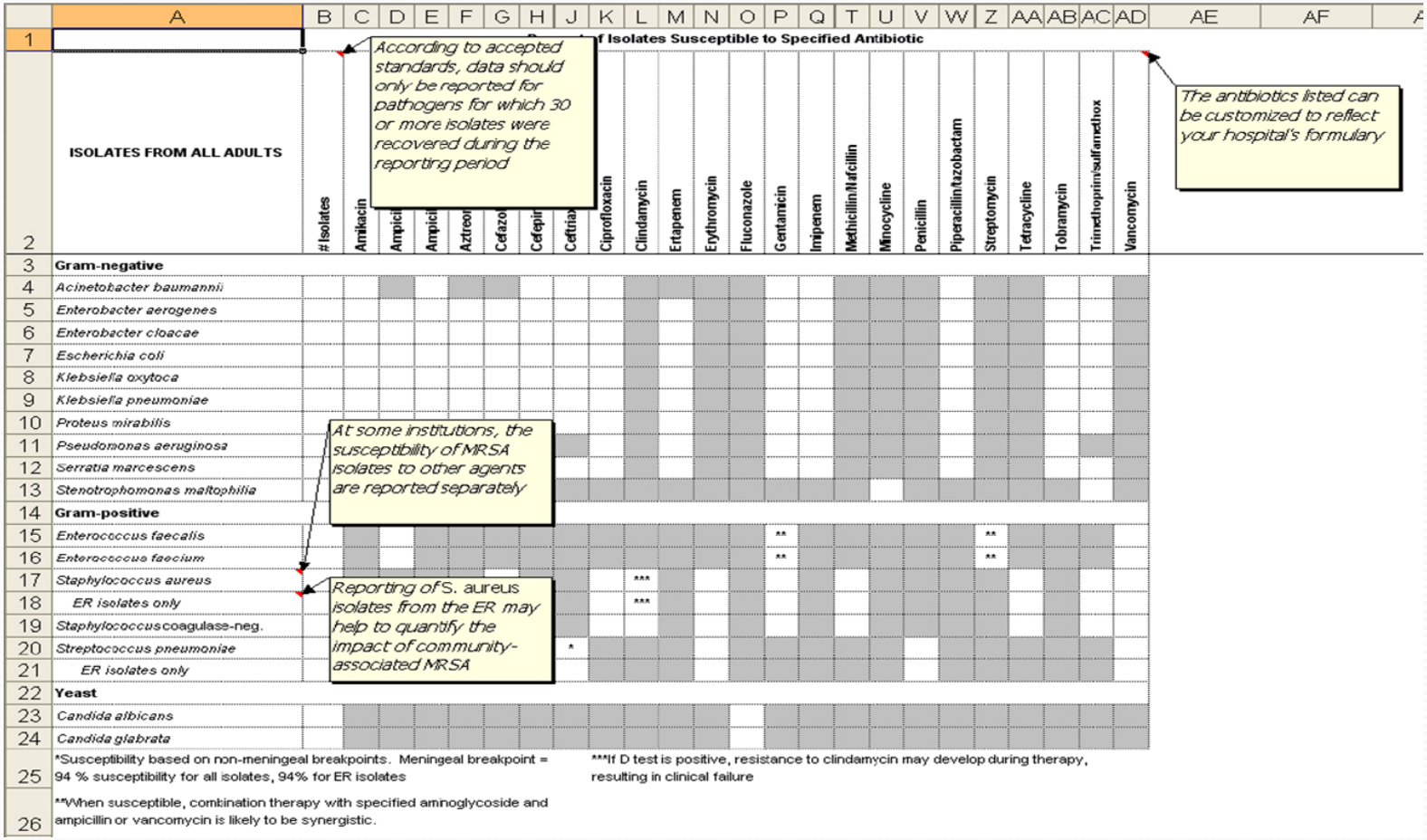


(a) *R and S values differ from table 12.7 due to differing concentrations of the antimicrobials.

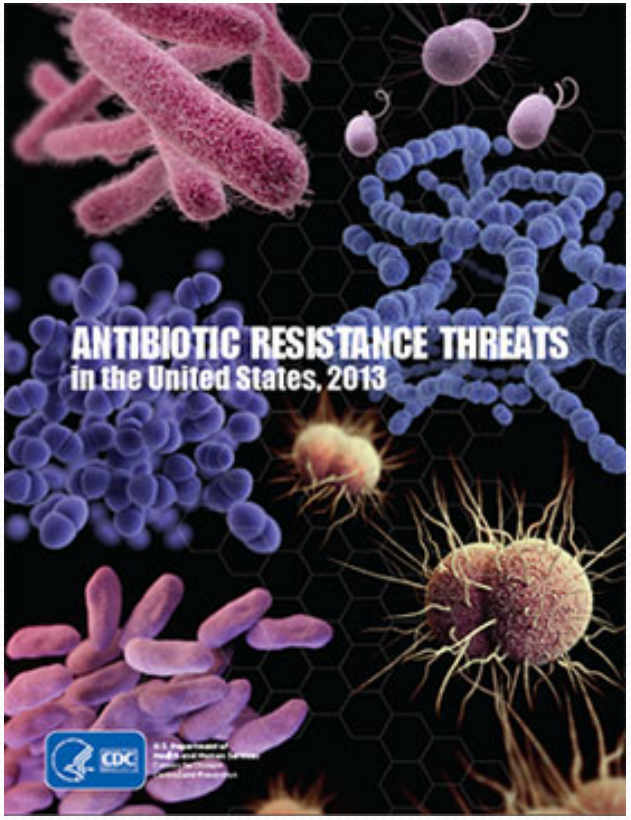


(c)

The Antibiogram



CDC: Resistant Organism Threats

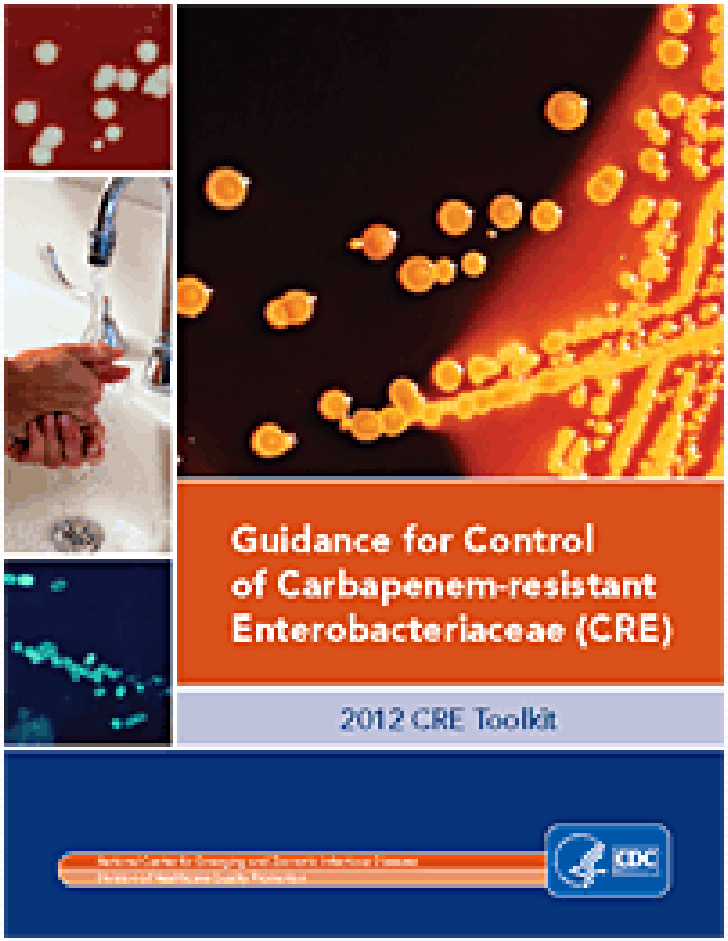


- As applicable to VAP/CAUTI:
- Urgent Threats:
  - Carbapenem-resistant Enterobacteriaceae (CRE)
- Serious Threats:
  - Multidrug-resistant Acinetobacter
  - Extended spectrum β-lactamase producing Enterobacteriaceae (ESBLs)
  - Vancomycin-resistant *Enterococcus (VRE)*
  - Multidrug-resistant *Pseudomonas aeruginosa*
  - Methicillin-resistant *Staphylococcus aureus (MRSA)*

Centers for Disease Control and Prevention. Antibiotic Resistance Threats in the United States, 2013. Issued Sep 2013. Avaialable at: http://www.cdc.gov/drugresistance/threat-report-2013/

CRE Definition

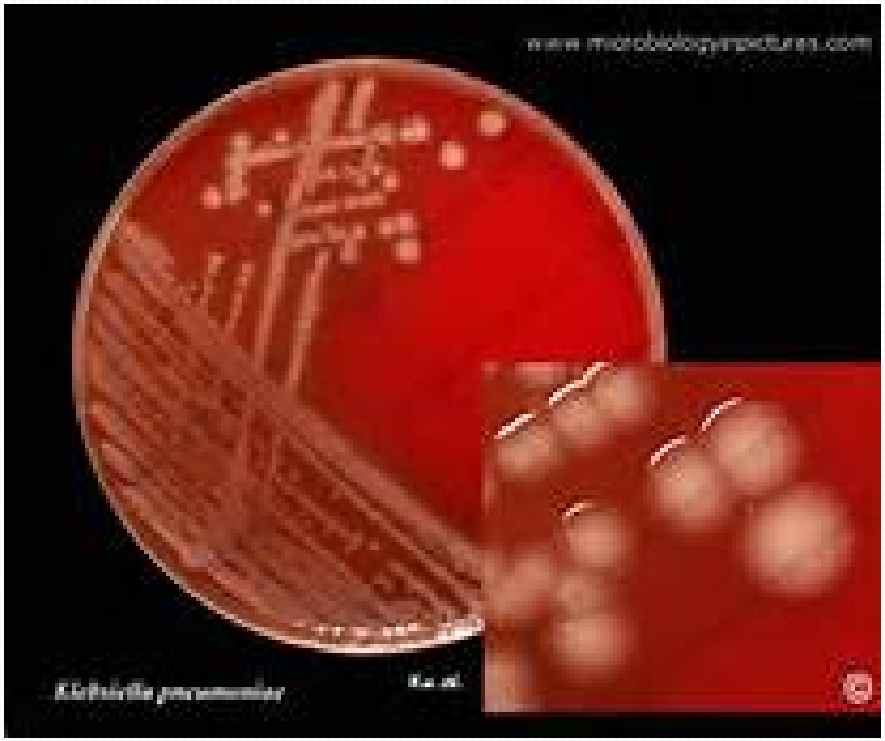
- CDC Defines CRE as Enterobacteriaceae that are:
  - Non-susceptible to one of the following carbopenems: doripenem, meropenem, or imipenem AND
  - Resistant to all of the following third-generation cephalosporins that were tested: ceftriaxone, cefotaxime, and ceftazidime (Note: All three of theseantimicrobials are recommendedas part of the primary or secondary susceptibility panels forEnterobacteriaceae)



Centers for Disease Control. Guidance for Control of Carbapenem-resistant Enterobacteriaceae, 2012 CRE Toolkit.

CRE Organisms

- *Klebsiella pneumoniae* (KPC)
- *E. coli*
- *Enterobacter* sp.
- *Proteus* sp.
- *Serratia* sp.



What is MIC?

- **Minimum inhibitory concentration** (MIC) is the lowest concentration of an antimicrobial that will inhibit the visible growth of a microorganism after overnight incubation.
- Minimum inhibitory concentrations are important in diagnostic laboratories to confirm resistance of microorganisms to an antimicrobial agent and also to monitor the activity of new antimicrobial agents.
- Measured in µg/ml = which is the lowest drug concentration that inhibited the growth of the organism.

CRE MIC Breakpoints

Appendix A: Previous and Current Clinical and Laboratory Standards Institute Interpretive Criteria for Carbapenems and Enterobacteriaceae

Agent	Previous Breakpoints (M100-S19) MIC (μg/mL)			Current Breakpoints (M100-S22) MIC (μg/mL)		
	S	I	R	S	I	R
Doripenem	-	-	-	≤1	2	≥4
Ertapenem	≤2	4	≥8	≤0.5	1	≥2
Imipenem	≤4	8	≥16	≤1	2	≥4
Meropenem	≤4	8	≥16	≤1	2	≥4

Centers for Disease Control. Guidance for Control of Carbapenem-resistant Enterobacteriaceae, 2012 CRE Toolkit.

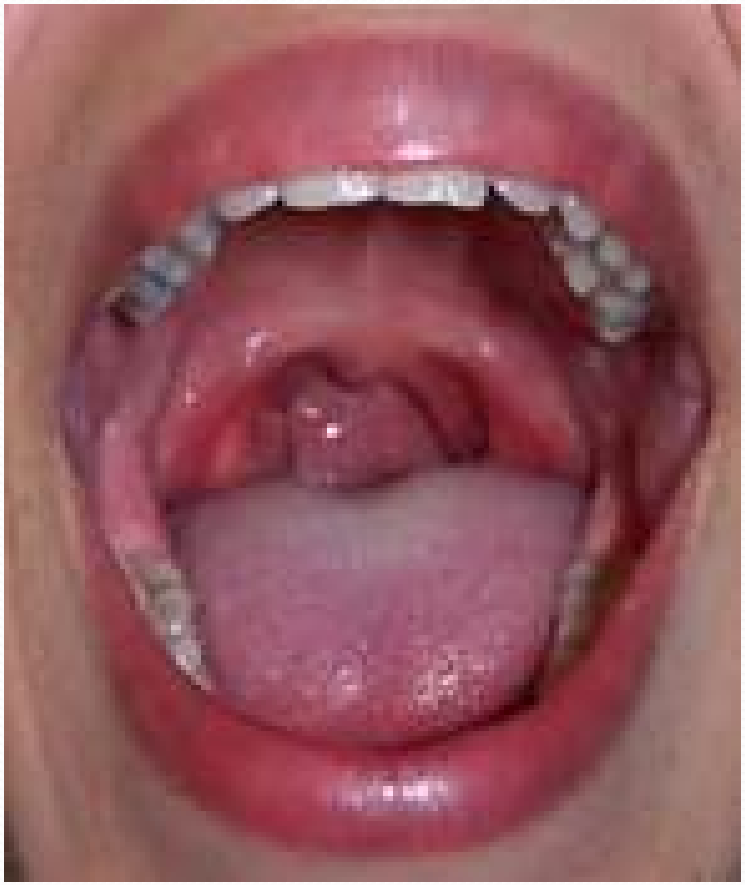
Normal Microbial Flora

- "**Indigenous microbiota**"

- The BACTERIA, fungi, and other microorganisms naturally present within the environment of the healthy body. Normal flora exist on the surface of the SKIN, within natural cavities such as the NOSE and MOUTH, in the gastrointestinal tract, and in the reproductive tract. These beneficial microbes participate in the body's immune response, digestive functions, and reproductive functions, among others.

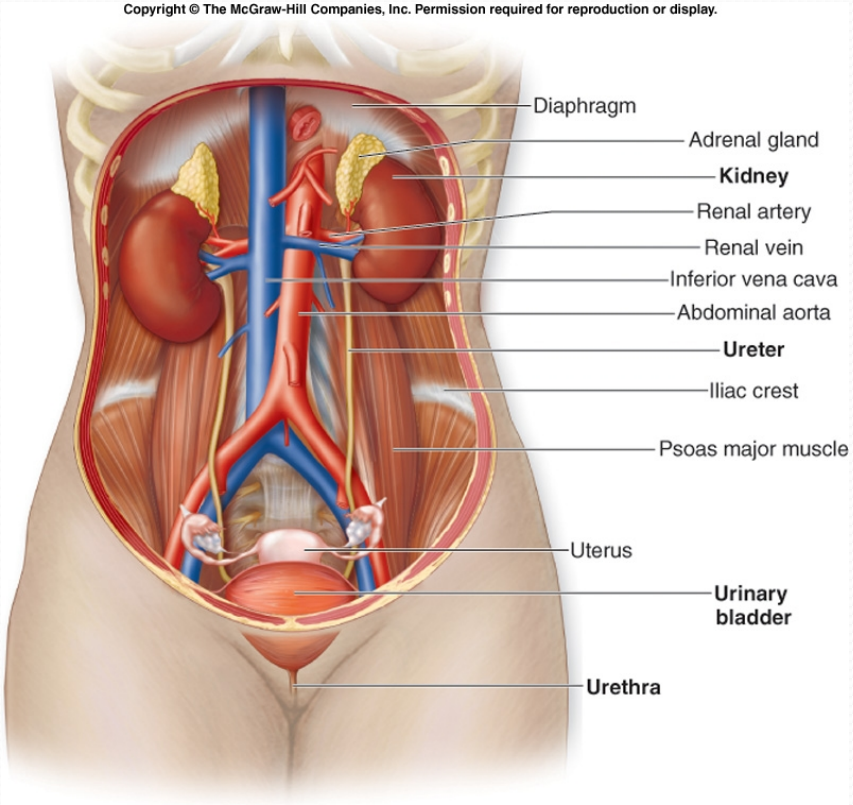
Normal Flora of the Mouth

- Viridens streptococci
- Coagulase-negative staphylococci
- *Veillonella* spp
- *Fusobacteium* spp
- *Treponema* spp
- *Bacteroides* spp
- *Neisseria* spp and *Brahamella catarhalis*
- *Streptococcus pneumoniae*
- Beta-hemolytic streptococci
- *Candida* spp
- *Haemophilus* spp
- Diptheroids
- *Actinomyces* spp
- *Eikenella corrodens*
- *Staphylococcus aureus*



Normal Flora of the GU Tract-Vagina

- Viridens streptococci
- Coagulase-negative staphylococci
- *Veillonella* spp
- *Fusobacteium* spp
- *Treponema* spp
- *Bacteroides* spp
- *Neisseria* spp and *Brahamella catarhalis*
- *Streptococcus pneumoniae*
- Beta-hemolytic streptococci
- *Candida* spp
- *Haemophilus* spp
- Diptheroids
- *Actinomyces* spp
- *Eikenella corrodens*
- *Staphylococcus aureus*



Infections and Common Organisms

Infection/Site	Common Organisms	Less Common Organisms
Bronchitis	S. pneumoniae, H. influenzae, respiratory viruses	B. pertussis, RSV
Endocarditis	S. viridens, S. aureus, anaerobes	S. pyogenes, H. influenzae,
Gastroenteritis	Salmonella sp., Shigella sp., Campylobacter sp., E. coli OH157	Giardia sp., Yersinia sp., Vibrio sp.
Meningitis	H. influenzae, N. meningitides, S. pneumoniae	L. monocytogenes, C. neoformans, M. tuberculosis
Pneumonia (Community)	S. pneumoniae, H. influenzae, M. pneumoniae, C. pneumoniae	S. aureus, Gram neg bacilli, anaerobes, L. pneumophilia
Pneumonia (Healthcare-assoc)	Pseudomonas sp., S. aureus, Enterobacteriaceae	Legionella sp., S. pneumoniae
Septicemia	S. aureus, S. pneumoniae, E. coli, Klebsiella sp., Salmonella sp.	Clostridium sp., candida sp., Listeria sp.
Skin	S. aureus, S. pyogenes, Candida sp., dermatophytes	Gram neg bacilli, Clostridium sp.
Urinary Tract	E. coli, Enterococci, Candida sp., Klebsiella sp., Proteus sp.	Pseudomonas sp.

APIC Text of Infection Control and Epidemiology, 3rd Edition, Vol. 1 essential Elements. Microbiology Basics. 2009

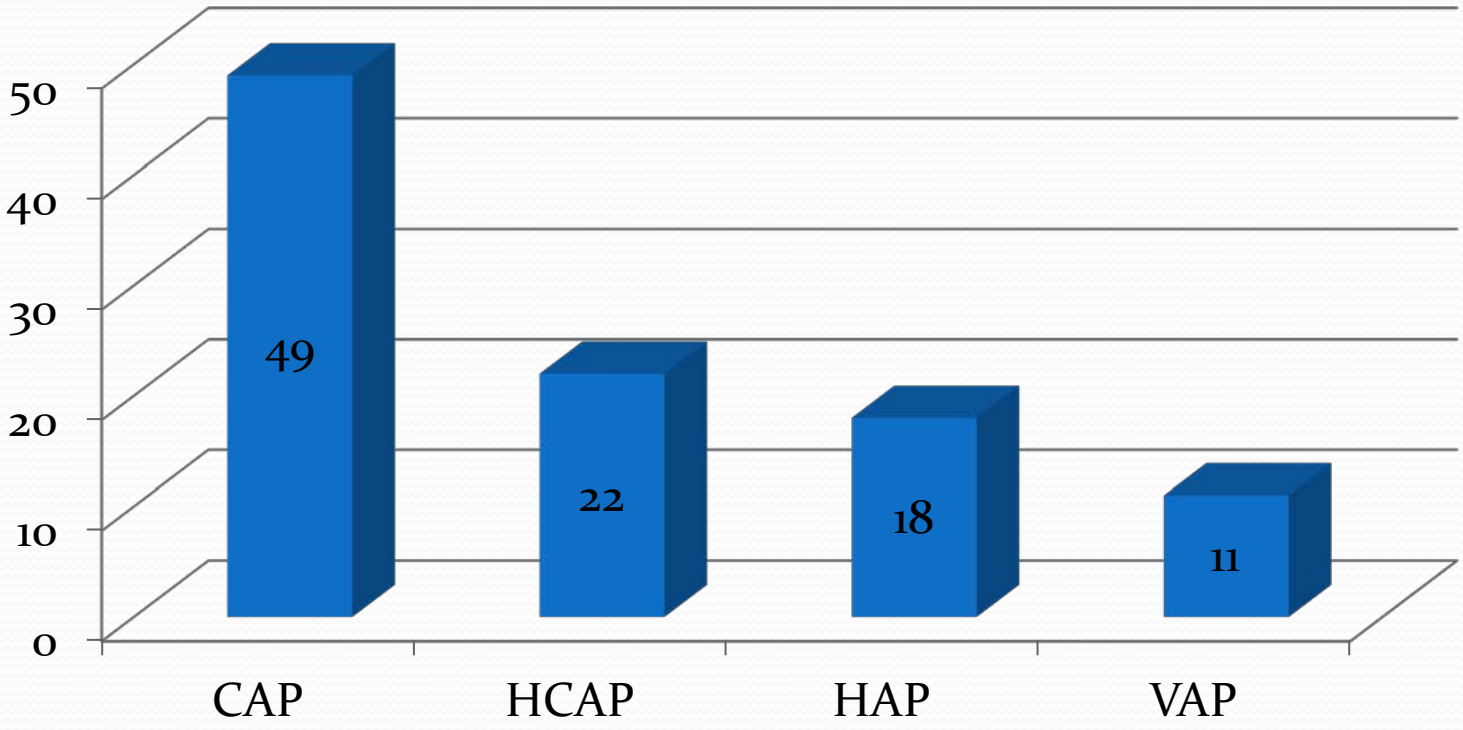
Healthcare Acquired Pneumonia

Classifications of Pneumonia

- CAP – *community-acquired pneumonia*
- HAP – *hospital-acquired pneumonia*
- VAP – *ventilator-associated pneumonia*
- NHAP – *nursing home-associated pneumonia*
- HCAP – *healthcare-associated pneumonia*

Hiramatsu K, et al. Healthcare-associated pneumonia: a new therapeutic paradigm. Chest 2005;128:3784-87.

Study of 4543 pts. with Culture-Positive Pneumonia: Incidence (%)



Kollef MH, et al. Epidemiology and outcomes of healthcare-associated pneumonia: results from a large US database of culture-positive pneumonia. Chest 2005;128:3854-62.

Study of 4543 pts. with Culture-Positive Pneumonia: LOS and Total Charges

Variable	CAP	HCAP	HAP	VAP
LOS, d	7.5	8.8	15.2	23.0
Total charges, $	25,218	27,647	65,292	150,841

Kollef MH, et al. Epidemiology and outcomes of healthcare-associated pneumonia: results from a large US database of culture-positive pneumonia. Chest 2005;128:3854-62.

Frequency of Pathogens (%)

Bacterial Pathogens	CAP	HCAP	HAP	VAP
S. Aureus (all)	25.5	46.7	47.1	42.5
MRSA (all)	8.9	26.5	22.9	14.6
MRSA (only)	6.2	18.3	16.8	11.8
MRSA as % of all S. aureus	34.8	56.8	48.6	34.4
S. Pneumoniae	16.6	5.5	3.1	5.8
Pseudomonas sp.	17.1	25.3	18.4	21.2
Haemophilus sp.	16.6	5.8	5.6	12.2
Klebsiella sp.	9.5	7.6	7.1	8.4
Escherichia sp.	4.8	5.2	4.7	6.4
Enterobacter sp.	2.9	3.5	4.3	5.6
Acinetobacter sp.	1.6	2.6	2.0	3.0

Kollef MH, et al. Epidemiology and outcomes of healthcare-associated pneumonia: results from a large US database of culture-positive pneumonia. Chest 2005;128:3854-62.

Healthcare-associated Pneumonia

- Introduced to describe a non-hospitalized population of
  - nursing home residents,
  - long-term care patients,
  - those undergoing same-day procedures,
  - patients receiving home or hospital-based intravenous therapy,
  - dialysis patients,
  - patients recently discharged from the hospital

Kollef MH, et al. Epidemiology and outcomes of healthcare-associated pneumonia: results from a large US database of culture-positive pneumonia. Chest 2005;128:3854-62.

HAP

- Major complication in patients hospitalized in either non-ICU or ICU settings and accounts for approx. half of all infections in the critically ill

- European study comparing the pathogens associated with early-onset and late-onset ICU-acquired pneumonia (498 pts. with pneumonia [12%], 298 classified as HAP)

- HAP classified as:
  - Early-onset HAP – pneumonia occurring within 7 days after admission or initiation of mechanical ventilation without receipt of previous antibiotics
  - Early-onset HAP with receipt of previous antibiotics
  - Late-onset HAP – pneumonia occurring 7 or more days after admission or initiation of mechanical ventilation without receipt of previous antibiotics
  - Late-onset HAP with receipt of previous antibiotics

Verhamme KM, et al. Pathogens in early-onset and late-onset intensive care unit-acquired pneumonia. Infect Cont Hosp Epidemiol 2007;28:389-97.

Study Results, 330 episodes

- Time
  - 194 events - < 7 days; 136 events - > 7 days
- Pathogens
  - *P. aeruginosa,* 16%
  - *H. influenzae,* 16%
  - MSSA, 15%
  - *E. coli*, 15%
  - *S. marcescens,* 15%
  - *Enterobacter sp.*, 14%
  - *K. pneumoniae,* 13%
  - 3/45 *Enterobacter sp.* and 2/42 *K.pneumoniae* were ESBL
- Risk Factor
  - Main risk factor was the previous use of antibiotics, therapeutic or prophylaxis

Verhamme KM, et al. Pathogens in early-onset and late-onset intensive care unit-acquired pneumonia. Infect Cont Hosp Epidemiol 2007;28:389-97

VAP vs. HAP Flora

- Study of VAP and HAP pathogens for purposes of optimizing therapy
- University of North Carolina Hospitals study conducted system-wide, 2000-2003
- Used definitions as described by ATS
- Did not include CAP or HCAP
- Specimens obtained via bronchoscopy, expectorated sputum, or tracheal aspirates

Weber DJ, et al. Microbiology of ventilator-associated pneumonia compared with that of hospital-acquired pneumonia. Infect Control Hosp Epidemiol 2007;28:825-31.

Results, Epidemiology

- 588 lower respiratory therapy tract infections in 556 patients
- Incidence of pneumonia: 0.37%

Variable	VAP	HAP
No. of patients	309	247
No. of infections	327	261
No. of infections per pt.	1.06	1.06
Service		
•Medical	35 (10.7)	83 (31.8)
•Surgical	277 (84.7)	145 (55.6)
•Pediatric	9 (1.8)	6 (2.3)
•Other	6 (1.8)	27 (10.3)
Location		
•ICU	296 (90.5)	85 (32.6)
•Non-ICU, ward	31 (9.5)	176 (67.4)

Weber DJ, et al. Microbiology of ventilator-associated pneumonia compared with that of hospital-acquired pneumonia. Infect Control Hosp Epidemiol 2007;28:825-31.

Results, Pathogens

- Pathogens isolated from 92.4% of patients with VAP and 76.6% from HAP patients

Pathogen	Pts. with VAP	Pts. with HAP
S. aureus		
•All	128 (32.0)	115 (42.6)
•Oxacillin sensitive	37 (9.3)	36 (13.3)
•Oxacillin resistant	71 (17.8)	55 (20.4)
Enterobacteriaceae	59 (14.8)	44 (16.3)
•*E. coli*	15 (3.6)	8 (2.9)
•*K. pneumoniae*	8 (2.0)	13 (4.8)
•*S. marcescens*	10 (2.5)	5 (1.8)
Non-Enterobacteriaceae	160 (40.8)	53 (19.7)
•P. Aeruginosa	70 (17.5)	25 (9.26)
•Acinetobacter sp.	31 (7.8)	9 (3.3)
•S. Maltophilia	27 (6.8)	3 (1.1)
•H. Influenzae	18 (4.5)	6 (2.2)

Weber DJ, et al. Microbiology of ventilator-associated pneumonia compared with that of hospital-acquired pneumonia. Infect Control Hosp Epidemiol 2007;28:825-31.

Results, Time of Infection

- Pathogens statistically associated with

- VAP:
  - Early-onset (0-4 days): oxacillin-susceptible *S. aureus*, *S. pneumoniae, Hemophilus* sp.
  - Late-onset (5+ days): *Acinetobacter* sp. and *S. maltophilia*

- HAP:
  - Early-onset (0-4 days): only *S. pneumoniae*.
  - Late-onset (5+ days): oxacillin-resistant *S. aureus* and *P.aeruginosa*

Weber DJ, et al. Microbiology of ventilator-associated pneumonia compared with that of hospital-acquired pneumonia. Infect Control Hosp Epidemiol 2007;28:825-31.

Ventilator Associated Events

NHSN (PNEU) Surveillance Definitions 2002 - Present

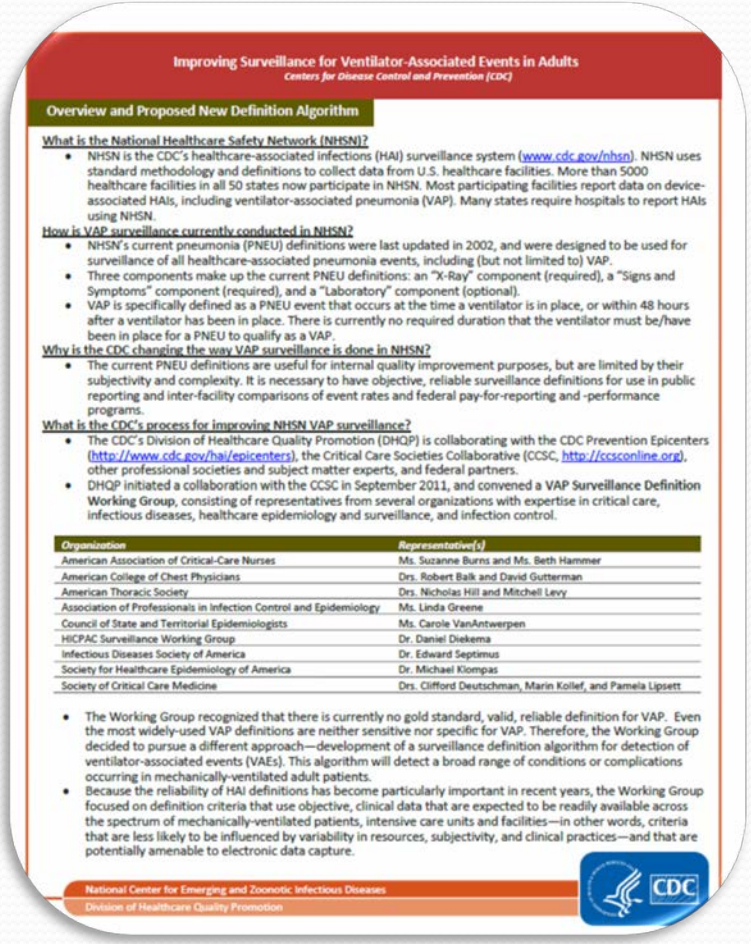
- There is currently no standard definition for VAP
- Combination of x-ray, signs/symptoms, and laboratory criteria
  - Chest imaging findings are required
  - Signs and symptoms of pneumonia are required
  - Laboratory evidence is optional
- Currently used definitions include subjective elements
  - Because of this there was no uniform way for public reporting of HAI rates, comparisons among facilities, or pay for performance programs

VAP Surveillance Limitations

- VAP is only one of many severe complications associated with mechanical ventilation
- VAP surveillance definitions are complicated, labor intensive, highly subjective, and nonspecific
- VAP surveillance may be associated with artificially lowering rates, create complacency, and prevent meaningful benchmarking between institutions

Klompas M. Ventilator-associated events surveillance: a patient safety opportunity. Curr Opin Crit Care 2013;19:1-8.

Improving Surveillance for Ventilator Associated Events in Adults



Improving Surveillance for Ventilator-Associated Events in Adults

Centers for Disease Control and Prevention (CDC)

Overview and Proposed New Definition Algorithm

What is the National Healthcare Safety Network (NHSN)?

- NHSN is the CDC's healthcare-associated infections (HAI) surveillance system (www.cdc.gov/nhsn). NHSN uses standard methodology and definitions to collect data from U.S. healthcare facilities. More than 5000 healthcare facilities in all 50 states now participate in NHSN. Most participating facilities report data on device-associated HAIs, including ventilator-associated pneumonia (VAP). Many states require hospitals to report HAIs using NHSN.

How is VAP surveillance currently conducted in NHSN?

- NHSN's current pneumonia (PNEU) definitions were last updated in 2002, and were designed to be used for surveillance of all healthcare-associated pneumonia events, including (but not limited to) VAP.
- Three components make up the current PNEU definitions: an "X-Ray" component (required), a "Signs and Symptoms" component (required), and a "Laboratory" component (optional).
- VAP is specifically defined as a PNEU event that occurs at the time a ventilator is in place, or within 48 hours after a ventilator has been in place. There is currently no required duration that the ventilator must be/have been in place for a PNEU to qualify as a VAP.

Why is the CDC changing the way VAP surveillance is done in NHSN?

- The current PNEU definitions are useful for internal quality improvement purposes, but are limited by their subjectivity and complexity. It is necessary to have objective, reliable surveillance definitions for use in public reporting and inter-facility comparisons of event rates and federal pay-for-reporting and -performance programs.

What is the CDC's process for improving NHSN VAP surveillance?

- The CDC's Division of Healthcare Quality Promotion (DHQP) is collaborating with the CDC Prevention Epicenters (http://www.cdc.gov/hai/epicenters), the Critical Care Societies Collaborative (CCSC, http://ccsconline.org), other professional societies and subject matter experts, and federal partners.
- DHQP initiated a collaboration with the CCSC in September 2011, and convened a **VAP Surveillance Definition Working Group**, consisting of representatives from several organizations with expertise in critical care, infectious diseases, healthcare epidemiology and surveillance, and infection control.

Organization	*Representative(s)*
American Association of Critical-Care Nurses	Ms. Suzanne Burns and Ms. Beth Hammer
American College of Chest Physicians	Drs. Robert Balk and David Gutterman
American Thoracic Society	Drs. Nicholas Hill and Mitchell Levy
Association of Professionals in Infection Control and Epidemiology	Ms. Linda Greene
Council of State and Territorial Epidemiologists	Ms. Carole VanAntwerpen
HICPAC Surveillance Working Group	Dr. Daniel Diekema
Infectious Diseases Society of America	Dr. Edward Septimus
Society for Healthcare Epidemiology of America	Dr. Michael Klompas
Society of Critical Care Medicine	Drs. Clifford Deutschman, Marin Kollef, and Pamela Lipsett

- The Working Group recognized that there is currently no gold standard, valid, reliable definition for VAP. Even the most widely-used VAP definitions are neither sensitive nor specific for VAP. Therefore, the Working Group decided to pursue a different approach—development of a surveillance definition algorithm for detection of ventilator-associated events (VAEs). This algorithm will detect a broad range of conditions or complications occurring in mechanically-ventilated adult patients.
- Because the reliability of HAI definitions has become particularly important in recent years, the Working Group focused on definition criteria that use objective, clinical data that are expected to be readily available across the spectrum of mechanically-ventilated patients, intensive care units and facilities—in other words, criteria that are less likely to be influenced by variability in resources, subjectivity, and clinical practices—and that are potentially amenable to electronic data capture.

National Center for Emerging and Zoonotic Infectious Diseases
Division of Healthcare Quality Promotion

CDC

- New Definition
  - Detects complications and conditions including, but not limited to VAP
  - Requires a minimum period of time on ventilator
  - Focuses on readily available, objective, clinical date
  - Does not include chest radiograph findings
- The goal for implementation in NHSN (National Healthcare Safety Network) is January 2013.

The New VAE Algorithm

- It is a surveillance algorithm and is not intended for use in the clinical management of patients
- There are 3 Tiers of the new VAE definition

Tier	Category	Elements
1	***Ventilator Associated Conditions***	**FiO2, PEEP**
		
2	***Infection-Related Ventilator-Associated Complications***	**Fever or WBC and New antimicrobial agent**
		
3	***Possible and Probable VAP***	**Purulent secretions and/or other positive laboratory evidence**

Tier 1: Ventilator-Associated Condition (VAC)

Patient has a baseline period of stability or improvement on the ventilator, defined by ≥ 2 calendar days of stable or decreasing daily minimum FiO_2 or PEEP values. The baseline period is defined as the two calendar days immediately preceding the first day of increased daily minimum PEEP or FiO_2.

AND

After a period of stability or improvement on the ventilator, the patient has at least ONE of the following indicators of worsening oxygenation:

1. Increase in daily minimum FiO_2 of ≥ 0.20 (20 points) over the daily minimum FiO_2 in the baseline period, sustained for ≥ 2 calendar days

OR

2. Increase in daily minimum PEEP values of ≥ 3 cmH_2O over the daily minimum PEEP in the baseline period, sustained for ≥ 2 calendar days.

Tier 2: Infection-Related Vent-Assoc Complication (IVAC)

Patient meets criteria for VAC

AND

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, the patient meets BOTH of the following criteria:

1) Temperature > 38 °C or < 36 °C , **OR** white blood cell count ≥ 12,000 cells/mm³ or ≤ 4,000 cells/mm³.

AND

2) A new antimicrobial agent(s)* is started, and is continued for ≥ 4 calendar days.

*See Appendix for eligible agents.

Look for abnormal temp or white count during VAE Window Period

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys /Epis	Org
1	10	60								
2	5	40								
3	5	40	36.9	37.6	12.1	12.1				
4	8	60	38.1	39.2	14.5	16.8				
5	8	50	38.4	38.9	12.6	15.9				
6	7	40	36.5	37.8	11.1	13.6				
7	5	40								
8	5	40								

NOTE: Look for MULTIPLE Temp/WBC readings per day and record the MIN / MAX!!

IVAC Antimicrobial Criterion

- **Probably the most complicated portion of the VAE surveillance definition algorithm**
- **Rules for meeting this criterion are not perfect—but we need a standardized method for assessment of antimicrobial therapy, without needing knowledge of dosing, renal function, indication for therapy, etc.**

Figuring out if a "new" antimicrobial agent(s) has been given

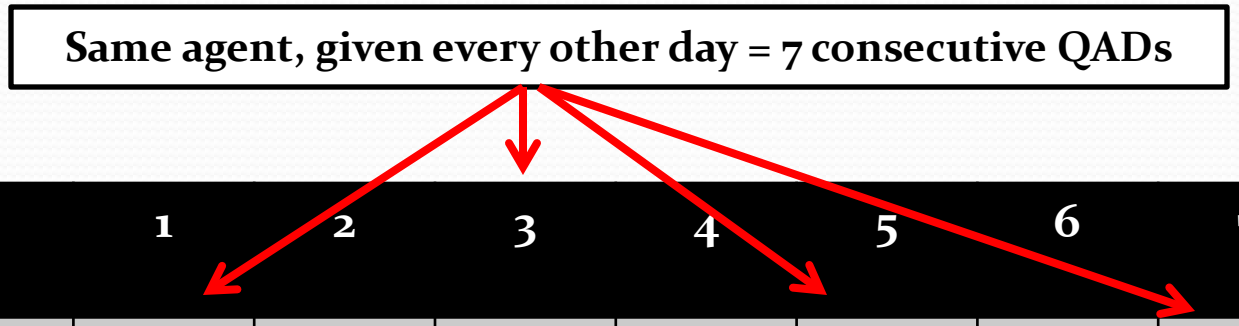
- **New antimicrobial agent: Defined as any agent listed in the protocol Appendix that is initiated on or after the third calendar day of mechanical ventilation AND in the VAE Window Period (i.e., the period typically defined by the 2 calendar days before, the day of, and the 2 calendar days after the onset date of the VAE).**
  - The agent is considered new for the purposes of this definition if it was NOT given to the patient on either of the 2 days preceding the current start date.
  - A new agent must be continued for ≥ 4 consecutive days.
  - There is no requirement that the same antimicrobial agent be given on the 4 consecutive days.
  - New agent must be administered IV, IM, via digestive tract or via respiratory tract

Figuring out if ≥ 4 days of therapy have been given: Qualifiying Antimicrobial Days (QAD)

- **A day on which the patient was administered an antimicrobial agent that was determined to be "new" within the VAE Window Period.**
- **Four consecutive QADs are needed to meet the IVAC antimicrobial criterion—starting within the VAE Window Period.**

QADs: Same Agent

- **Days between administrations of a new antimicrobial agent also count as QADs as long as there is a gap of no more than 1 calendar day between administrations of the same drug. For example, if levofloxacin is given on VAE Day 1, has not been given in the 2 preceding calendar days, and is given again on VAE Days 3, 5, and 7, there are 7 QADs—because the days between levofloxacin does also count as QADs.**

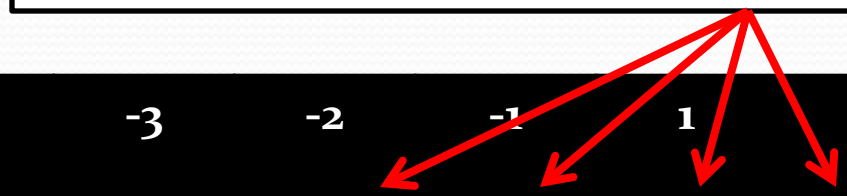


VAE Day	-2	-1	1	2	3	4	5	6	7
Abx #1	--	--	Levo	--	Levo	--	Levo	--	Levo
QAD	--	--	Yes	Yes	Yes	Yes	Yes	Yes	Yes

QADs: Different Agents

- **By contrast, days between administrations of different antimicrobial agents do NOT count as QADs**
  - For example, if levofloxacin is given to the patient on VAE Days -2 and – 1 only, no antimicrobials are given on VAE Day 1, and meropenem is given only on VAE Day 2 (remember there is no VAE Day 0), then there are <u>not</u> 4 consecutive QADs. VAE Days -2 and -1 count as 2 consecutive QADs, but VAE Day 1 cannot be counted as a QAD because it is a day between different antimicrobial agents.

Different agents, with gap between agents: only 2 consecutive QADs



VAE Day	-4	-3	-2	-1	1	2	3	4	5
Abx #1	--	--	**Levo**	**Levo**	--	--	--	--	--
Abx #2	--	--	--	--	--	**Mero**	--	--	--
QAD	--	--	Yes	Yes	--	Yes	--	--	--

New antimicrobial agent started and continued for 4 days

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys /Epis	Org
1	10	60					None			
2	5	40					None			
3	5	40	36.9	37.6	12.1	12.1	None			
4	8	60	38.1	39.2	14.5	16.8	Yes			
5	8	50	38.4	38.9	12.6	15.9	Yes			
6	7	40	36.5	37.8	11.1	13.6	Yes	=IVAC		
7	5	40					Yes			
8	5	40					Yes			

Tier 3A: Possible VAP

Patient meets criteria for VAC and IVAC

AND

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, ONE of the following criteria is met:

1) Purulent respiratory secretions (from one or more specimen collections)
   - Defined as secretions from the lungs, bronchi, or trachea that contain ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field (lpf, x100)
   - If the laboratory reports semi-quantitative results, those results must be equivalent to the above quantitative thresholds.

OR

2) Positive culture (qualitative, semi-quantitative) or sputum* endotracheal aspirate*, bronchoalveolar lavage*, lung tissue, or protected specimen brushing*

**Excludes the following*:*
- Normal respiratory/oral flora, mixed respiratory/oral flora or equivalent
- *Candida* species or yeasts not otherwise specified
- Coagulase-Negative *Staphylococcus* species
- *Enterococcus* species

Tier 3B: Probable VAP

VAC, IVAC plus the following …

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, ONE of the following criteria is met:

1) Purulent respiratory secretions (from one or more specimen collections—and defined as for possible VAP)

AND one of the following (see Table 2):

- Positive culture of endotracheal aspirate*, ≥ 10^5 CFU/ml or equivalent semi-quantitative result
- Positive culture of bronchoalveolar lavage*, 10^4 CFU/ml or equivalent semi-quantitative result
- Positive culture of lung tissue, 10^4 CFU/g or equivalent semi-quantitative result
- Positive culture of protected specimen brush*, 10^3 CFU/ml or equivalent semi-quantitative result

**Same organism exclusions as noted for Possible VAP.*

OR

2) One of the following (without requirement for purulent respiratory secretions):

- Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube)
- Positive lung histopathology
- Positive diagnostic test for Legionella spp.
- Positive diagnostic test on respiratory secretions for influenza virus, repiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus

TABLE 5. Distribution of Rank Order of Selected Pathogens Associated with Healthcare-Associated Infections (HAIs) Reported to the National Healthcare Safety Network, by Type of HAI, 2009–2010

	Overall		CLABSI		CAUTI		VAP		SSI	
Pathogen	No. (%) of pathogens	Rank	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]
Staphylococcus aureus	12,635 (15.6)	1	3,735 (12.3)	2	442 (2.1)	...	2,043 (24.1)	1	6,415 (30.4)	1
Escherichia coli	9,351 (11.5)	2	1,206 (4.0)	9	5,660 (26.8)	1	504 (5.9)	6	1,981 (9.4)	3
Coagulase-negative staphylococci	9,261 (11.4)	3	6,245 (20.5)	1	467 (2.2)	...	72 (0.9)	...	2,477 (11.7)	2
Klebsiella (*pneumoniae*/*oxytoca*)	6,470 (8.0)	4	2,407 (7.9)	5	2,365 (11.2)	3	854 (10.1)	3	844 (4.0)	7
Pseudomonas aeruginosa	6,111 (7.5)	5	1,166 (3.8)	10	2,381 (11.3)	2	1,408 (16.6)	2	1,156 (5.5)	5
Enterococcus faecalis	5,484 (6.8)	6	2,680 (8.8)	3	1,519 (7.2)	5	45 (0.5)	...	1,240 (5.9)	4
Candida albicans	4,275 (5.3)	7	1,974 (6.5)	7	1,887 (8.9)	4	147 (1.7)	...	267 (1.3)	...
Enterobacter spp.	3,821 (4.7)	8	1,365 (4.5)	8	880 (4.2)	8	727 (8.6)	4	849 (4.0)	6
Other *Candida* spp. or NOS	3,408 (4.2)	9	2,465 (8.1)	4	811 (3.8)	9	36 (0.4)	...	96 (0.5)	...
Enterococcus faecium	3,314 (4.1)	10	2,118 (7.0)	6	654 (3.1)	10	25 (0.3)	...	517 (2.5)	...
Enterococcus spp.	2,409 (3.0)	11	703 (2.3)	12	1,010 (4.8)	7	11 (0.1)	...	685 (3.2)	8
Proteus spp.	2,031 (2.5)	12	232 (0.8)	...	1,013 (4.8)	6	119 (1.4)	...	667 (3.2)	9
Serratia spp.	1,737 (2.1)	13	762 (2.5)	11	204 (1.0)	...	386 (4.6)	7	385 (1.8)	...
Acinetobacter baumannii	1,490 (1.8)	14	629 (2.1)	13	185 (0.9)	...	557 (6.6)	5	119 (0.6)	...
Other[a]	9,304 (11.5)	...	2,762 (9.1)	...	1,633 (7.7)	...	1,510 (17.8)	...	3,399 (16.1)	...
Total	81,139 (100)		30,454 (100)		21,111 (100)		8,474 (100)		21,100 (100)	

NOTE. CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; NOS, not otherwise specified; SSI, surgical site infection; VAP, ventilator-associated pneumonia.

[a] A rank is not given if pathogen is not in the top 14 reported for the specific HAI type listed in Table 3 of the supplemental report on the CDC website (http://www.cdc.gov/nhsn/dataStat.html).

TABLE 7. Percentage of Pathogenic Isolates Resistant to Selected Antimicrobial Agents, National Healthcare Safety Network, 2009–2010

Pathogen, antimicrobial[a]	CLABSI			CAUTI			VAP			SSI		
	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %
Staphylococcus aureus	3,735			442			2,043			6,415		
OX/METH		3,611 (96.7)	54.6		438 (99.1)	58.7		1,974 (96.6)	48.4		6,304 (98.3)	43.7
Enterococcus spp.												
E. faecium	2,118			654			25			517		
VAN		2,069 (97.7)	82.6		639 (97.7)	82.5		23 (92)	82.6		509 (98.5)	62.3
E. faecalis	2,680			1,519			45			1,240		
VAN		2,578 (96.2)	9.5		1,446 (95.2)	8.4		41 (91.1)	9.8		1,187 (95.7)	6.2
Klebsiella (*pneumoniae/oxytoca*)	2,407			2,365			854			844		
ESC4		2,109 (87.6)	28.8		1,998 (84.5)	26.9		747 (87.5)	23.8		710 (84.1)	13.2
Carbapenems		1,858 (77.2)	12.8		1,520 (64.3)	12.5		617 (72.2)	11.2		582 (69.0)	7.9
MDR1		1,932 (80.3)	16.8		1,650 (69.8)	16.1		658 (77.0)	13.4		621 (73.6)	6.8
Escherichia coli	1,206			5,660			504			1,981		
ESC4		1,067 (88.5)	19.0		4,656 (82.3)	12.3		429 (85.1)	16.3		1,627 (82.1)	10.9
FQ3		1,137 (94.3)	41.8		5,513 (97.4)	31.2		466 (92.5)	35.2		1,876 (94.7)	25.3
Carbapenems		931 (77.2)	1.9		3,579 (63.2)	2.3		344 (68.3)	3.5		1,330 (67.1)	2.0
MDR1		992 (82.3)	3.7		3,929 (69.4)	2.0		365 (72.4)	3.3		1,390 (70.2)	1.6
Enterobacter spp.	1,365			880			727			849		
ESC4		1,309 (95.9)	37.4		818 (93.0)	38.5		690 (94.9)	30.1		816 (96.1)	27.7
Carbapenems		1,041 (76.3)	4.0		614 (69.8)	4.6		530 (72.9)	3.6		594 (70.0)	2.4
MDR1		1,123 (82.3)	3.7		667 (75.8)	4.8		579 (79.6)	1.4		648 (76.3)	1.7
Pseudomonas aeruginosa	1,166			2,381			1,408			1,156		
AMINOS		819 (70.2)	10.0		1,495 (62.8)	10.9		920 (65.3)	11.3		664 (57.4)	6.0
ESC2		1,120 (96.1)	26.1		2,294 (96.3)	25.2		1,355 (96.2)	28.4		1,097 (94.9)	10.2
FQ2		1,114 (95.5)	30.5		2,337 (98.2)	33.5		1,378 (97.9)	32.7		1,111 (96.1)	16.9
Carbapenems		982 (84.2)	26.1		1,883 (79.1)	21.3		1,162 (82.5)	30.2		872 (75.4)	11.0
PIP/PIPTAZ		809 (69.4)	17.4		1,792 (75.3)	16.6		1,059 (75.2)	19.1		818 (70.8)	6.8
MDR2		1,096 (94)	15.4		2,250 (94.5)	14.0		1,342 (95.3)	17.7		1,053 (91.1)	5.3
Acinetobacter baumannii	629			185			557			119		
Carbapenems		522 (83)	62.6		128 (69.2)	74.2		449 (80.6)	61.2		102 (85.7)	37.3
MDR3		617 (98.1)	67.6		183 (98.9)	77.6		552 (99.1)	63.4		114 (95.8)	43.9

NOTE. CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; SSI, surgical site infection; VAP, ventilator-associated pneumonia.
[a] AMINOS, aminoglycosides (amikacin, gentamicin, tobramycin). Carbapenems are imipenem and meropenem. ESC2, extended-spectrum (ES) cephalosporins (cefepime, ceftazidime); ESC4, ES cephalosporins (cefepime, cefotaxime, ceftazidime, ceftriaxone). FQ2, fluoroquinolones (ciprofloxacin, levofloxacin); FQ3, fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin). MDR1, pathogens tests as "I" (intermediate) or "R" (resistant) to at least 1 drug in 3 of the 5 following classes: ESC4, FQ3, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; MDR2, pathogen must test as I or R to at least 1 drug in 3 of the 5 following classes: ESC2, FQ2, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; MDR3, pathogen must test as I or R to at least 1 drug in 3 of the 6 following classes: ESC2, FQ2, aminoglycosides, carbapenems, piperacillin or piperacillin/tazobactam, and ampicillin/sulbactam. OX/METH, oxacillin/methicillin; PIP, piperacillin; PIPTAZ, piperacillin/tazobactam; VAN, vancomycin.

Purulent Respiratory Secretions

- Gram stain polymorphonuclear leukocyte ("polys", "PMN", neutrophil) counts and squamous epithelial cell counts
- Can be used alone to meet Possible VAP definition, or in combination with a semi-quantitative or quantitative culture result (with the appropriate growth) to meet the Probable VAP definition

How do I relate my lab's semi-quantitative Gram stain reporting to the quantitative threshold is the algorithm?

- Ask your laboratory manager/director first—he/she may be able to tell you
- If your laboratory does not have this information, use the following guidance* …

1+ = occasional or rare = <1 cell per low power field (lpf)
2+ = few = 1-9 cells per lpf
3+ =moderate = 10-25 cells per lpf
4+ = heavy = >25 cells per lpf

- This means that in the absence of information from your lab, "**purulent respiratory secretions**" are defined by "heavy" 4+ or ≥25 neutrophils per low power field AND "rare", "occasional", "few", 1+ or 2+, or ≤ 10 squamous epithelial cells per lpf
- *This is preliminary! Please make sure to review the protocol in 2013 for updates*

*Reference: Garcia, LS (Ed.). (2010). Clinical Microbiology Procedures Handbook. Herndon, VA: ASM Press, page 3.2.1.16.

Lower Respiratory Culture Results

- **Appropriate specimen types include:**
  - Sputum, endotracheal aspirate, bronchoalveolar lavage, protected specimen brushings, lung tissue, pleural fluid
- **Exclude the following as a pathogen unless isolated from lung tissue or pleural fluid**
  - *Candida* species or yeast not otherwise specified
  - Coagulase negative *Staphylococcus* species
  - *Enterococcus* species
- **Exclude the following culture results (or similar) …**
  - Normal respiratory flora / Normal oral flora
  - Mixed respiratory flora / Mixed oral flora
  - Altered oral / respiratory flora

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys /Epis	Org
1	10									
2	5									
3	5	40	36.9	37.6	12.1	12.1	None	ETA	>25/ <10	Staph aureus
4	8	60	38.1	39.2	14.5	16.8	Yes	--	--	--
5	8	50	38.4	38.9	12.6	15.9	Yes	--	--	--
6	7	40	36.5	37.8	11.1	13.6	Yes	--	--	--
7	5	40					Yes			
8	5	40								

Purulent respiratory secretions OR
ETA culture positive for S. aureus

= Possible VAP

Probable VAP

VAC, IVAC plus the following…

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, ONE of the following criteria is met:

1) Purulent respiratory secretions (from one or more specimen collections—and defined as for possible VAP)

AND one of the following (see Table 2):

- Positive culture of endotracheal aspirate*, ≥ 10^5 CFU/ml or equivalent semi-quantitative result
- Positive culture of bronchoalveolar lavage*, 10^4 CFU/ml or equivalent semi-quantitative result
- Positive culture of lung tissue, 10^4 CFU/g or equivalent semi-quantitative result
- Positive culture of protected specimen brush*, 10^3 CFU/ml or equivalent semi-quantitative result

**Same organism exclusions as noted for Possible VAP.*

2) One of the following (without requirement for purulent respiratory secretions):

- Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube)
- Positive lung histopathology
- Positive diagnostic test for Legionella spp.
- Positive diagnostic test on respiratory secretions for influenza virus, repiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus

Purulent respiratory secretions AND positive quantitative or semi-quantitative ETA culture *(meeting specified threshold)*

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Poly s/Epis	Org
1	10	60					None			
2	5	40					None			
3	5	40	36.9	37.6	12.1	12.1	None	ETA	≥25/ ≤10	10^5 cfu/ml *S. aureus*
4	8	60	38.1	39.2	14.5	16.8	Yes	--	--	--
5	8	50	38.4	38.9	12.6	15.9	Yes	--	--	--
6	7	40	36.5	37.8	11.1	13.6	Yes	--	--	--
7	5	40					Yes			
8	5	40								

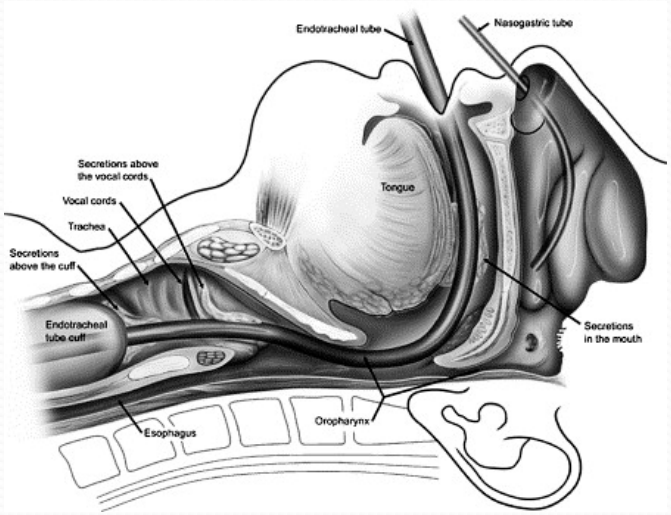
= **Probable VAP**

Pathogenesis of Healtcare-Acquired Pneumonia Including VAP

An Early Review of Oral Colonization & Respiratory Infection

The efficacy and cost-effectiveness of various intervention strategies for the prevention and control of nosocomial pneumonia, particularly for patients on mechanical ventilation, have been extensively reviewed.1, 2, 3, 4, 5, 6 In 2004, the Healthcare Infection Control Practices Advisory Committee (HICPAC) of the US Centers for Disease Control and Prevention (CDC) issued an evidence-based guideline7 that lists graded recommendations addressing a wide range of issues, including the need to educate health care workers on risk-reduction practices, the safe handling and cleaning of respiratory care devices such as mechanical ventilators and humidifiers, the duration of use of disposable ventilator circuits and closed suction catheters, the suctioning of subglottic secretions, the placement of patients in semirecumbent positions, the use of stress ulcer medications, and the selective decontamination of the digestive tract.

Two interventions that have emerged in the scientific literature as contributory to the prevention of pneumonia in hospitalized patients, and are currently not fully addressed in either the CDC pneumonia prevention guideline or other published sets of recommendations, are the performance and frequency of oropharyngeal care and the elimination of dental plaque to reduce bacterial colonization. This article reviews the scientific evidence that bacterial colonization of oropharyngeal tissues and dental plaque is a major precursor to the development of respiratory infection and in particular to ventilator-associated pneumonia (VAP). In addition, specific recommendations addressing clinical interventions in this area are made with the goal of improving the assessment and care of patients on mechanical ventilation.



Garcia R.
A review of the possible role of oral and dental colonization on the occurrence of health care-associated pneumonia: underappreciated risk and a call for interventions. Am J Infect Control. 2005 Nov;33(9):527-41.

Comprehensive Oral Care Interventions

"Strategies to prevent VAP are likely to be successful only if based upon a sound understanding of pathogenesis and epidemiology. The major route for acquiring endemic VAP is oropharyngeal colonization by endogenous flora or by pathogens acquired exogenously from the intensive care unit environment, especially the hands or apparel of health-care workers, contaminated equipment, hospital water, or air. The stomach represents a potential site of secondary colonization and reservoir of nosocomial gram-negative bacilli."

Safdar N, Crnich CJ, Maki DG. The pathogenesis of ventilator-associated pneumonia: its relevance to developing effective strategies for prevention. Respir Care 2005;50:725-39.

Resource: Linking Oral and Dental Colonization with Respiratory Infection

- Review of 11 case-control and cohort studies and 9 RCTs; meta-analysis of five of these studies
- Authors found an association between periodontal disease and pneumonia and a potential association between periodontal disease and COPD.
- Also found that the incidence of pneumonia was reduced by an average of 40% through mechanical and/or topical chemical disinfection or antibiotics.

Scannapieco FA, et al. Association between periodontal disease and risk for nosocomial bacterial pneumonia and chronic obstructive pulmonary disease. A systematic review. Ann Periodontol 2003;8:54-69.

Resource: Linking Oral and Dental Colonization with Respiratory Infection

- Based on Evidence Scales as used by Canadian Task Force on Preventive Health
- Review of 5 studies examining association **between pneumonia and oral health:**
  - Conclusion: *fair evidence (Grade B recommendation)*
- Review of 10 studies examining association **between oral health interventions and the occurrence of pneumonia:**
  - Conclusion: *good evidence (Grade A recommendation)*
- Overall Conclusion:
  - *"Oral hygiene and frequent professional oral health care are useful for reducing the occurrence of pneumonia among high-risk elderly adults living in nursing homes and especially in ICUs"*

Azarpazhooh A. Systematic review of the association between respiratory diseases and oral health. J Periodontol 2006;77:1465-82.

Prevention of VAP: Modulation of Colonization – *Oral Care*

Professional organizations are now recognizing comprehensive oral care

APIC 2009 Guide to the Elimination of Ventilator-Associated Pneumonia[7]

Key prevention strategies:

- *Perform routine antiseptic mouth care*

Example mouth care and documentation form includes the following:

- *Perform routine antiseptic mouth care*
- *Brush teeth q12*
- *Provide oral care every 2 to 4 hours with antiseptic*
- *Apply mouth moisturizer to oral mucosa and lips*
- *Suction orally as necessary*

IHI Guidelines[8] Recommendations

Doctors and nurses can help prevent VAP by using a bundle of 5 "care steps." The bundle of care steps are as follows:

- *Elevation of the Head of the Bed*
- *Daily "Sedation Vacations" and Assessment of Readiness to Extubate*
- *Peptic Ulcer Disease Prophylaxis*
- *Deep Venous Thrombosis Prophylaxis*
- *Daily Oral Care with Chlorhexidine*

CDC Guidelines for preventing Healthcare-Associated Pneumonia[1,5]

"… Develop and implement a comprehensive oral-hygiene program (that might include use of an antiseptic agent) for patients in acute-care settings or residents in long-term care facilities who are at risk for health-care associated pneumonia (II)"

AACN Procedure Manual for Critical Care – Oral Care Interventions; 2005, 2010[1,6]

"Assess oral cavity and lips every 8 hours, and perform oral care every 2 to 4 hours and as needed.[2] With oral care, assess for buildup of plaque on teeth or potential infection related to oral abscess."

"Perform oral hygiene, using pediatric or adult (soft) toothbrush, at least twice a day. Gently brush patient's teeth to clean and remove plaque from teeth."[2]

"Use toothpaste or cleansing solution that assists in the breakdown of debris."

"Cleansing solution should contain additives that assist in the breakdown of mucus in the mouth. Sodium bicarbonate assists in the removal of debris accumulation on oral tissue and teeth".

"In addition to brushing twice daily, use oral swabs with a 1.5% hydrogen peroxide solution to clean mouth every 2 to 4 hours."[2]

"Antiseptic oral rinses (chlorhexidine, cetylpyridinium chloride [CPC], added after brushing or done in conjunction with comprehensive oral care did achieve elimination of VAP."[9]

"With each cleansing, apply a mouth moisturizer to the oral mucosa and lips to keep tissue moist."[2]

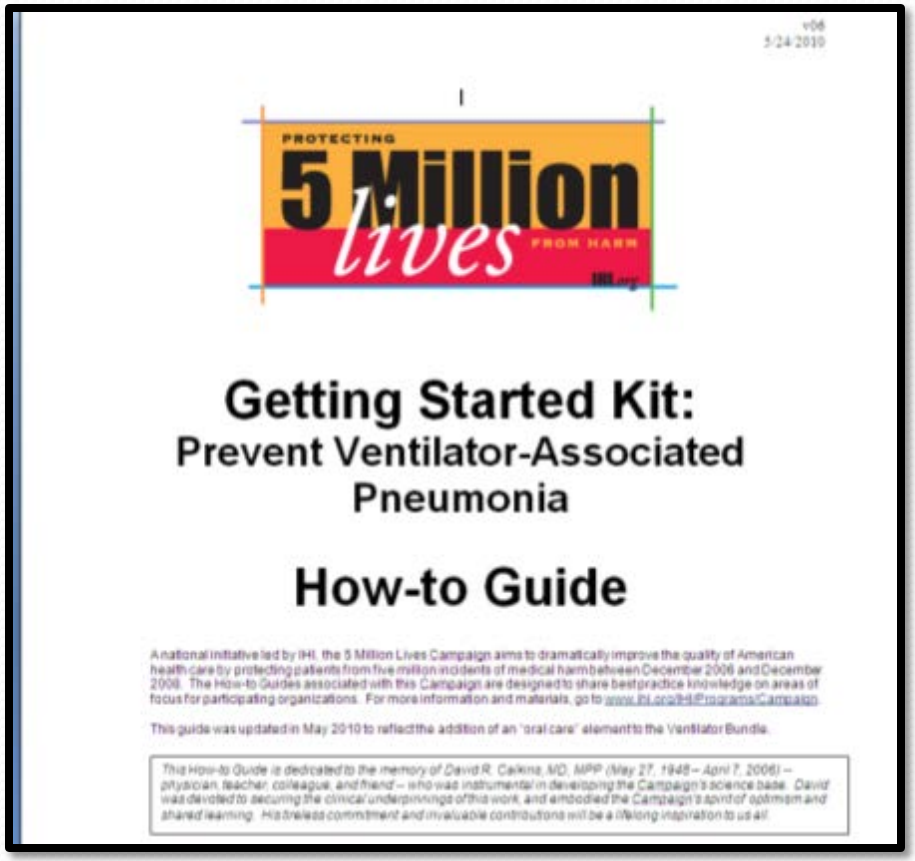
"Suction oral cavity/pharynx frequently."[3]

1. In addition to other interventions. **2.** Level IV: Limited clinical studies to support recommendations. **3.** Continuous suctioning: Level II: Theory based, no research data to support recommendations; recommendations from expert consensus group may exist. Intermittent suctioning: Level IV: Limited clinical studies to support recommendations. **4.** Category IA: Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies. **5.** Tablan OC, et al., Guidelines for preventing health-care-associated-pneumonia, 2003, Recommendations of CDC and Healthcare Infection Control Practices Advisory Committee (HICPAC), 2003. **6.** Scott JM, Vollman KM, Endotracheal tube and oral care. In DJ Lynn-McHale Wiegand and KK Carlson (Eds.) AACN Procedure Manual for Critical Care, Fifth Ed., pp. 28-33, Sixth Ed., p. 34., Elsevier Saunders, St. Louis, MO. **7.** APIC 2009 Guide to the Elimination of Ventilator-Associated Pneumonia, pp. 28,40. **8.** 5 Million Lives Campaign. Getting Started Kit: Prevent Ventilator-Associated Pneumonia How-to Guide. Cambridge, MA: Institute for Healthcare Improvement; 2010 (Available at www.ihi.org). **9.** Level B: Well-designed, controlled studies with results that consistently support a specific action, intervention, or treatment.

SHEA & CDC on Oral Care

	SHEA, 2008	CDC, 2003
Oral Care	*"Perform regular antiseptic oral care in accordance with product guidelines"* (A-I)	*"Develop and implement a comprehensive oral-hygiene program (that might include the use of an antiseptic agent) for patients in acute-care settings or residents in long-term care facilities who are at high risk of developing health-care-associated pneumonia"* (II)

Updated IHI Bundle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PROTECTING 5 Million lives FROM HARM

IHI.org

Getting Started Kit:
Prevent Ventilator-Associated Pneumonia

How-to Guide

A national initiative led by IHI, the 5 Million Lives Campaign aims to dramatically improve the quality of American health care by protecting patients from five million incidents of medical harm between December 2006 and December 2008. The How-to Guides associated with this Campaign are designed to share best practice knowledge on areas of focus for participating organizations. For more information and materials, go to www.ihi.org/IHI/Programs/Campaign.

This guide was updated in May 2010 to reflect the addition of an 'oral care' element to the Ventilator Bundle.

This How-to Guide is dedicated to the memory of David R. Calkins, MD, MPP (May 27, 1948 – April 7, 2006) – physician, teacher, colleague, and friend – who was instrumental in developing the Campaign's science base. David was devoted to securing the clinical underpinnings of this work, and embodied the Campaign's spirit of optimism and shared learning. His tireless commitment and invaluable contributions will be a lifelong inspiration to us all.

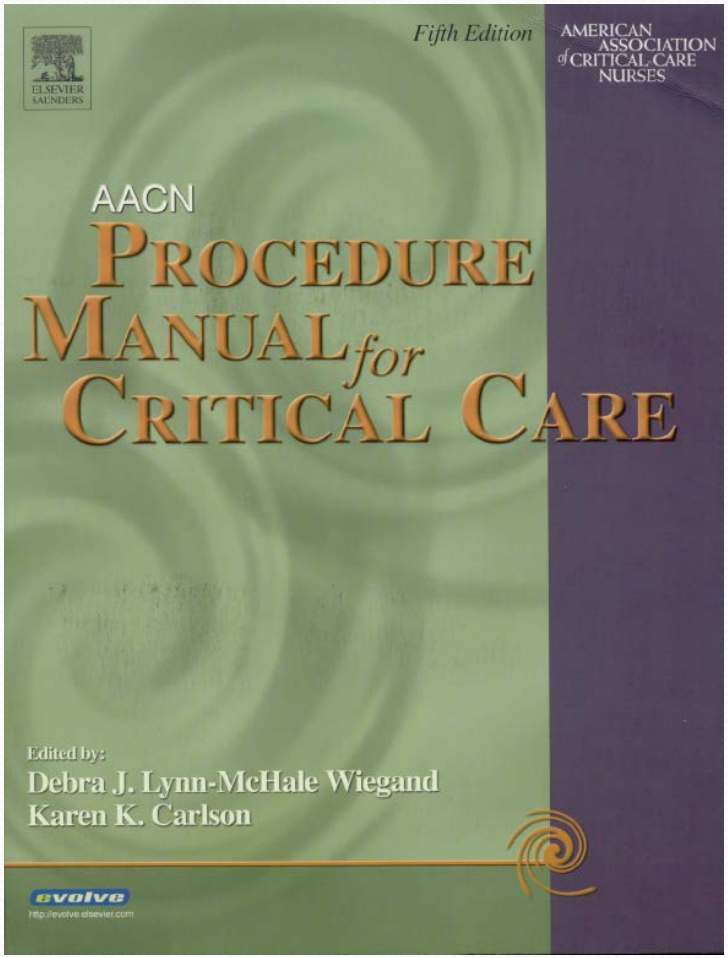
1. Elevation of the head of the bed (HOB) to between 30 and 45 degrees
2. Daily "sedative interruption" and daily assessment of readiness to extubate
3. Peptic ulcer disease (PUD) prophylaxis
4. Deep venous thrombosis (DVT) prophylaxis (unless contraindicated)

In the spring of 2010, IHI faculty determined that there is support in the evidence for the addition of a fifth element in this work:

5. Daily oral care with chlorhexidine

IHI 100K Lives Campaign. Getting Started Kit: VAP How-to Guide

AACN 6th Edition



- Q12 Brushing with pediatric brush
- Q2 to Q4 hour swabbing with half strength peroxide
- Use of muco solvents like sodium bicarbonate
- Moisturize the oral cavity

- "Antiseptic oral rinses (chlorhexidine, cetylpyridinium chloride [CPC], added after brushing or done in conjunction with comprehensive oral care did achieve elimination of VAP"

What is Comprehensive Oral Care?

- Identification of patients at risk
- Oral Health Assessment
- Oral care (at set intervals)
  - Dental care (plaque removal)
  - Suctioning
  - Oral tissue care
  - Use of an antiseptic, e.g., Chlorhexidine
- Compliance with protocols

Which Patients Are At Risk?

- Liver disease prior to and during transplantation
- End-stage renal disease undergoing hemodialysis
- Cardiovascular disease undergoing surgery
- Abdominal cancer, head and neck cancer
- Leukemia
- COPD
- Cerebral palsy
- Asthma, stroke, chronic bronchitis, pharyngitis, HIV infection, diabetes, alcoholism, Parkinson's Disease
- Hospitalized, Institutionalized elderly individuals

Lam OLT, et al. Effectiveness of oral hygiene interventions against oral and oropharyngeal reservoirs of aerobic and facultatively anaerobic gram negative bacilli. AJIC 2012;40:175-82.

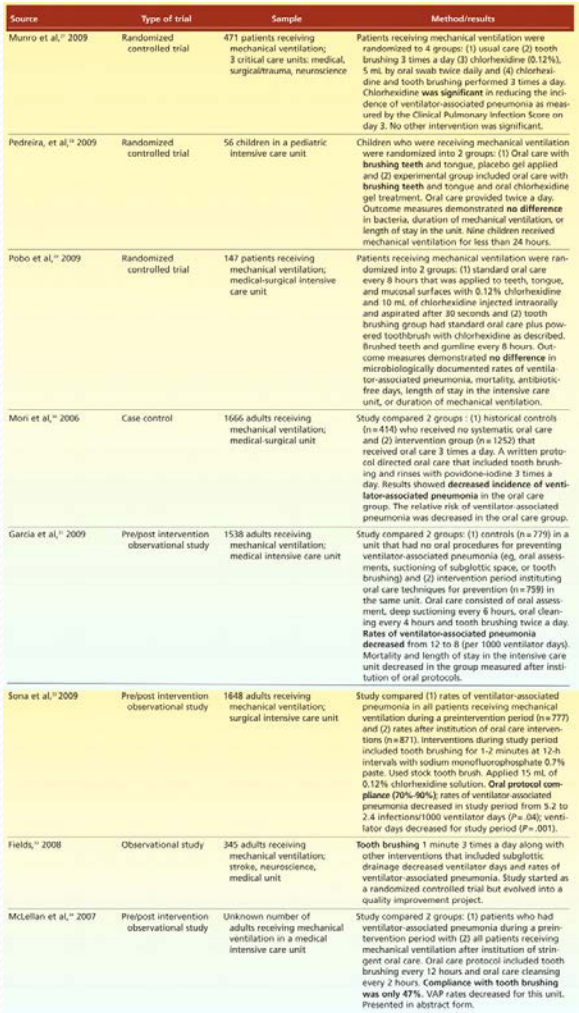
Oral Health Assessment

Category	Rating	1	2	3	4
Lips	1 2 3 4	Smooth, pink, moist, intact	Slightly wrinkled and dry; one or more isolated reddened areas	Dry and somewhat swollen; may have one or two isolated blisters; inflammatory line of demarcation	Extremely dry and edematous; entire lip inflamed; generalized blisters or ulceration
Gingiva and oral mucosa	1 2 3 4	Smooth, pink, moist, intact	Pale and slightly dry; one or two isolated lesions, blisters, or reddened areas	Dry and somewhat swollen; generalized redness; more than two isolated lesions, blisters, or reddened areas.	Extremely dry and edematous; entire mucous quite red and inflamed; multiple confluent ulcers
Tongue	1 2 3 4	Smooth, pink, moist, intact	Slightly dry; one or two isolated lesions, blisters, or reddened areas; papillae prominent, particularly at base	Dry and somewhat swollen; generalized redness but tip and papillae are redder; one or two isolated lesions or blisters	Extremely dry and edematous; thick and engorged; entire tongue quite inflamed; tip very red and demarcated with coating; multiple blisters or ulcers
Teeth	1 2 3 4	Clean, no debris	Minimal debris, mostly between teeth	Moderate debris clinging to half of visible enamel	Covered with debris
Saliva	1 2 3 4	Thin, watery, plentiful	Increased	Scanty; may be thicker than normal	Thick and ropy, visicid, or mucoid

Oral Dysfunction Score: Total None=5, Mild = 6-10, Moderate = 11-15, Severe = 16-20

Oral care update: From prevention to treatment. Nurs manage 2003;34, Supp. 3.

Toothbrushing

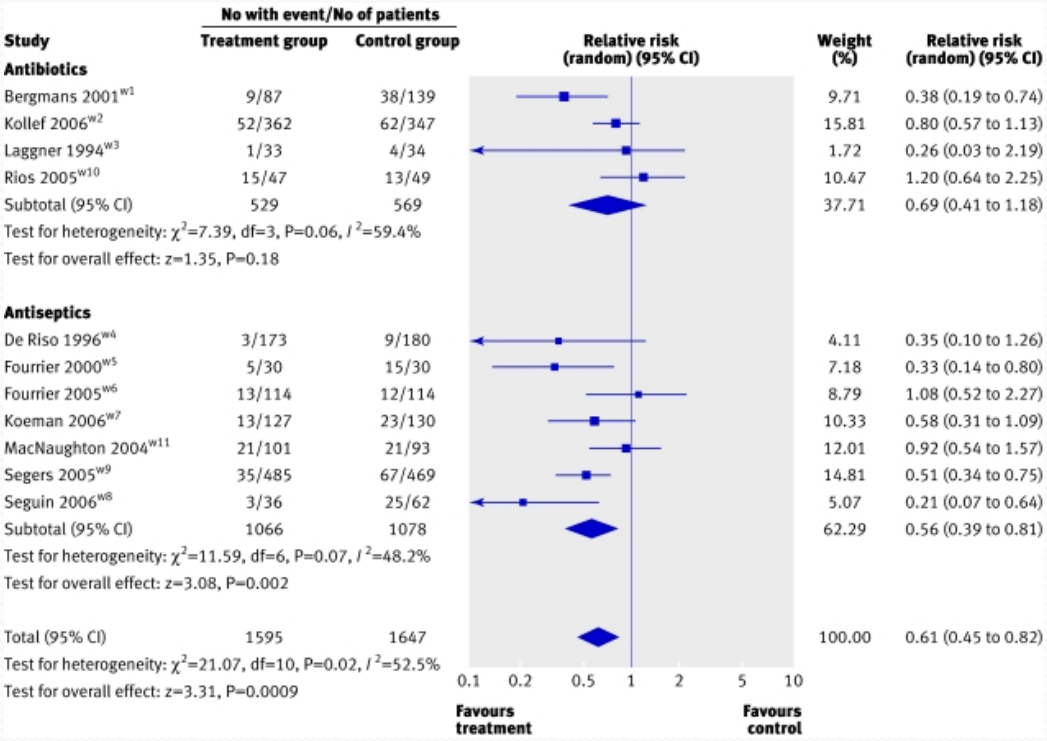


Source	Type of trial	Sample	Method/results
Munro et al,[17] 2009	Randomized controlled trial	471 patients receiving mechanical ventilation; 3 critical care units: medical, surgical/trauma, neuroscience	Patients receiving mechanical ventilation were randomized to 4 groups: (1) usual care (2) tooth brushing 3 times a day (3) chlorhexidine (0.12%), 5 mL by oral swab twice daily and (4) chlorhexidine and tooth brushing performed 3 times a day. Chlorhexidine **was significant** in reducing the incidence of ventilator-associated pneumonia as measured by the Clinical Pulmonary Infection Score on day 3. No other intervention was significant.
Pedreira, et al,[18] 2009	Randomized controlled trial	56 children in a pediatric intensive care unit	Children who were receiving mechanical ventilation were randomized into 2 groups: (1) Oral care with **brushing teeth** and tongue, placebo gel applied and (2) experimental group included oral care with **brushing teeth** and tongue and oral chlorhexidine gel treatment. Oral care provided twice a day. Outcome measures demonstrated **no difference** in bacteria, duration of mechanical ventilation, or length of stay in the unit. Nine children received mechanical ventilation for less than 24 hours.
Pobo et al,[19] 2009	Randomized controlled trial	147 patients receiving mechanical ventilation; medical-surgical intensive care unit	Patients receiving mechanical ventilation were randomized into 2 groups: (1) standard oral care every 8 hours that was applied to teeth, tongue, and mucosal surfaces with 0.12% chlorhexidine and 10 mL of chlorhexidine injected intraorally and aspirated after 30 seconds and (2) tooth brushing group had standard oral care plus powered toothbrush with chlorhexidine as described. Brushed teeth and gumline every 8 hours. Outcome measures demonstrated **no difference** in microbiologically documented rates of ventilator-associated pneumonia, mortality, antibiotic-free days, length of stay in the intensive care unit, or duration of mechanical ventilation.
Mori et al,[20] 2006	Case control	1666 adults receiving mechanical ventilation; medical-surgical unit	Study compared 2 groups : (1) historical controls (n = 414) who received no systematic oral care and (2) intervention group (n = 1252) that received oral care 3 times a day. A written protocol directed oral care that included tooth brushing and rinses with povidone-iodine 3 times a day. Results showed **decreased incidence of ventilator-associated pneumonia** in the oral care group. The relative risk of ventilator-associated pneumonia was decreased in the oral care group.
Garcia et al,[21] 2009	Pre/post intervention observational study	1538 adults receiving mechanical ventilation; medical intensive care unit	Study compared 2 groups: (1) controls (n = 779) in a unit that had no oral procedures for preventing ventilator-associated pneumonia (eg, oral assessments, suctioning of subglottic space, or tooth brushing) and (2) intervention period instituting oral care techniques for prevention (n = 759) in the same unit. Oral care consisted of oral assessment, deep suctioning every 6 hours, oral cleaning every 4 hours and tooth brushing twice a day. **Rates of ventilator-associated pneumonia decreased** from 12 to 8 (per 1000 ventilator days). Mortality and length of stay in the intensive care unit decreased in the group measured after institution of oral protocols.
Sona et al,[22] 2009	Pre/post intervention observational study	1648 adults receiving mechanical ventilation; surgical intensive care unit	Study compared (1) rates of ventilator-associated pneumonia in all patients receiving mechanical ventilation during a preintervention period (n = 777) and (2) rates after institution of oral care interventions (n = 871). Interventions during study period included tooth brushing for 1-2 minutes at 12-h intervals with sodium monofluorophosphate 0.7% paste. Used stock tooth brush. Applied 15 mL of 0.12% chlorhexidine solution. **Oral protocol compliance (70%-90%)**; rates of ventilator-associated pneumonia decreased in study period from 3.2 to 2.4 infections/1000 ventilator days ($P = .04$); ventilator days decreased for study period ($P = .001$).
Fields,[23] 2008	Observational study	345 adults receiving mechanical ventilation; stroke, neuroscience, medical unit	**Tooth brushing** 1 minute 3 times a day along with other interventions that included subglottic drainage decreased ventilator days and rates of ventilator-associated pneumonia. Study started as a randomized controlled trial but evolved into a quality improvement project.
McLellan et al,[24] 2007	Pre/post intervention observational study	Unknown number of adults receiving mechanical ventilation in a medical intensive care unit	Study compared 2 groups: (1) patients who had ventilator-associated pneumonia during a preintervention period with (2) all patients receiving mechanical ventilation after institution of stringent oral care. Oral care protocol included tooth brushing every 12 hours and oral care cleansing every 2 hours. **Compliance with tooth brushing was only 47%.** VAP rates decreased for this unit. Presented in abstract form.

- Review of 8 studies
- 3 RCTs, 1 case control, 3 observational
- Toothbrushing in all
- 5 of 8 showed VAP decrease
- Some design issues, definition issues

Ames NJ. Evidence to support tooth brushing in critically ill patients. AJCC 2011;20:242-50.

Resource 1: Oral Decontamination

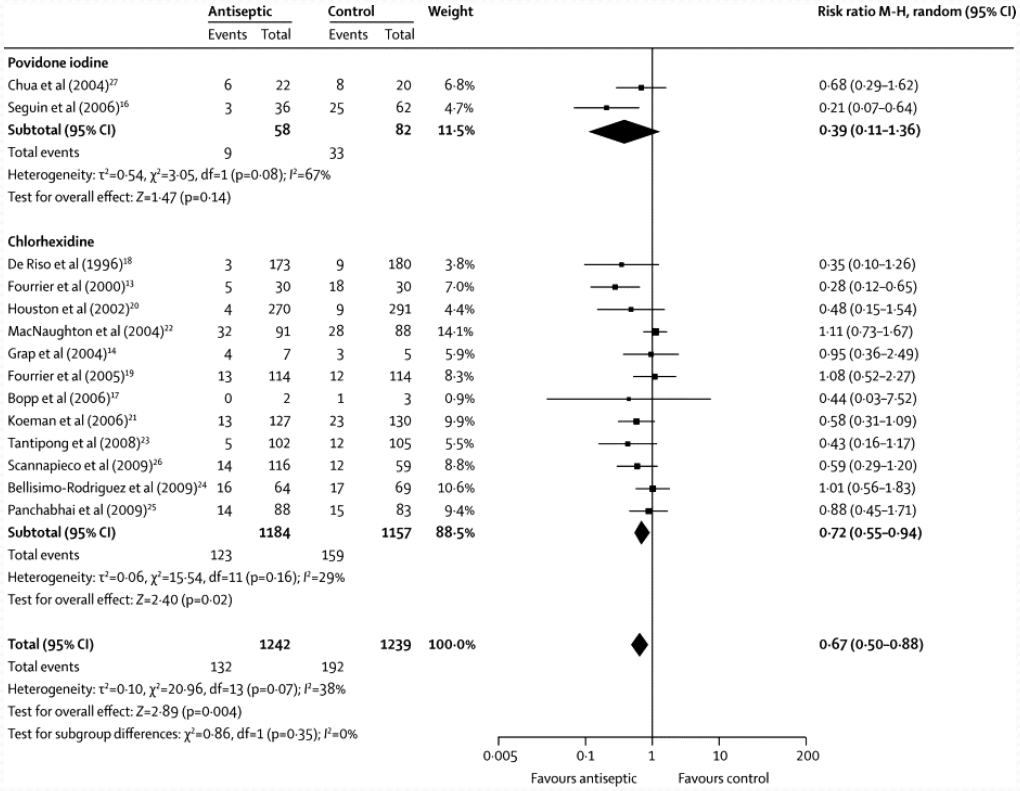


Study	No with event/No of patients: Treatment group	Control group	Weight (%)	Relative risk (random) (95% CI)
Antibiotics				
Bergmans 2001[w1]	9/87	38/139	9.71	0.38 (0.19 to 0.74)
Kollef 2006[w2]	52/362	62/347	15.81	0.80 (0.57 to 1.13)
Laggner 1994[w3]	1/33	4/34	1.72	0.26 (0.03 to 2.19)
Rios 2005[w10]	15/47	13/49	10.47	1.20 (0.64 to 2.25)
Subtotal (95% CI)	529	569	37.71	0.69 (0.41 to 1.18)
Test for heterogeneity: χ^2=7.39, df=3, P=0.06, I^2=59.4%				
Test for overall effect: z=1.35, P=0.18				
Antiseptics				
De Riso 1996[w4]	3/173	9/180	4.11	0.35 (0.10 to 1.26)
Fourrier 2000[w5]	5/30	15/30	7.18	0.33 (0.14 to 0.80)
Fourrier 2005[w6]	13/114	12/114	8.79	1.08 (0.52 to 2.27)
Koeman 2006[w7]	13/127	23/130	10.33	0.58 (0.31 to 1.09)
MacNaughton 2004[w11]	21/101	21/93	12.01	0.92 (0.54 to 1.57)
Segers 2005[w9]	35/485	67/469	14.81	0.51 (0.34 to 0.75)
Seguin 2006[w8]	3/36	25/62	5.07	0.21 (0.07 to 0.64)
Subtotal (95% CI)	1066	1078	62.29	0.56 (0.39 to 0.81)
Test for heterogeneity: χ^2=11.59, df=6, P=0.07, I^2=48.2%				
Test for overall effect: z=3.08, P=0.002				
Total (95% CI)	1595	1647	100.00	0.61 (0.45 to 0.82)
Test for heterogeneity: χ^2=21.07, df=10, P=0.02, I^2=52.5%				
Test for overall effect: z=3.31, P=0.0009				

- 4 trials, 3242 pts, application of antibiotics: not significant
- 7 trials, 2144 pts, ***oral application of antiseptics significantly reduced VAP***

Chan EY. Oral decontamination for prevention of pneumonia in mechanically ventilated adults: systematic review and meta-analysis. BMJ 2007;334:889-93.

Resource 2A: Oral Decontamination

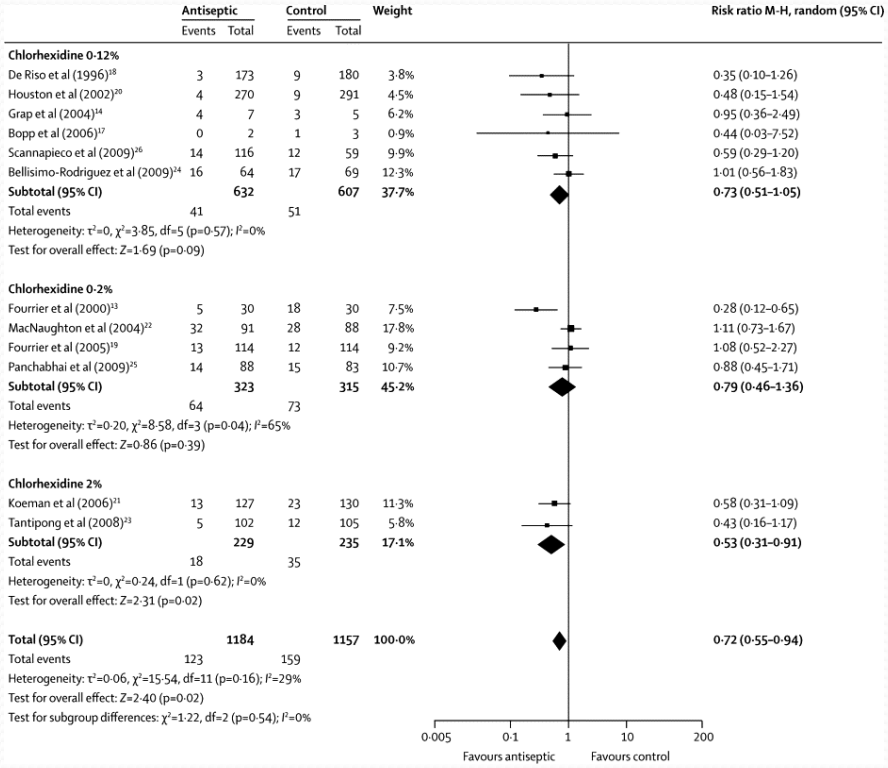


	Antiseptic Events	Antiseptic Total	Control Events	Control Total	Weight	Risk ratio M-H, random (95% CI)
Povidone iodine						
Chua et al (2004)[27]	6	22	8	20	6·8%	0·68 (0·29–1·62)
Seguin et al (2006)[16]	3	36	25	62	4·7%	0·21 (0·07–0·64)
Subtotal (95% CI)		**58**		**82**	**11·5%**	**0·39 (0·11–1·36)**
Total events	9		33			
Heterogeneity: τ^2=0·54, χ^2=3·05, df=1 (p=0·08); I^2=67%						
Test for overall effect: Z=1·47 (p=0·14)						
Chlorhexidine						
De Riso et al (1996)[18]	3	173	9	180	3·8%	0·35 (0·10–1·26)
Fourrier et al (2000)[13]	5	30	18	30	7·0%	0·28 (0·12–0·65)
Houston et al (2002)[20]	4	270	9	291	4·4%	0·48 (0·15–1·54)
MacNaughton et al (2004)[22]	32	91	28	88	14·1%	1·11 (0·73–1·67)
Grap et al (2004)[14]	4	7	3	5	5·9%	0·95 (0·36–2·49)
Fourrier et al (2005)[19]	13	114	12	114	8·3%	1·08 (0·52–2·27)
Bopp et al (2006)[17]	0	2	1	3	0·9%	0·44 (0·03–7·52)
Koeman et al (2006)[21]	13	127	23	130	9·9%	0·58 (0·31–1·09)
Tantipong et al (2008)[23]	5	102	12	105	5·5%	0·43 (0·16–1·17)
Scannapieco et al (2009)[26]	14	116	12	59	8·8%	0·59 (0·29–1·20)
Bellisimo-Rodriguez et al (2009)[24]	16	64	17	69	10·6%	1·01 (0·56–1·83)
Panchabhai et al (2009)[25]	14	88	15	83	9·4%	0·88 (0·45–1·71)
Subtotal (95% CI)		**1184**		**1157**	**88·5%**	**0·72 (0·55–0·94)**
Total events	123		159			
Heterogeneity: τ^2=0·06, χ^2=15·54, df=11 (p=0·16); I^2=29%						
Test for overall effect: Z=2·40 (p=0·02)						
Total (95% CI)		**1242**		**1239**	**100·0%**	**0·67 (0·50–0·88)**
Total events	132		192			
Heterogeneity: τ^2=0·10, χ^2=20·96, df=13 (p=0·07); I^2=38%						
Test for overall effect: Z=2·89 (p=0·004)						
Test for subgroup differences: χ^2=0·86, df=1 (p=0·35); I^2=0%						

- Meta-analysis of 14 RCT trials, 2481 pts, assessing the effect of oral care with CHG or PI on VAP
- Findings: ***CHG was effective in reducing VAP, whereas PI was not***

Labeau SO. Prevention of ventilator-associated pneumonia with oral antiseptics: a systematic review and meta-analysis. Lancet Infect Dis 2011;11:845-54.

Resource 2B: Oral Decontamination



	Antiseptic Events	Antiseptic Total	Control Events	Control Total	Weight	Risk ratio M-H, random (95% CI)
Chlorhexidine 0·12%						
De Riso et al (1996)[18]	3	173	9	180	3·8%	0·35 (0·10–1·26)
Houston et al (2002)[20]	4	270	9	291	4·5%	0·48 (0·15–1·54)
Grap et al (2004)[14]	4	7	3	5	6·2%	0·95 (0·36–2·49)
Bopp et al (2006)[17]	0	2	1	3	0·9%	0·44 (0·03–7·52)
Scannapieco et al (2009)[26]	14	116	12	59	9·9%	0·59 (0·29–1·20)
Bellisimo-Rodriguez et al (2009)[24]	16	64	17	69	12·3%	1·01 (0·56–1·83)
Subtotal (95% CI)		**632**		**607**	**37·7%**	**0·73 (0·51–1·05)**
Total events	41		51			
Heterogeneity: τ^2=0, χ^2=3·85, df=5 (p=0·57); I^2=0%						
Test for overall effect: Z=1·69 (p=0·09)						
Chlorhexidine 0·2%						
Fourrier et al (2000)[13]	5	30	18	30	7·5%	0·28 (0·12–0·65)
MacNaughton et al (2004)[22]	32	91	28	88	17·8%	1·11 (0·73–1·67)
Fourrier et al (2005)[19]	13	114	12	114	9·2%	1·08 (0·52–2·27)
Panchabhai et al (2009)[25]	14	88	15	83	10·7%	0·88 (0·45–1·71)
Subtotal (95% CI)		**323**		**315**	**45·2%**	**0·79 (0·46–1·36)**
Total events	64		73			
Heterogeneity: τ^2=0·20, χ^2=8·58, df=3 (p=0·04); I^2=65%						
Test for overall effect: Z=0·86 (p=0·39)						
Chlorhexidine 2%						
Koeman et al (2006)[21]	13	127	23	130	11·3%	0·58 (0·31–1·09)
Tantipong et al (2008)[23]	5	102	12	105	5·8%	0·43 (0·16–1·17)
Subtotal (95% CI)		**229**		**235**	**17·1%**	**0·53 (0·31–0·91)**
Total events	18		35			
Heterogeneity: τ^2=0, χ^2=0·24, df=1 (p=0·62); I^2=0%						
Test for overall effect: Z=2·31 (p=0·02)						
Total (95% CI)		**1184**		**1157**	**100·0%**	**0·72 (0·55–0·94)**
Total events	123		159			
Heterogeneity: τ^2=0·06, χ^2=15·54, df=11 (p=0·16); I^2=29%						
Test for overall effect: Z=2·40 (p=0·02)						
Test for subgroup differences: χ^2=1·22, df=2 (p=0·54); I^2=0%						

- Sub-analysis reviewed effectiveness of 2%, 0.2%, and 0.12% CHG
- Findings: ***CHG was most effective at 2% strength in reducing VAP***

Labeau SO. Prevention of ventilator-associated pneumonia with oral antiseptics: a systematic review and meta-analysis. Lancet Infect Dis 2011;11:845-54.

Reducing VAP Through Advanced Oral-Dental Care: A 48-Month Study

AJCC American Journal of Critical Care

Reducing Ventilator-Associated Pneumonia Through Advanced Oral-Dental Care: A 48-Month Study

Robert Garcia, Linda Jendresky, Larry Colbert, Althea Bailey, Mohammed Zaman and Mujbur Majumder

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AMERICAN ASSOCIATION of CRITICAL-CARE NURSES

- Objective: Determine the effectiveness of comprehensive oral and dental care system and protocol on the rate of VAP
- MICU patients >18 yrs. on mechanical ventilation >48 hrs.
- Standards of care during the entire 48-month study included 7d vent circuit replacement, 24-hour HME filter replacement, 24-hour closed suction catheter replacement, semirecumbent position unless contraindicated, administration of stress ulcer prophylaxis, and use of a weaning protocol.

Garcia R, Jendresky L, Colbert L, Bailey A. 48-month study on reducing VAP using advanced oral-dental care: protocol compliance, rates, mortality, and cost. Am J Crit Care 2009

Reducing VAP Through Advanced Oral-Dental Care: A 48-Month Study

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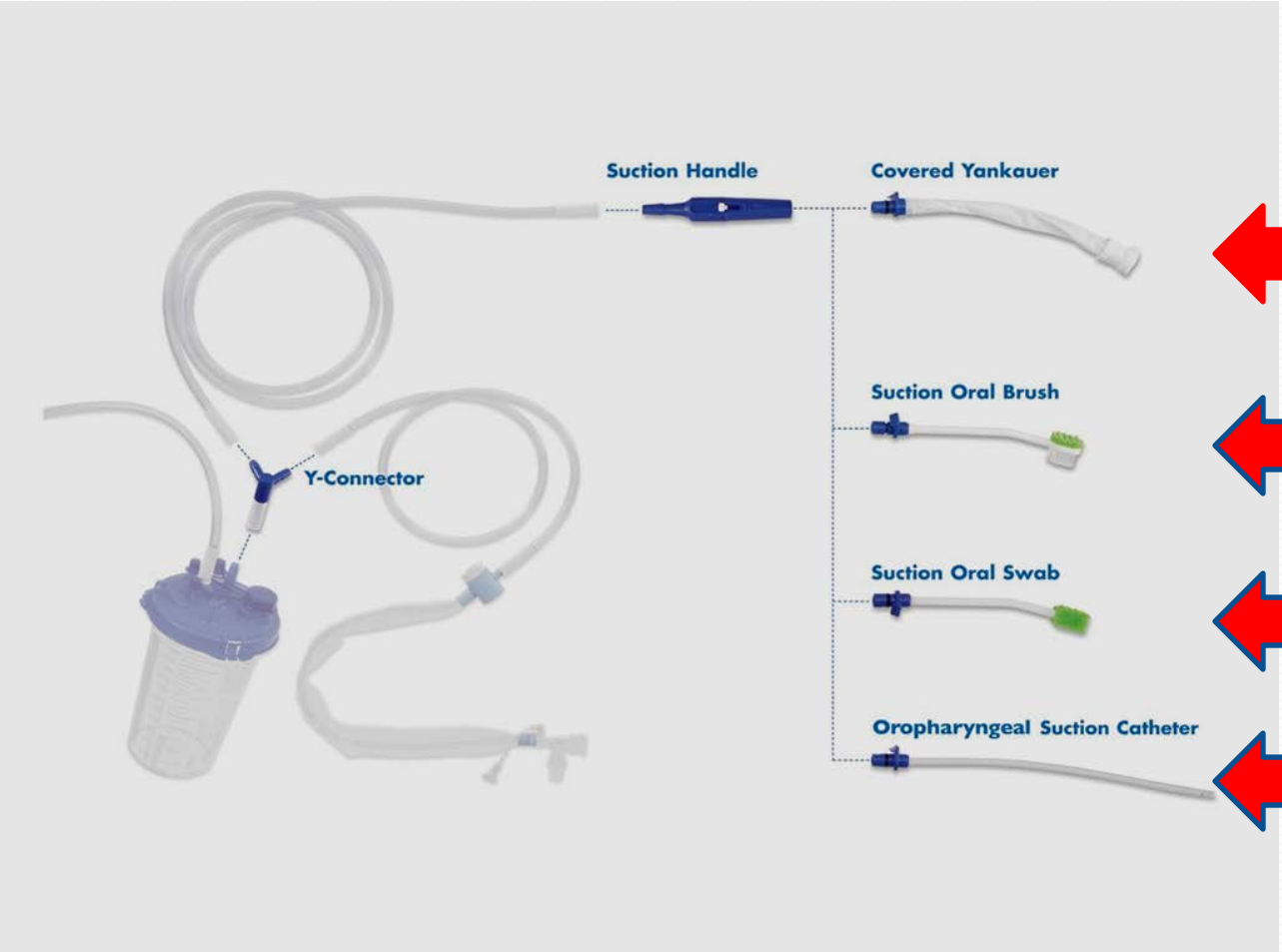
AMERICAN ASSOCIATION of CRITICAL-CARE NURSES

- Method
  - 12 mth pre-intervention period
    - 779 pts
    - Standard oral care
  - 12 mth intervention period
    - 759 patients
    - Oropharyngeal suctioning above cuff Q6h
    - Oral tissue and gum cleansing Q4h
    - Toothbrushing Q12h with 0.05% cetypyridinium chloride
    - Education & Monitoring

Tools & Protocol



As needed

Every 12 hrs

Every 6 hrs

Every 4 hrs

Catheter-Associated UTIs

The Source of Troubles

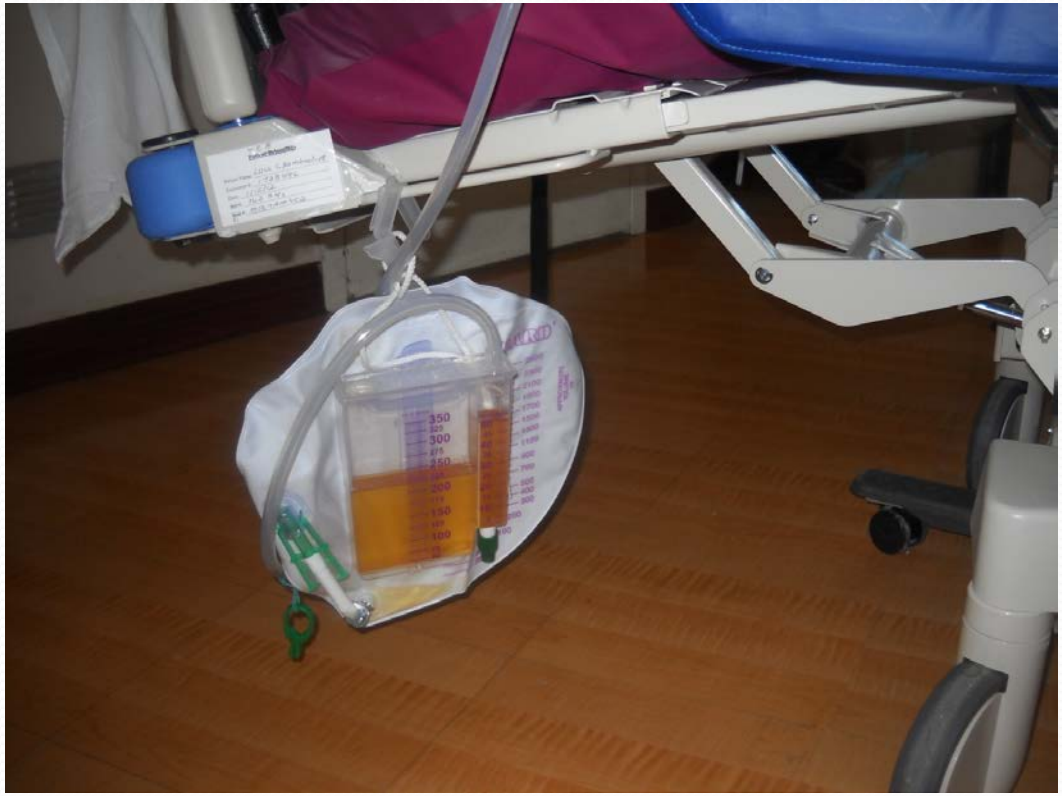


TABLE 5. Distribution of Rank Order of Selected Pathogens Associated with Healthcare-Associated Infections (HAIs) Reported to the National Healthcare Safety Network, by Type of HAI, 2009–2010

Pathogen	Overall		CLABSI		CAUTI		VAP		SSI	
	No. (%) of pathogens	Rank	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]
Staphylococcus aureus	12,635 (15.6)	1	3,735 (12.3)	2	442 (2.1)	...	2,043 (24.1)	1	6,415 (30.4)	1
Escherichia coli	9,351 (11.5)	2	1,206 (4.0)	9	5,660 (26.8)	1	504 (5.9)	6	1,981 (9.4)	3
Coagulase-negative staphylococci	9,261 (11.4)	3	6,245 (20.5)	1	467 (2.2)	...	72 (0.9)	...	2,477 (11.7)	2
Klebsiella (*pneumoniae*/*oxytoca*)	6,470 (8.0)	4	2,407 (7.9)	5	2,365 (11.2)	3	854 (10.1)	3	844 (4.0)	7
Pseudomonas aeruginosa	6,111 (7.5)	5	1,166 (3.8)	10	2,381 (11.3)	2	1,408 (16.6)	2	1,156 (5.5)	5
Enterococcus faecalis	5,484 (6.8)	6	2,680 (8.8)	3	1,519 (7.2)	5	45 (0.5)	...	1,240 (5.9)	4
Candida albicans	4,275 (5.3)	7	1,974 (6.5)	7	1,887 (8.9)	4	147 (1.7)	...	267 (1.3)	...
Enterobacter spp.	3,821 (4.7)	8	1,365 (4.5)	8	880 (4.2)	8	727 (8.6)	4	849 (4.0)	6
Other *Candida* spp. or NOS	3,408 (4.2)	9	2,465 (8.1)	4	811 (3.8)	9	36 (0.4)	...	96 (0.5)	...
Enterococcus faecium	3,314 (4.1)	10	2,118 (7.0)	6	654 (3.1)	10	25 (0.3)	...	517 (2.5)	...
Enterococcus spp.	2,409 (3.0)	11	703 (2.3)	12	1,010 (4.8)	7	11 (0.1)	...	685 (3.2)	8
Proteus spp.	2,031 (2.5)	12	232 (0.8)	...	1,013 (4.8)	6	119 (1.4)	...	667 (3.2)	9
Serratia spp.	1,737 (2.1)	13	762 (2.5)	11	204 (1.0)	...	386 (4.6)	7	385 (1.8)	...
Acinetobacter baumannii	1,490 (1.8)	14	629 (2.1)	13	185 (0.9)	...	557 (6.6)	5	119 (0.6)	...
Other[a]	9,304 (11.5)	...	2,762 (9.1)	...	1,633 (7.7)	...	1,510 (17.8)	...	3,399 (16.1)	...
Total	81,139 (100)		30,454 (100)		21,111 (100)		8,474 (100)		21,100 (100)	

NOTE. CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; NOS, not otherwise specified; SSI, surgical site infection; VAP, ventilator-associated pneumonia.

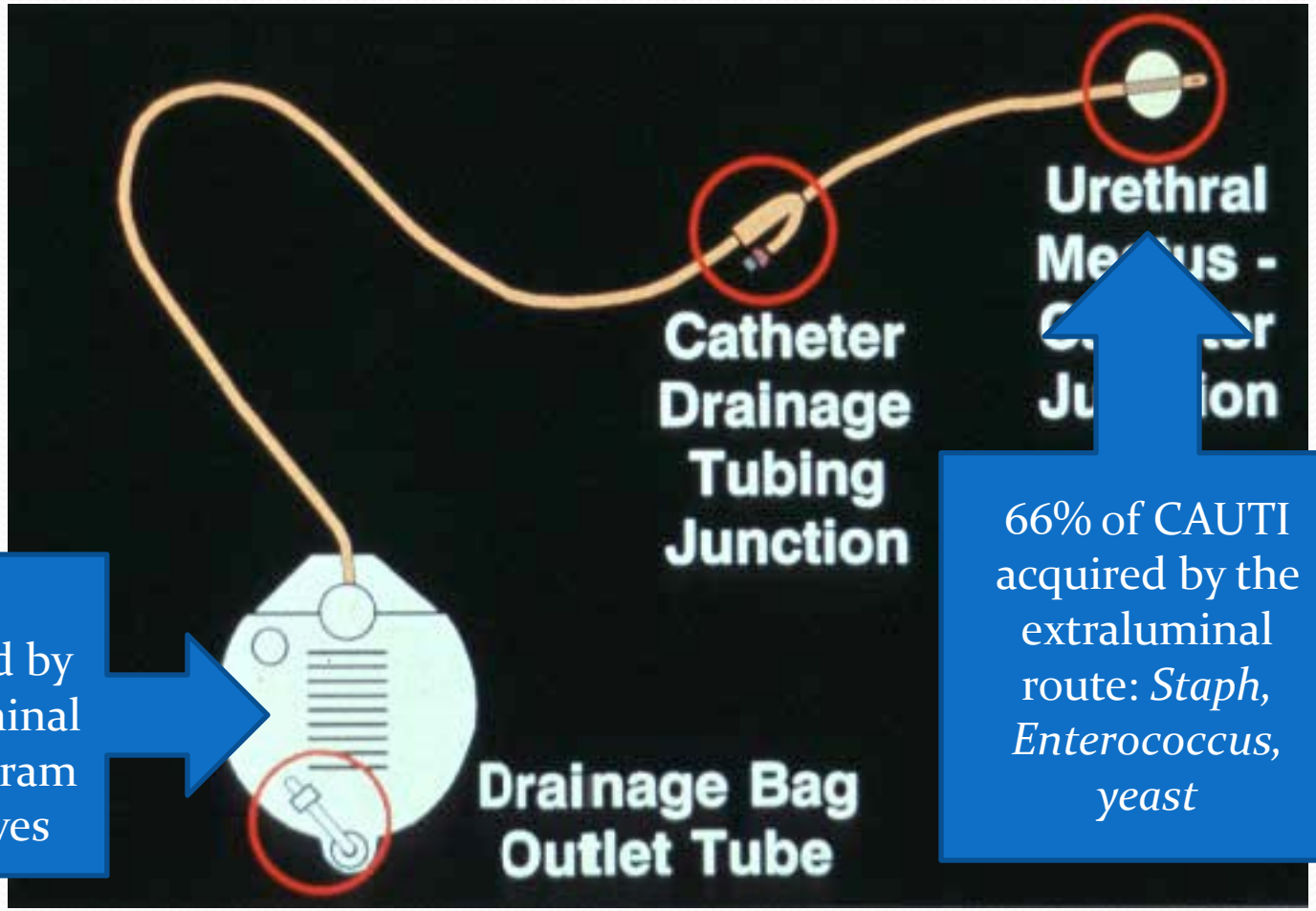
[a] A rank is not given if pathogen is not in the top 14 reported for the specific HAI type listed in Table 3 of the supplemental report on the CDC website (http://www.cdc.gov/nhsn/dataStat.html).

TABLE 7. Percentage of Pathogenic Isolates Resistant to Selected Antimicrobial Agents, National Healthcare Safety Network, 2009–2010

Pathogen, antimicrobial[a]	CLABSI			CAUTI			VAP			SSI		
	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %
Staphylococcus aureus	3,735			442			2,043			6,415		
OX/METH		3,611 (96.7)	54.6		438 (99.1)	58.7		1,974 (96.6)	48.4		6,304 (98.3)	43.7
Enterococcus spp.												
E. faecium	2,118			654			25			517		
VAN		2,069 (97.7)	82.6		639 (97.7)	82.5		23 (92)	82.6		509 (98.5)	62.3
E. faecalis	2,680			1,519			45			1,240		
VAN		2,578 (96.2)	9.5		1,446 (95.2)	8.4		41 (91.1)	9.8		1,187 (95.7)	6.2
Klebsiella (*pneumoniae/oxytoca*)	2,407			2,365			854			844		
ESC4		2,109 (87.6)	28.8		1,998 (84.5)	26.9		747 (87.5)	23.8		710 (84.1)	13.2
Carbapenems		1,858 (77.2)	12.8		1,520 (64.3)	12.5		617 (72.2)	11.2		582 (69.0)	7.9
MDR1		1,932 (80.3)	16.8		1,650 (69.8)	16.1		658 (77.0)	13.4		621 (73.6)	6.8
Escherichia coli	1,206			5,660			504			1,981		
ESC4		1,067 (88.5)	19.0		4,656 (82.3)	12.3		429 (85.1)	16.3		1,627 (82.1)	10.9
FQ3		1,137 (94.3)	41.8		5,513 (97.4)	31.2		466 (92.5)	35.2		1,876 (94.7)	25.3
Carbapenems		931 (77.2)	1.9		3,579 (63.2)	2.3		344 (68.3)	3.5		1,330 (67.1)	2.0
MDR1		992 (82.3)	3.7		3,929 (69.4)	2.0		365 (72.4)	3.3		1,390 (70.2)	1.6
Enterobacter spp.	1,365			880			727			849		
ESC4		1,309 (95.9)	37.4		818 (93.0)	38.5		690 (94.9)	30.1		816 (96.1)	27.7
Carbapenems		1,041 (76.3)	4.0		614 (69.8)	4.6		530 (72.9)	3.6		594 (70.0)	2.4
MDR1		1,123 (82.3)	3.7		667 (75.8)	4.8		579 (79.6)	1.4		648 (76.3)	1.7
Pseudomonas aeruginosa	1,166			2,381			1,408			1,156		
AMINOS		819 (70.2)	10.0		1,495 (62.8)	10.9		920 (65.3)	11.3		664 (57.4)	6.0
ESC2		1,120 (96.1)	26.1		2,294 (96.3)	25.2		1,355 (96.2)	28.4		1,097 (94.9)	10.2
FQ2		1,114 (95.5)	30.5		2,337 (98.2)	33.5		1,378 (97.9)	32.7		1,111 (96.1)	16.9
Carbapenems		982 (84.2)	26.1		1,883 (79.1)	21.3		1,162 (82.5)	30.2		872 (75.4)	11.0
PIP/PIPTAZ		809 (69.4)	17.4		1,792 (75.3)	16.6		1,059 (75.2)	19.1		818 (70.8)	6.8
MDR2		1,096 (94)	15.4		2,250 (94.5)	14.0		1,342 (95.3)	17.7		1,053 (91.1)	5.3
Acinetobacter baumannii	629			185			557			119		
Carbapenems		522 (83)	62.6		128 (69.2)	74.2		449 (80.6)	61.2		102 (85.7)	37.3
MDR3		617 (98.1)	67.6		183 (98.9)	77.6		552 (99.1)	63.4		114 (95.8)	43.9

NOTE. CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; SSI, surgical site infection; VAP, ventilator-associated pneumonia.
[a] AMINOS, aminoglycosides (amikacin, gentamicin, tobramycin). Carbapenems are imipenem and meropenem. ESC2, extended-spectrum (ES) cephalosporins (cefepime, ceftazidime); ESC4, ES cephalosporins (cefepime, cefotaxime, ceftazidime, ceftriaxone). FQ2, fluoroquinolones (ciprofloxacin, levofloxacin); FQ3, fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin). MDR1, pathogens tests as "I" (intermediate) or "R" (resistant) to at least 1 drug in 3 of the 5 following classes: ESC4, FQ3, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; MDR2, pathogen must test as I or R to at least 1 drug in 3 of the 5 following classes: ESC2, FQ2, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; MDR3, pathogen must test as I or R to at least 1 drug in 3 of the 6 following classes: ESC2, FQ2, aminoglycosides, carbapenems, piperacillin or piperacillin/tazobactam, and ampicillin/sulbactam. OX/METH, oxacillin/methicillin; PIP, piperacillin; PIPTAZ, piperacillin/tazobactam; VAN, vancomycin.

Pathogenesis



34% acquired by intraluminal route: Gram negatives

66% of CAUTI acquired by the extraluminal route: *Staph, Enterococcus, yeast*

Tambyah PA. A prospective study of pathogenesis of catheter-associated urinary tract infections. Mayo Clin Proc 1999;74:131-6.

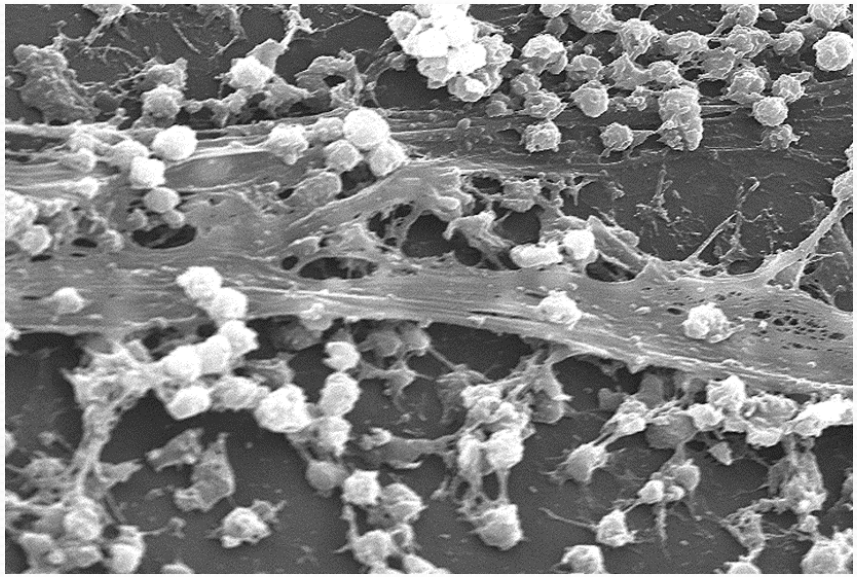
Pathogenesis

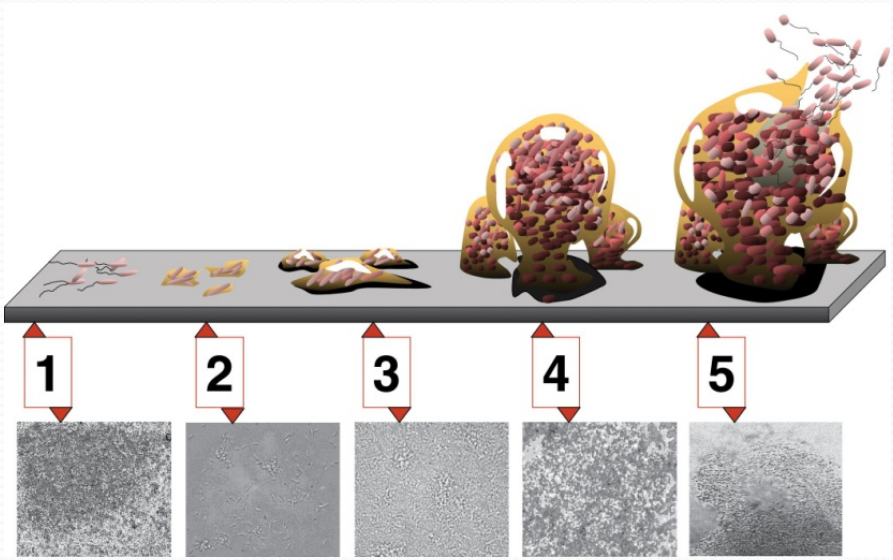
- Extraluminal acquisition of organisms is usually associated with endogenous organisms, i.e., bacteria that colonize the patient's own perineum
- Intraluminal acquisition is most often associated with exogenous organisms and result from cross-contamination from the hands of healthcare workers
- Approx. 15% of episodes of healthcare-associated bacteruria occur in clusters from intrahospital transmission

Maki DG. Engineering out the risk of infection with urinary catheters. Emerg Infect Dis 2001;7:1-6.

Catheter Biofilms

- Biofilms are composed of clusters of mircoorganisms in a polysaccharide matrix
- They form on intraluminal and extraluminal surfaces
- Organisms in biofilms may ascend the catheter in 1-3 days
- Biofilms form a protective environment for organisms with poor penetration by antimicrobials





Saint S. Biofilms and catheter-associated urinary tract infections. Infectious Dis Clin North America 2003;17:411-32.

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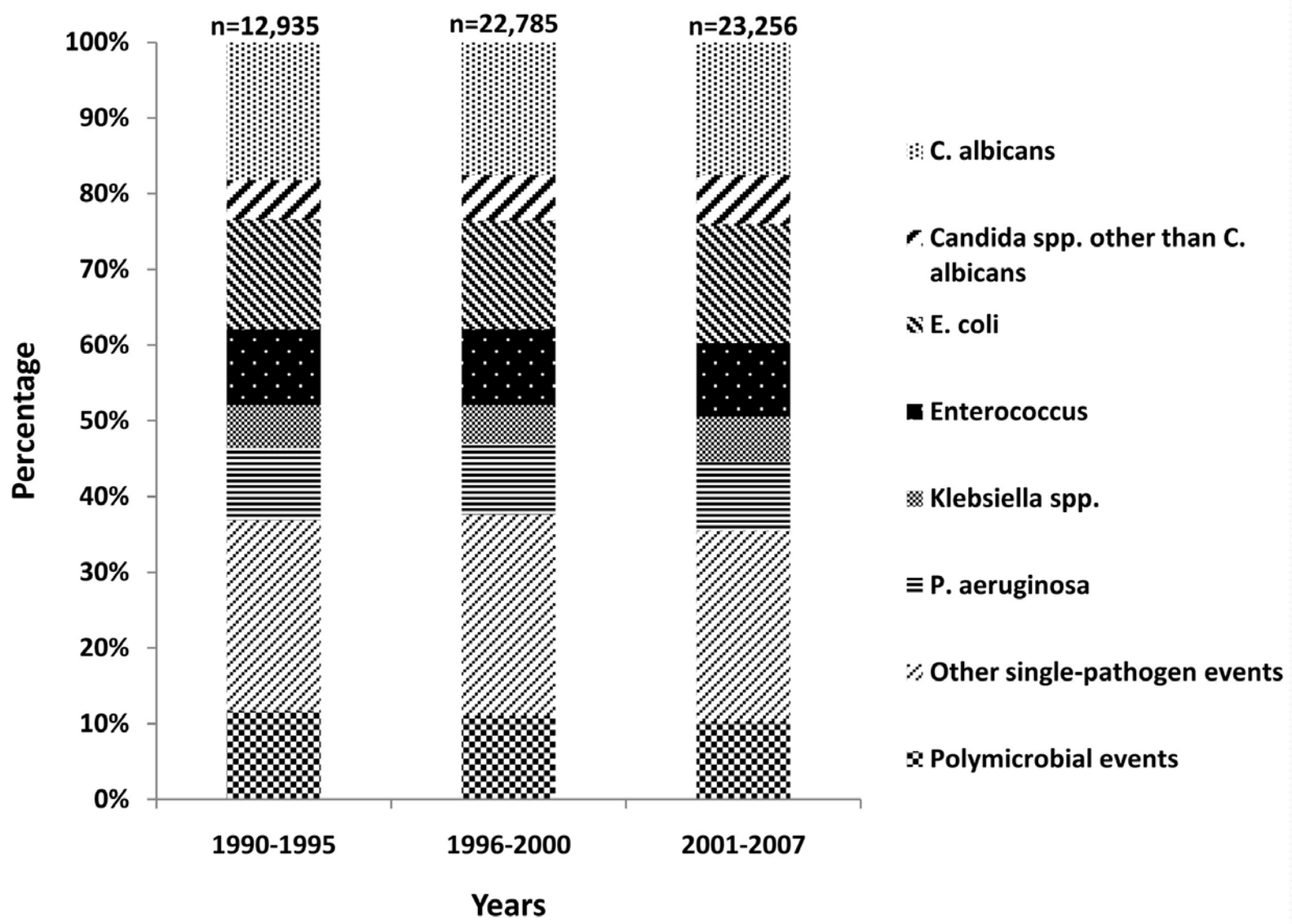


Burton DC. Trends in Catheter-associated urinary tract infections in adult intensive care units-United States, 1990-2007. Infect Cont Hosp Epidemiol 2011;32:748-56.

Prevention Recommendations

Published Guidelines on Prevention of CAUTI

- **CDC**: Gould CV, et al. Guideline for prevention of catheter-associated urinary tract infections 2009. Healthcare Infection Control Practices Advisory Committee, CDC, Atlanta, GA, 2009.
- **SHEA**: Lo E, et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals. Infect Control Hosp Epidemiol 2008;29:S41-S50.
- **IDSA**: Hooton TM, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International clinical practice guidelines from the Infectious Diseases Society of America. CID 1010;50:625-663.
- **APIC**: Greene L, et al. Guide to the elimination of catheter-associated urinary tract infections (CAUTIs). Association of Professionals in Infection Control. Washington, DC, 2008.

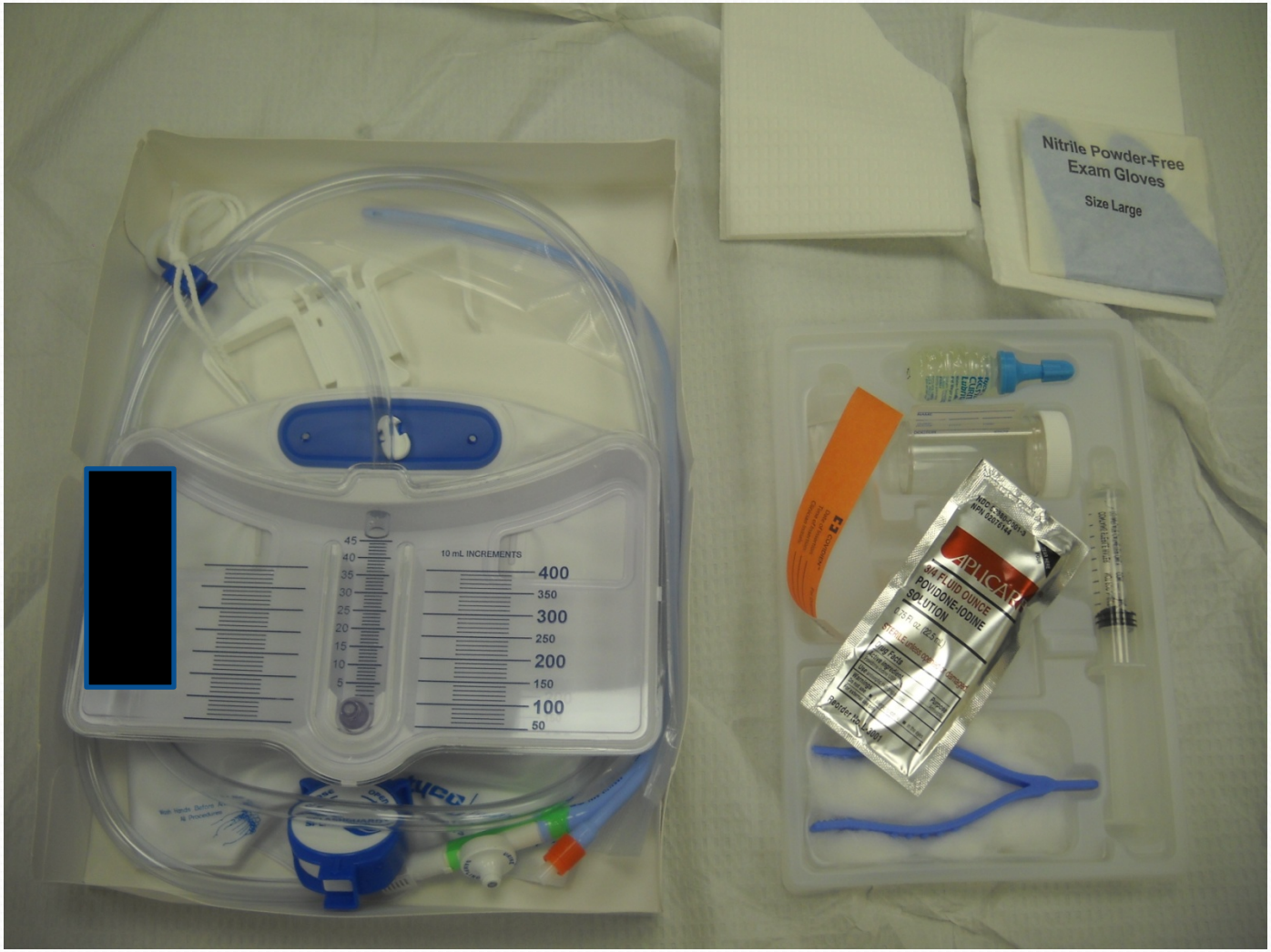
Published Guidelines on Prevention of CAUTI

- **European Assoc. of Urology**: Tenke P, et al. European and Asian guidelines on management and prevention of catheter-associated urinary tract infections. International J Antimicrobial Agents 2008;31S:S68-S78.

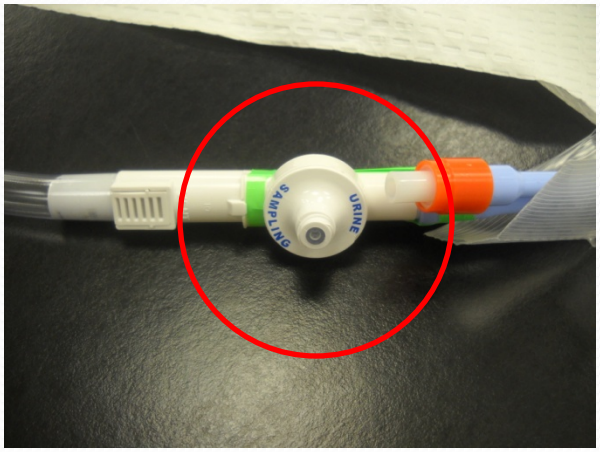
- **DOH of England**: Pratt RJ, et al. EPIC 2: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. J Hosp Infect 2007;65(Supp. 1):S1-64.

- **WOCN:** Nursing interventions to reduce the risk of catheter-associated urinary tract infections. Parts 1-3, 2009, J Wound Ostomy Continence Nurs;36, 23-34, 137-54, 156-9.

Sample Urinary Catheter Insertion Kit

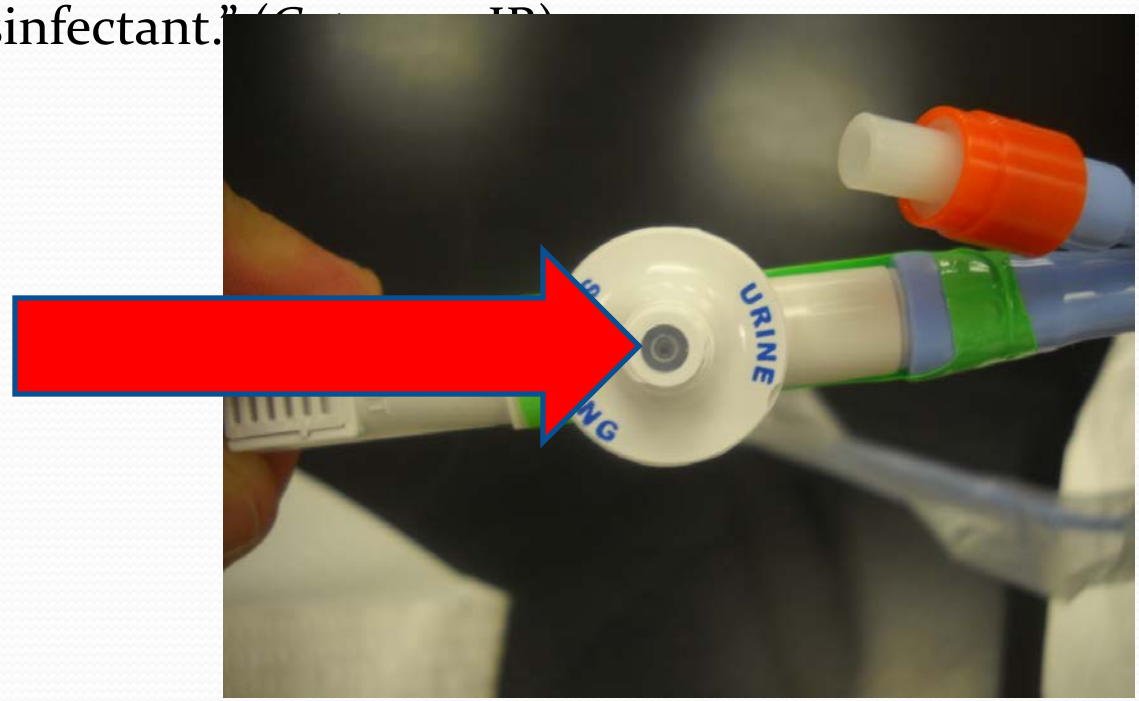


What to Look For in Catheter P



How should we collect urine specimens?

- "If a small volume of fresh urine is needed for examination (i.e. urinalysis or culture), aspirate the urine from the needleless sampling port with a sterile syringe/cannula adaptor after cleansing the port with a disinfectant."



Implementation Strategies

Consensus Across all Guidelines

1. Catheterize only when necessary and only for as long as necessary

2. Insert catheters using aseptic techniques and sterile equipment

3. Maintain closed, sterile drainage system

Conway LJ. Guidelines to prevent catheter-associated urinary tract infection: 1980-2010. Heart and Lung, 2011; in press.

Implementation Strategies

- Daily reviews of patients with indwelling catheters
- Standardized reminders
- Automatic stop orders
- Nurse-directed protocols to discontinue catheters

Examples of CAUTI Reduction Strategies (1)

- **Study Unit**: Med-Surg-Trauma ICU
- **Objective**: reduce CAUTI by decreasing use of urinary catheters
- **Intervention period**: 12 mos
- **Team**: Multidisciplinary including staff nurses
- **Methods**: Use of criteria-based urinary catheter guidelines, a decision-making algorithm, and a daily checklist
- ***Results***:
  - *Usage – decreased from a mean cath device days of 4.72 vs. 2.98*
  - *Decrease of 408 catheter days*
  - *CAUTI rates – decreased 33%*

Reilly LR. Reducing foley catheter device days in an intensive care unit. AACN Adv Crit Care 2008;17:272-83.

Examples of CAUTI Reduction Strategies (2)

- **Study Unit**: MICU
- **Objective**: reduce CAUTI by decreasing use of urinary catheters
- **Intervention period**: 11 mo vs. 6 mo
- **Methods**: daily evaluation using criteria for appropriate use
- ***Results***:
  - *Usage – decreased from 311.7 d/mo to 238.6 d/mo*
  - *CAUTI rates – decreased from 4.7/1000 CD to zero*
  - *32% of device days were considered inappropriate*

Elpern EH. Reducing use of indwelling urinary catheters and associated urinary tract infections. AJCC 2009;18:535-41.

Examples of CAUTI Reduction Strategies (3)

- **Study Unit**: 228-bed hospital
- **Objective**: reduce CAUTI by decreasing use of urinary catheters
- **Intervention period**: 6 mo
- **Team:** infection control, education, nursing, performance, improvement , risk management, and pharmacy
- **Methods**: weekly catheter patrols to identify patients with catheters and appropriateness of use
- ***Results***:
  - *CAUTI rates – decreased from 4 CAUTI/mo to zero*

McLaughlin A. Catheter patrols: a unique way to reduce the use of convenience urinary catheters. Ger Nurs 1996;17:240-43.

Examples of CAUTI Reduction Strategies (4)

- **Study Unit**: 4 hospital wards (2 control, 2 intervention)
- **Objective**: decrease use of urinary catheters
- **Methods**: A simple written reminder provided to the patient's clinical team that the patient has a urinary catheter
- ***Results***:
  - *5,678 patients evaluated*
  - *Control group – avg. proportion of time pts. catheterized increased by 15.1%*
  - *Intervention group - avg. proportion of time pts. catheterized decreased by 7.6%*

McLaughlin A. Catheter patrols: a unique way to reduce the use of convenience urinary catheters. Ger Nurs 1996;17:240-43.

Examples of CAUTI Reduction Strategies (5)

- **Study Unit**: Adult ICUs, Large hospital, Taiwan
- **Objective**: reduce CAUTIs and decrease use of urinary catheters
- **Study period**: Nov 2000-Dec 2002
- **Methods**: Nurse-generated daily reminders provided to the physicians to remove unnecessary urinary catheters 5 days after insertion
- ***Results***:
  - *6,297 patients evaluated*
  - *Avg. duration of catheterization decreased from 7.0d to 4.6d*
  - *CAUTI rate – decreased from 11.5/1000 CD to 8.3/1000 CD*
  - *Monthly cost of antibiotics was reduced by 69%*

Huang W-C. Catheter-associated urinary tract infections in intensive care units can be reduced by prompting physicians to remove unnecessary catheters. ICHE 2004;25:974-78.

Examples of CAUTI Reduction Strategies (6)

- **Study Unit**: 4 general medical units
- **Objective**: reduce CAUTIs and decrease use of urinary catheters
- **Intervention period**: 2 periods, one year each
- **Methods**: CPOE system updating physician of urinary catheter insertion and prompting options for minimizing duration; nurse-directed protocol for removal; use of bladder scanners
- ***Results***:
  - *81% of caths inserted in ED; only 22% had physician orders*
  - *Catheter days – decrease from 892 to 521 to 184*
  - *CAUTI rate (per 1000 CD) – decreased from 36 to 19 to 11*
  - *CAUTI reduced by 81%*

Topal J. Prevention of nosocomial catheter-associated urinary tract infections through computerized feedback to physicians and a nurse-directed protocol. Am J Med Qual 2005;20:121-26.

Examples of CAUTI Reduction Strategies (7)

- **Study Unit**: 2 units, medical-cardiology (VA med ctr)
- **Objective**: decrease use of urinary catheters
- **Intervention period**: 8 weeks each unit; cross-over study
- **Methods**: computer-based order for insertion, computer-generated reminders to remove catheters
- ***Results***:
  - *29% of patients on control ward had orders vs. 92% in study group*
  - *Catheter days – Control - 8 vs. Study group - 3*
  - *No enough study power to detect CAUTI difference*

Cornia PB. Computer-based order entry decreases duration of indwelling urinary catheterization in hospitalized patients. Am J Med 2003;114:404-7.

Examples of CAUTI Reduction Strategies (8)

- **Study Unit**: 3 hospitals, Ontario, Canada
- **Objective**: reduce CAUTIs and decrease use of urinary catheters
- **Design**: patients with urinary catheters randomized to stop orders for removal of catheters if specified criteria were not present or to usual care
- ***Results***:
  - *692 patients in the study*
  - *Inappropriate catheter days: Control – 3.89 vs. Study group – 2.20*
  - *Total catheter days: Control – 5.04 vs. Study group – 3.70*
  - *CAUTI rate: Control – 19%, Study – 20%*

Loeb M. Stop orders to reduce inappropriate urinary catheterization in hospitalized patients: a randomized controlled trial. J Gen Intern Med 2008;23:816-20.

Examples of CAUTI Reduction Strategies (9)

- **Study Unit**: 28-bed medical-surgical ICU
- **Objective**: reduce CAUTIs
- **Intervention Period**: one year
- **Methods:** physician-led multidisciplinary rounds, use of prevention bundles, culture changes with focus on team decision making process
- **UTI bundle**: regular assessment of continued need, sterile insertion technique, daily perineal care, drainage bag lower than patient's bladder, secure all catheters, use silver-coated catheters in selected cases
- ***Results***:
  - *Urinary catheter days: Baseline – 7,691 vs. Study – 5,780*
  - *CAUTI rate (per 1000 CD) Baseline – 3.8, Study – 2.4*

Jain M. Decilne in ICU adverse events, nosocomial infections and cost through a quality improvement initiative focusing on teamwork and culture change. Qual Saf Health Care 2006;15:235-39.

Conclusion

"The bulk of the evidence is consistent with the view that multimodal strategies could prevent between 25% and 75% of catheter-associated urinary tract infections"

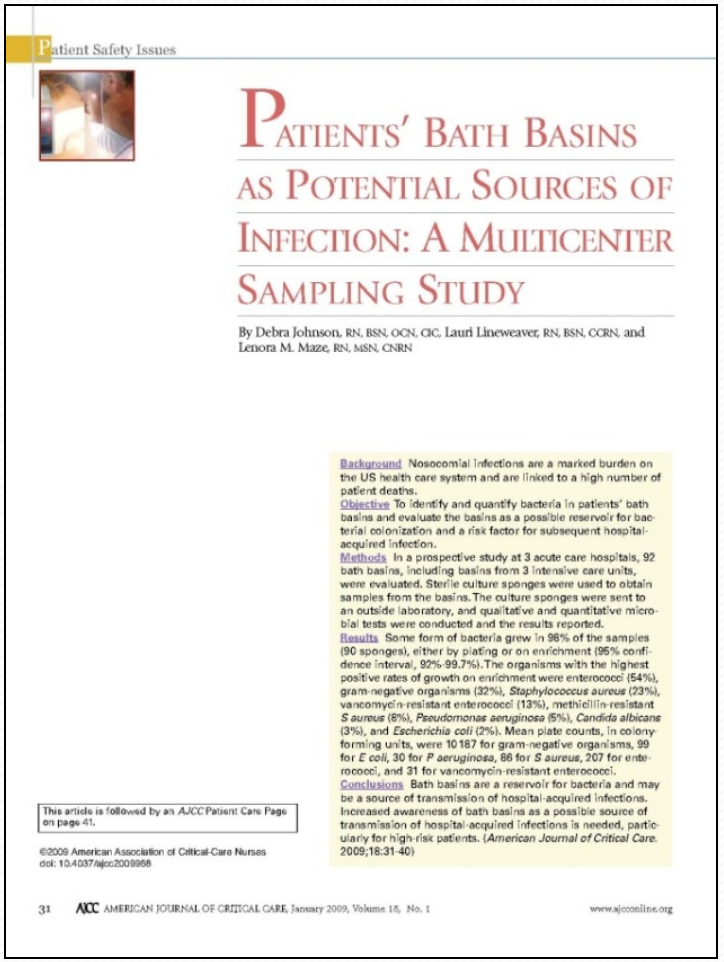
Saint S. Catheter-associated urinary tract infection and the Medicare Rule changes. Ann Intern Med 2009;150:877-84.

Novel Strategy

Is a Bath Basin a Source of Pathogens Implicated in Causing HAI's?

(1) A Multicenter Sampling Study

- Prospective study at 3 acute care hospitals
- Samples taken of bath basins used at least twice for whole-body bathing of patients hospitalized for >48h
- 92 bath basins sampled (bath water drained, allowed to air dry for at least 2 hours)
- Specimens taken using sterile culture sponge



Patient Safety Issues

PATIENTS' BATH BASINS AS POTENTIAL SOURCES OF INFECTION: A MULTICENTER SAMPLING STUDY

By Debra Johnson, RN, BSN, OCN, CIC, Lauri Lineweaver, RN, BSN, CCRN, and Lenora M. Maze, RN, MSN, CNRN

Background Nosocomial infections are a marked burden on the US health care system and are linked to a high number of patient deaths.
Objective To identify and quantify bacteria in patients' bath basins and evaluate the basins as a possible reservoir for bacterial colonization and a risk factor for subsequent hospital-acquired infection.
Methods In a prospective study at 3 acute care hospitals, 92 bath basins, including basins from 3 intensive care units, were evaluated. Sterile culture sponges were used to obtain samples from the basins. The culture sponges were sent to an outside laboratory, and qualitative and quantitative microbial tests were conducted and the results reported.
Results Some form of bacteria grew in 98% of the samples (90 sponges), either by plating or on enrichment (95% confidence interval, 92%-99.7%). The organisms with the highest positive rates of growth on enrichment were enterococci (54%), gram-negative organisms (32%), *Staphylococcus aureus* (23%), vancomycin-resistant enterococci (13%), methicillin-resistant *S aureus* (8%), *Pseudomonas aeruginosa* (5%), *Candida albicans* (3%), and *Escherichia coli* (2%). Mean plate counts, in colony-forming units, were 10 187 for gram-negative organisms, 99 for *E coli*, 30 for *P aeruginosa*, 86 for *S aureus*, 207 for enterococci, and 31 for vancomycin-resistant enterococci.
Conclusions Bath basins are a reservoir for bacteria and may be a source of transmission of hospital-acquired infections. Increased awareness of bath basins as a possible source of transmission of hospital-acquired infections is needed, particularly for high-risk patients. (*American Journal of Critical Care.* 2009;18:31-40)

This article is followed by an *AJCC* Patient Care Page on page 41.

doi: 10.4037/ajcc2009968

Johnson D. Patient's bath basins as potential sources of infection: a multicenter sampling study. AJCC 2009;18:31-40.

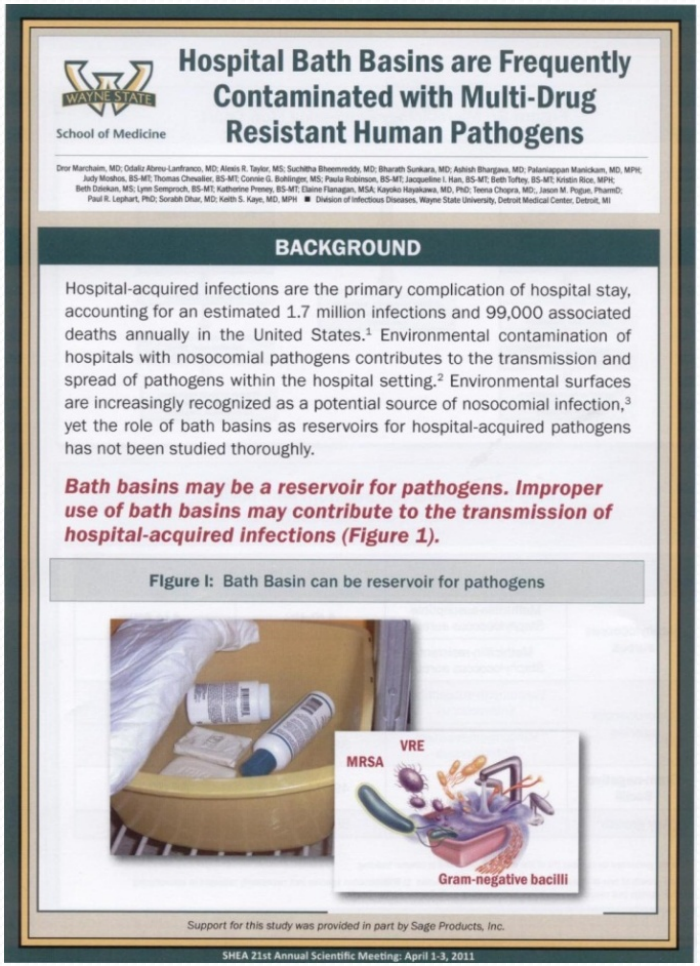
Results

- Bacteria grew in **98%** of the samples

- Organisms with highest positive rates of growth:
  - Enterococci (54%)
  - Gram-negative organisms (32%)
  - *Staphylococcus aureus* (23%)
  - VRE (13%)
  - MRSA (8%)
  - *Pseudomonas aeruginosa* (5%)
  - *Candida albicans* (3%)
  - *E. coli* (2%)

Johnson D. Patient's bath basins as potential sources of infection: a multicenter sampling study. AJCC 2009;18:31-40.

(2) Multi-National, Multi-Center Bath Basin Study



Hospital Bath Basins are Frequently Contaminated with Multi-Drug Resistant Human Pathogens

School of Medicine

Dror Marchaim, MD; Odaliz Abreu-Lanfranco, MD; Alexis R. Taylor, MS; Suchitha Bheemreddy, MD; Bharath Sunkara, MD; Ashish Bhargava, MD; Palaniappan Manickam, MD, MPH; Judy Moshos, BS-MT; Thomas Chevalier, BS-MT; Connie G. Bohlinger, MS; Paula Robinson, BS-MT; Jacqueline I. Han, BS-MT; Beth Tofte, BS-MT; Kristin Rice, MPH; Beth Dzielsen, MS; Lynn Semproch, BS-MT; Katherine Prensy, BS-MT; Elaine Flanagan, MSA; Kayoko Hayakawa, MD, PhD; Teena Chopra, MD; Jason M. Pogue, PharmD; Paul R. Lephart, PhD; Sorabh Dhar, MD; Keith S. Kaye, MD, MPH ■ Division of Infectious Diseases, Wayne State University, Detroit Medical Center, Detroit, MI

BACKGROUND

Hospital-acquired infections are the primary complication of hospital stay, accounting for an estimated 1.7 million infections and 99,000 associated deaths annually in the United States.[1] Environmental contamination of hospitals with nosocomial pathogens contributes to the transmission and spread of pathogens within the hospital setting.[2] Environmental surfaces are increasingly recognized as a potential source of nosocomial infection,[3] yet the role of bath basins as reservoirs for hospital-acquired pathogens has not been studied thoroughly.

Bath basins may be a reservoir for pathogens. Improper use of bath basins may contribute to the transmission of hospital-acquired infections (Figure 1).

Figure I: Bath Basin can be reservoir for pathogens

Support for this study was provided in part by Sage Products, Inc.

SHEA 21st Annual Scientific Meeting: April 1-3, 2011

- Objective: "To investigate the role of bath basins as potential reservoirs of common multi-drug resistant organisms associated with nosocomial outbreaks."
- Total was 1103 basins in 88 hospitals throughout North America including 70 basins through their hospital system (Detroit Medical Center).

Presented at SHEA International Conference, March, 2011 by Dr. Dror Marchaim, In-Press AJIC in 2012

Results

Table I: Pathogens cultured from bath basins in the United States and Canada (N = 1103)

Pathogen		No. of positive basins (N=1103)	No. of positive hospitals (N=88)
Staphylococcus aureus	Methicillin-susceptible *Staphylococcus aureus*	4 (0.4%)	4 (4.5%)
	Methicillin-resistant *Staphylococcus aureus*	36 (3.3%)	28 (31.8%)
Enterococcus species	Vancomycin-susceptible *Enterococcus*	29 (2.7%)	14 (15.9%)
	Vancomycin-resistant *Enterococcus*	385 (34.9%)	80 (90.9%)
Gram-negative Bacilli		495 (44.9%)	86 (97.7%)
Any growth[A]		686 (62.2%)	88 (100%)

Data are presented as number (%) of the total number listed in column heading.

[A] Only growth of one of these 5 classes of bacteria was included: 1) *Enterococcus* species (not necessarily resistant to vancomycin); 2) S. *aureus* (not necessarily resistant to methicillin); or 3) Gram-negative bacilli.

Thank You!
Go Cowboys!

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