Back to the Basics of Disinfection

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DISCLOSURES

- Consultation (2017)
  - PDI
  - ASP
- Honoraria (2017)
  - PDI
  - Kennall
- Grants to UNC or UNC Hospitals (2017)
  - CDC, CMS

Back to the Basics of Disinfection

- Overview of disinfection
- Low-level disinfection
  - Role of environment in disease transmission
  - Products and practices for surface disinfection
    - New issues
      - Inactivation of emerging pathogens (e.g., CRE, *C. auris*)
  - Technologies for terminal room decontamination (not including technologies with limited data)
- High-level disinfection
  - Reprocessing channeled scopes
  - Shift from HLD to sterilization
  - HPV

Sources of Healthcare-Associated Pathogens

Weinstein RA. Am J Med 1991:91 (suppl 3B):179S

- Endogenous flora (SSI, UTI, CLABSI): 40-60%
- Exogenous: 20-40% (e.g., cross-infection via contaminated hands [staff, visitors])
- Other (environment): 20%
  - Medical devices
  - Contact with environmental surfaces (direct and indirect contact)

Medical/Surgical Devices

WA Rutala, DJ Weber, and HICPAC, www.cdc.gov

EH Spaulding believed that how an object will be disinfected depended on the object's intended use (developed 1968).

CRITICAL-medical/surgical devices which enter normally sterile tissue or the vascular system or through which blood flows should be sterile.

SEMICRITICAL-medical devices that touch mucous membranes or skin that is not intact require a disinfection process (high-level disinfection [HLD]) that kills all microorganisms but high numbers of bacterial spores.

NONCRITICAL-medical devices that touch only intact skin require low-level disinfection.

Critical Medical/Surgical Devices

Rutala et al. ICHE 2014;35:883; Rutala et al. ICHE 2014;35:1068; Rutala et al. AJIC 2016;44:e47



- Critical
  - Transmission: direct contact
  - Control measure: sterilization
  - Surgical instruments
    - Enormous margin of safety, rare outbreaks (2 in 60 years)
    - ~85% of surgical instruments <100 microbes
    - Washer/disinfector removes or inactivates 10-100 million
    - Sterilization kills 1 trillion spores

Noncritical Medical Devices

Rutala et al. AJIC 2016;44:e1; Rutala, Weber. Env Issues NI, Farber 1987

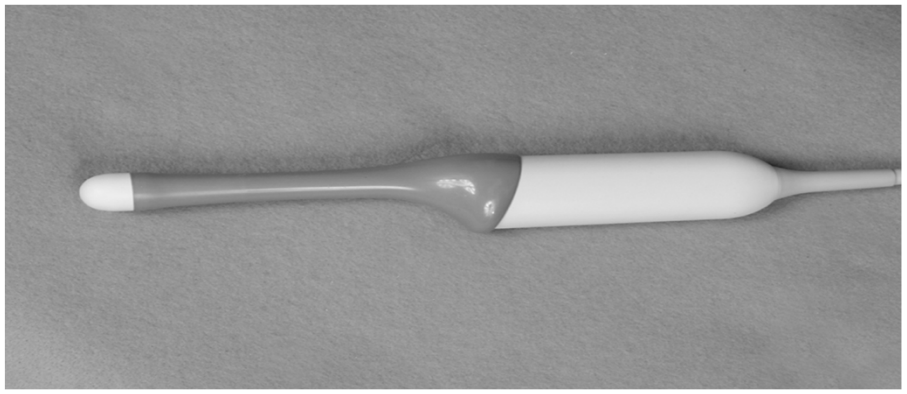


- Contact: intact skin (noncritical medical devices, surfaces)
- Transmission: secondary transmission by contaminating hands/gloves via contact with the environment and transfer to patient
- Control measures: hand hygiene and low-level disinfection
- Noncritical devices (stethoscopes, blood pressure cuffs, wound vacuum), rare outbreaks

Semicritical Medical Devices

Rutala et al. AJIC 2016;44:e47





- Semicritical
  - Transmission: direct contact
  - Control measure: high-level disinfection
  - Endoscopes top ECRI list of 10 technology hazards, >130 outbreaks (GI, bronchoscopes)
    - 0 margin of safety
      - Microbial load, 10^7-10^{10}
      - Complexity
      - Biofilm
  - Other semicritical devices, rare outbreaks
    - ENT scopes, endocavitary probes (prostate, vaginal, TEE), laryngoscopes, cystoscopes
    - Reduced microbial load, less complex

ENVIRONMENTAL CONTAMINATION LEADS TO HAIs

- There is increasing evidence to support the contribution of the environment to disease transmission
- This supports comprehensive disinfecting regimens (goal is not sterilization) to reduce the risk of acquiring a pathogen from the healthcare environment/equipment

Environmental Contamination Leads to HAIs

Weber, Kanamori, Rutala. Curr Op Infect Dis .2016.



- Evidence environment contributes
- Role-MRSA, VRE, *C. difficile*
- Surfaces are contaminated-~25%
- EIP survive days, weeks, months
- Contact with surfaces results in hand contamination; contaminated hands transmit EIP to patients
- Disinfection reduces contamination
- Disinfection (daily) reduces HAIs
- Rooms not adequately cleaned

Admission to Room Previously Occupied by Patient C/I with Epidemiologically Important Pathogen



- Results in the newly admitted patient having an increased risk of acquiring that pathogen by 39-353%
- For example, increased risk for *C. difficile* is 235% (11.0% vs 4.6%)

EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

- Study design: Retrospective cohort analysis, 2005-2006
- Setting: Medical ICU at a tertiary care hospital
- Methods: All patients evaluated for diagnosis of CDI 48 hours after ICU admission and within 30 days after ICU discharge
- Results (acquisition of CDI)
  - Admission to room previously occupied by CDI = 11.0%
  - Admission to room not previously occupied by CDI = 4.6% (p=0.002)

Shaughnessy MK, et al. ICHE 2011;32:201-206

TABLE 3. Multivariate Analysis of Risk Factors for Acquisition of *Clostridium difficile* Infection (CDI)

Risk factor	HR (95% CI)	*P*
Prior room occupant with CDI	2.35 (1.21–4.54)	.01
Greater age	1.00 (0.99–1.01)	.71
Higher APACHE III score	1.00 (1.00–1.01)	.06
Proton pump inhibitor use	1.11 (0.44–2.78)	.83
Antibiotic exposure		
Norfloxacin	0.38 (0.05–2.72)	.33
Levofloxacin	1.08 (0.67–1.73)	.75
Ciprofloxacin	0.49 (0.15–1.67)	.23
Fluoroquinolones	1.17 (0.72–1.91)	.53
Clindamycin	0.45 (0.14–1.42)	.17
Third- or fourth-generation cephalosporins	1.17 (0.76–1.79)	.48
Carbapenems	1.05 (0.63–1.75)	.84
Piperacillin-tazobactam	1.31 (0.82–2.10)	.27
Other penicillin	0.47 (0.23–0.98)	.04
Metronidazole	1.31 (0.83–2.07)	.24
Vancomycin		
Oral	1.38 (0.32–5.89)	.67
Intravenous	1.55 (0.88–2.73)	.13
Aminoglycosides	1.27 (0.78–2.06)	.35
Multiple (≥3 antibiotic classes)	1.28 (0.75–2.21)	.37

NOTE. APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; HR, hazard ratio.

ACQUISITION OF MRSA ON HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES



ACQUISITION OF MRSA ON HANDS/GLOVES AFTER CONTACT WITH CONTAMINATED EQUIPMENT



TRANSFER OF MRSA FROM PATIENT OR ENVIRONMENT TO IV DEVICE AND TRANSMISSON OF PATHOGEN



ACQUISITION OF *C. difficile* ON PATIENT HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES AND THEN INOCULATION OF MOUTH



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LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

Exposure time ≥ 1 min

Germicide	Use Concentration
Ethyl or isopropyl alcohol	70-90%
Chlorine	100ppm (1:500 dilution)
Phenolic	UD
Iodophor	UD
Quaternary ammonium (QUAT)	UD
QUAT with alcohol	RTU
Improved hydrogen peroxide (HP)	0.5%, 1.4%
Peracetic acid with HP (*C. difficile*)	UD

UD=Manufacturer's recommended use dilution; others in development/testing-electrolyzed water; polymeric guanidine; cold-air atmospheric pressure plasma (Boyce Antimicrob Res IC 2016. 5:10)

Issues Related to Disinfection Protocols

Boyce et al. ICHE 2016;37:340-342

- Inappropriate over-dilution of disinfectant solutions by housekeepers or by malfunctioning automated dilutions systems may result in applying disinfectants using inappropriate solutions
  - Audit of 33 automated dispensing stations that mix concentrated disinfectant with water to yield desired in-use QUAT conc of 800 ppm
  - QUAT solutions dispensed were tested with test strips, ~50% of stations delivered solutions with 200-400ppm
  - Several flaws in dispensing system

PROPERTIES OF AN IDEAL SURFACE DISINFECTANT

Rutala WA, Weber DJ. Infect Control Hosp Epidemiol 2014;35:855-865

- Broad spectrum
- Fast acting
- Remains wet
- Not affected by environmental factors
- Nontoxic
- Surface compatibility
- Persistence
- Easy to use
- Acceptable odor
- Economical
- Solubility
- Stability
- Cleaner
- Nonflammable

Key Considerations for Selecting the Ideal Disinfectant for Your Facility

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865

Consideration	Question to Ask	Score (1-10)
Kill Claims	Does the product kill the most prevalent healthcare pathogens	
Kill Times and Wet-Contact Times	How quickly does the product kill the prevalent healthcare pathogens. Ideally, contact time greater than or equal to the kill claim.	
Safety	Does the product have an acceptable toxicity rating, flammability rating	
Ease-of-Use	Odor acceptable, shelf-life, in convenient forms (wipes, spray), water soluble, works in organic matter, one-step (cleans/disinfects)	
Other factors	Supplier offers comprehensive training/education, 24-7 customer support, overall cost acceptable (product capabilities, cost per compliant use, help standardize disinfectants in facility	

Note: Consider the 5 components shown, give each product a score (1 is worst and 10 is best) in each of the 5 categories, and select the product with the highest score as the optimal choice (maximum score is 50).

Quaternary ammonium compounds

(e.g., didecyl dimethyl ammonium bromide, dioctyl dimethyl ammonium bromide)
Rutala, Weber. Am J Infect Control 2013;41:S36-S41

Advantages

- Bactericidal, fungicidal, virucidal against enveloped viruses (e.g., HIV)
- Good cleaning agents
- EPA registered
- Surface compatible
- Persistent antimicrobial activity when undisturbed
- Inexpensive (in dilutable form)
- Not flammable

Disadvantages

- Not sporicidal
- In general, not tuberculocidal and virucidal against non-enveloped viruses
- High water hardness and cotton/gauze can make less microbicidal
- A few reports documented asthma as result of exposure to benzalkonium chloride
- Affected by organic matter
- Multiple outbreaks ascribed to contaminated benzalkonium chloride

Alcohol

Rutala, Weber. Am J Infect Control 2013;41:S36-S41

Advantages

- Bactericidal, tuberculocidal, fungicidal, virucidal
- Fast acting
- Non-corrosive
- Non-staining
- Used to disinfect small surfaces such as rubber stoppers on medication vials
- No toxic residue

Disadvantages

- Not sporicidal
- Affected by organic matter
- Slow acting against non-enveloped viruses (e.g., norovirus)
- No detergent or cleaning properties
- Not EPA registered
- Damage some instruments (e.g., harden rubber, deteriorate glue)
- Flammable (large amounts require special storage)
- Evaporates rapidly making contact time compliance difficult
- Not recommended for use on large surfaces
- Outbreaks ascribed to contaminated alcohol

Quat/Alcohol vs Quat

Rutala et al. Antimicrob Agents Chemother 2006. 50:1419-1424

- Adenovirus is a hardy virus that is relatively resistant to disinfectants
- Quat about <0.5 $\log_{10}$ reduction against adenovirus with 1m exposure time
- Accelerated hydrogen peroxide (0.5%) demonstrates ~0.7 $\log_{10}$ reduction against adenovirus with 1m exposure time
- Quat/Alcohol demonstrates a ~4 $\log_{10}$ reduction against adenovirus with 1m exposure time
- Chlorine (~5000ppm) demonstrates a ~5 $\log_{10}$ reduction against adenovirus with 1m exposure time
- Quat/Alcohol has improved virucidal activity compared to Quat and accelerated hydrogen peroxide

Improved Hydrogen Peroxide

Rutala, Weber. Am J Infect Control 2013;41:S36-S41

Advantages

- Bactericidal, tuberculocidal, fungicidal, virucidal
- Fast efficacy
- Easy compliance with wet-contact times
- Safe for workers (lowest EPA toxicity category, IV)
- Benign for the environment
- Surface compatible
- Non-staining
- EPA registered
- Not flammable

Disadvantages

- More expensive than most other disinfecting actives
- Not sporicidal at low concentrations

Sodium Hypochlorite

Rutala, Weber. Am J Infect Control 2013;41:S36-S41

Advantages

- Bactericidal, tuberculocidal, fungicidal, virucidal
- Sporicidal
- Fast acting
- Inexpensive (in dilutable form)
- Not flammable
- Unaffected by water hardness
- Reduces biofilms on surfaces
- Relatively stable (e.g., 50% reduction in chlorine concentration in 30 days)
- Used as the disinfectant in water treatment
- EPA registered

Disadvantages

- Reaction hazard with acids and ammonias
- Leaves salt residue
- Corrosive to metals (some ready-to-use products may be formulated with corrosion inhibitors)
- Unstable active (some ready-to-use products may be formulated with stabilizers to achieve longer shelf life)
- Affected by organic matter
- Discolors/stains fabrics
- Potential hazard is production of trihalomethane
- Odor (some ready-to-use products may be formulated with odor inhibitors). Irritating at high concentrations.

Phenolics

Rutala, Weber. Am J Infect Control 2013;41:S36-S41

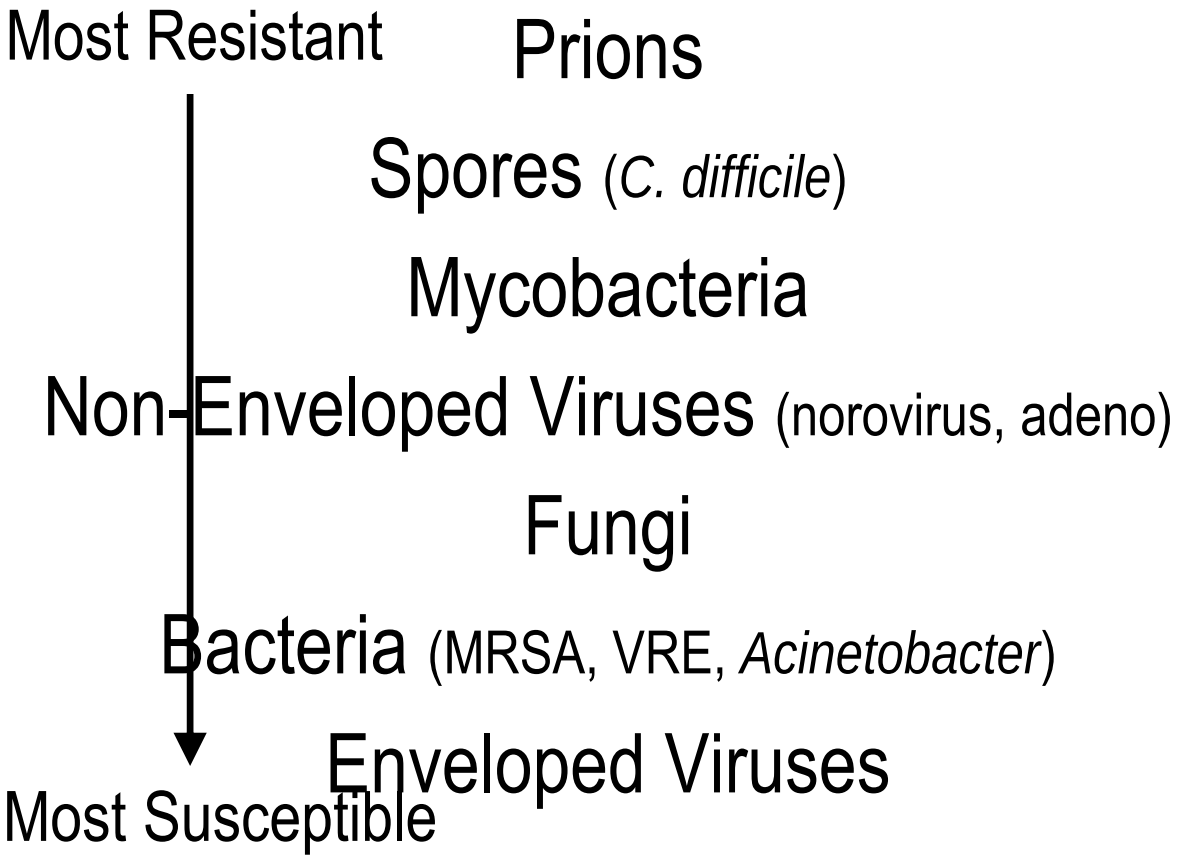
Advantages

- Bactericidal, tuberculocidal, fungicidal, virucidal
- Inexpensive (in dilutable form)
- Non-staining
- Not flammable
- EPA registered

Disadvantages

- Not sporicidal
- Absorbed by porous materials and irritate tissue
- Depigmentation of skin caused by certain phenolics
- Hyperbilirubinemia in infants when phenolic not prepared as recommended

Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants



Norovirus: Microbiology and Epidemiology

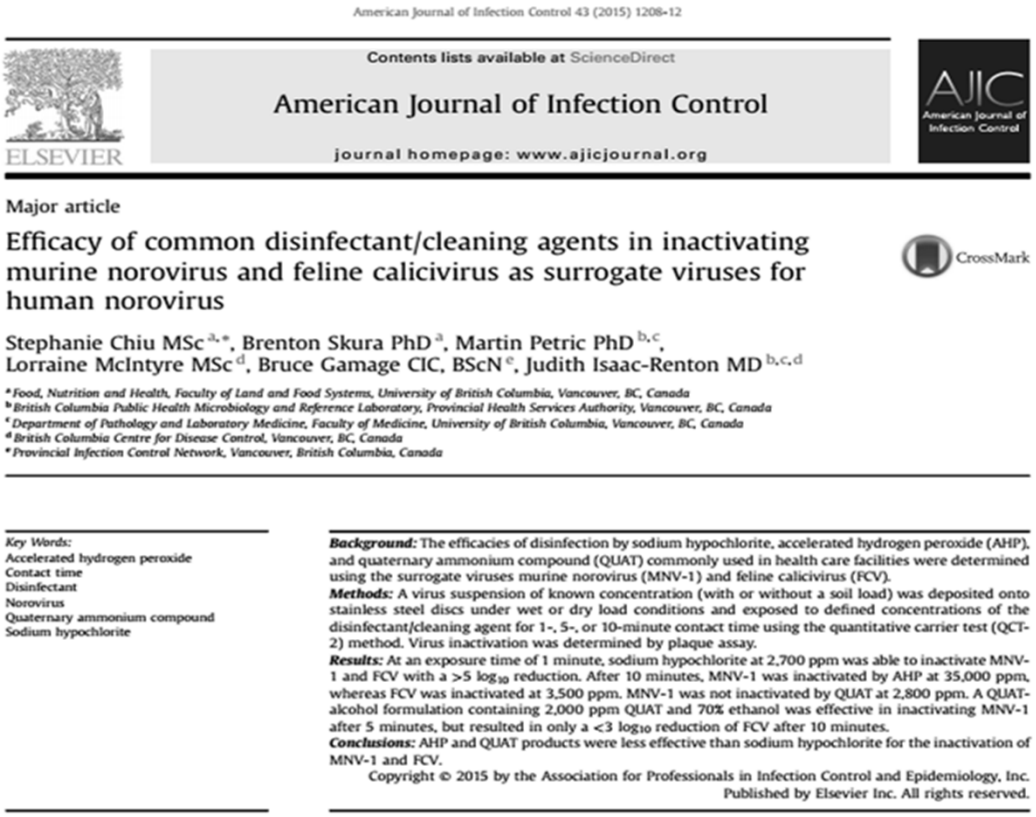
Weber, Rutala et al. AJIC 2010:38:S25-33

- Classified as a calicivirus: RNA virus, non-enveloped
- Prevalence
  - Causes an estimated 23 million infections per year in the US
  - Results in 50,000 hospitalizations per year (310 fatalities)
  - Accounts for >90% of nonbacterial and ~50% of all-cause epidemic gastroenteritis
- Infectious dose: 10-100 viruses (ID_{50} = 18 viruses)
- Fecal-oral transmission (shedding for up to 2-3 weeks)
  - Direct contact and via fomites/surfaces; food and water
- Droplet transmission? (via ingestion of airborne droplets of virus-containing particles)
- May cause chronic infection in transplant recipients

Why Chlorine for Norovirus?

- Chlorine is the most robust disinfectant against a wide range of pathogens including norovirus, rotavirus, adenovirus and *C. difficile*
- Types of isolation at UNC Hospitals: Contact Enteric and Contact. Contact we use Quat, Quat/Alc and Contact Enteric (*C. difficile*, norovirus) we use chlorine
- Use of two products simplifies training of healthcare providers regarding isolation signs and EVS training regarding the two disinfectants
- Additionally, when confronted with a norovirus outbreak (and possibly a closed unit), we recommend the most effective and proven control measures to terminate the outbreak
  - Hand hygiene with soap and water
  - Chlorine disinfection of surfaces

Accelerated Hydrogen Peroxide and QUAT Less Effective at 10m than Sodium Hypochlorite at 1m



American Journal of Infection Control 43 (2015) 1208-12

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Efficacy of common disinfectant/cleaning agents in inactivating murine norovirus and feline calicivirus as surrogate viruses for human norovirus

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Key Words:
Accelerated hydrogen peroxide
Contact time
Disinfectant
Norovirus
Quaternary ammonium compound
Sodium hypochlorite

Background: The efficacies of disinfection by sodium hypochlorite, accelerated hydrogen peroxide (AHP), and quaternary ammonium compound (QUAT) commonly used in health care facilities were determined using the surrogate viruses murine norovirus (MNV-1) and feline calicivirus (FCV).
Methods: A virus suspension of known concentration (with or without a soil load) was deposited onto stainless steel discs under wet or dry load conditions and exposed to defined concentrations of the disinfectant/cleaning agent for 1-, 5-, or 10-minute contact time using the quantitative carrier test (QCT-2) method. Virus inactivation was determined by plaque assay.
Results: At an exposure time of 1 minute, sodium hypochlorite at 2,700 ppm was able to inactivate MNV-1 and FCV with a >5 $\log_{10}$ reduction. After 10 minutes, MNV-1 was inactivated by AHP at 35,000 ppm, whereas FCV was inactivated at 3,500 ppm. MNV-1 was not inactivated by QUAT at 2,800 ppm. A QUAT-alcohol formulation containing 2,000 ppm QUAT and 70% ethanol was effective in inactivating MNV-1 after 5 minutes, but resulted in only a <3 $\log_{10}$ reduction of FCV after 10 minutes.
Conclusions: AHP and QUAT products were less effective than sodium hypochlorite for the inactivation of MNV-1 and FCV.

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Accelerated Hydrogen Peroxide and QUAT Less Effective at 10m than Sodium Hypochlorite at 1m

Table 1
Summary of the most effective concentrations and contact times of commonly used disinfectants against MNV-1 and FCV, with and without soil load

	MNV-1						FCV					
	Without soil load			With soil load			Without soil load			With soil load		
Disinfectant	Concentration (ppm)/contact time (min)	Wet and dry load mean* log_{10} reduction† Wet	Dry	Concentration (ppm)/contact time (min)	Wet and dry load mean* log_{10} reduction† Wet	Dry	Concentration (ppm)/contact time (min)	Wet and dry load mean* log_{10} reduction† Wet	Dry	Concentration (ppm)/contact time (min)	Wet and dry load mean* log_{10} reduction† Wet	Dry
Sodium hypochlorite	2700/1	**6.8**	**5.9**	5400/1	**6.4**	**6.7**	5400/1	**5.7**	**5.4**	2700/5	**5.3**	**4.8**
	1350/5	**6.0**	**5.5**	1350/5	**6.5**	**5.5**	1350/5	**4.6**	**4.9**	1350/10	**5.4**	**4.6**
	675/10	**6.4**	**5.6**				1350/10	**5.6**	**5.3**			
AHP	35,000/10	**6.5**	**5.6 (est)**	35,000/10	**6.3**	**5.6 (est)**	1750/5	**5.7**	**5.2**	7000/5	**5.1**	**4.8**
										3500/10	**5.1**	**4.8**
RTU AHP	5000/10	2.6	1.0	5000/10	0.8	0.9	5000/10	**6.0**	**5.5**	5000/10	**5.4**	**5.0**
QUAT	2800/10	2.0	3.2	NT		NT	2800/10	3.6	3.3	NT		NT
QUAT-alcohol (70% ethanol)	2000/5	**6.9**	**6.2 (est)**	NT		NT	2000/10	2.4	2.9	NT		NT

NT, not tested.
*Mean values from experimental trials performed in triplicate.
†Bold values indicate complete inactivation with no virus plaques observed.

A QUAT-alcohol containing 2000 ppm QUAT and 70% ethanol was effective in inactivating MNV after 5 minutes

Surface Disinfection: Treatment Time (Wipes/Sprays) versus Contact Time (Liquids)

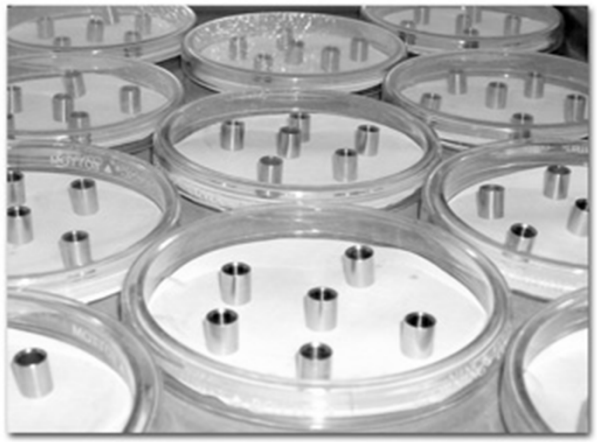
Dilutable liquid disinfectant-contact time is “wet” time

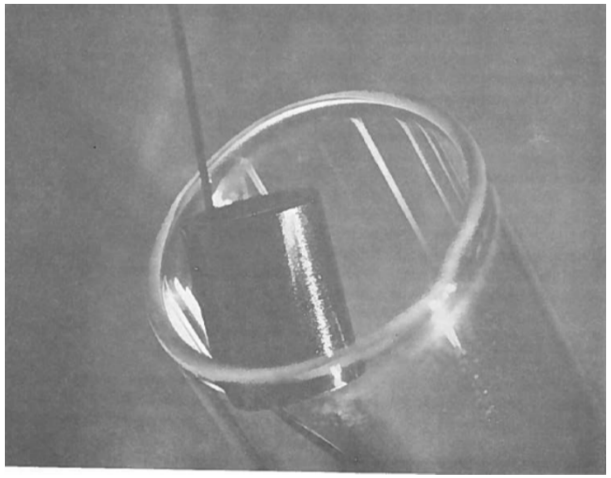
Wipes/Sprays-treatment time is undisturbed time (“wet” time is not relevant)

Surface Disinfection:

Treatment Time (Wipes/Sprays) versus Contact Time (Liquids)

Rutala, Weber. Submitted for publication





- Registration test for liquid disinfectants is the AOAC Use-Dilution Method (UDM).
- SS cylinders are inoculated with the test organism (*S. aureus, S. choleraesuis, P. aeruginosa*) and then dried. After drying, the cylinder is transferred to a disinfectant tube and immersed in the disinfectant for the contact time (e.g., 5 minutes).
- Thus, for liquid disinfectants tested by the UDM, the contact time should be the “wet” time (not undisturbed time).

Surface Disinfection:

Treatment Time (Wipes/Sprays) versus Contact Time (Liquids)

Rutala, Weber. Submitted for publication. Photos James Clayton.



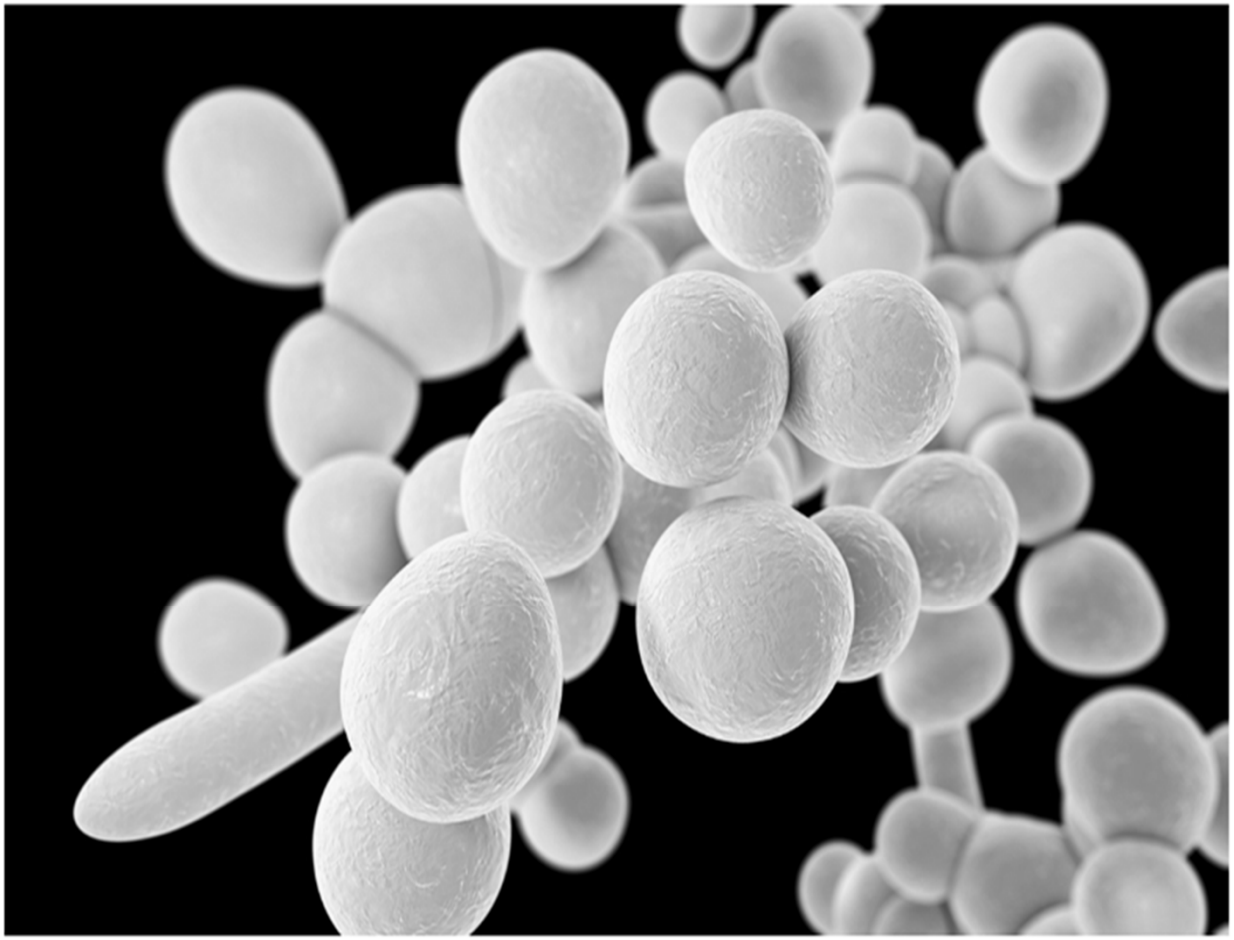
- Registration test for wipe is EPA Disinfectant Towelette Test
- Treatment time is equal to combination of physical removal and inactivation caused by the disinfectant regardless of the surface appearance (i.e. wet or dry)
- Thus, if disinfectant wipe has a registration time of 1 minute, then the surface should be allowed to remain undisturbed for the registration time of 1 minute (i.e. wet time is not relevant)

Candida auris

Cadnum et al . ICHE 2017;38:1240-1243

- *Candida auris* is a globally emerging pathogen that is often resistant to multiple antifungal agents
- In several reports, *C. auris* has been recovered from the hospital environment
- CDC has recommended daily and post-discharge disinfection of surfaces in rooms of patients with *C. auris* infection.
- No hospital disinfectants are registered for use specifically against *C. auris*, and its susceptibility to germicides in not known

Deadly, drug-resistant Candida yeast infection spreads in the US



Candida auris causes multidrug-resistant infections that can result in organ failure

Kateryna Kon/Science Photo Library

Effectiveness of Disinfectants Against *Candida auris* and Other *Candida* Species

Cadnum et al . ICHE 2017;38:1240-1243

TABLE 1. Characteristics of the Disinfectants Tested

Disinfectant	Active Components	Contact Time[a]	Sporicidal Claim[b]	*Candida albicans* Claim[c]
Clorox Healthcare bleach germicidal cleaner	Sodium hypochlorite 0.65%	1 min	Yes	Yes
Clorox Healthcare Fuzion cleaner disinfectant	Sodium hypochlorite 0.39%	1 min	Yes	Yes
Clorox germicidal bleach (1:10 dilution)	Sodium hypochlorite 0.825% when diluted	1 min	Yes	Yes
OxyCide daily disinfectant	Peracetic acid 1200 parts per million, hydrogen peroxide <1%, acetic acid	3 min	Yes	Yes
Clorox Healthcare hydrogen peroxide cleaner disinfectant	Hydrogen peroxide 1.4%	1 min[d]	No	Yes
Oxivir Tb	Hydrogen peroxide 0.5%	10 min	No	Yes
White distilled vinegar	Acetic acid >5% (pH 2.0)	3 min[e]	No	No
Purell healthcare surface disinfectant	Ethyl alcohol 29.4%	30 s	No	Yes
Lysol all-purpose cleaner	Alkyl dimethyl benzyl ammonium chlorides	10 min	No	Yes
Virex II 256	Didecyl dimethyl ammonium chloride, n-Alkyl dimethyl benzyl ammonium chloride	10 min	No	Yes

[a]Contact time for disinfectants based on manufacturers' recommendations for *Candida albicans* unless otherwise specified.
[b]Environmental Protection Agency–registered claim against *Clostridium difficile* spores.
[c]Environmental Protection Agency–registered claim against *Candida albicans*.
[d]A 1-minute exposure was used, but the claim is based on a 3-minute exposure.
[e]There is no established contact time for vinegar.

Effectiveness of Disinfectants Against *Candida auris* and Other *Candida* Species

Cadnum et al . ICHE 2017;38:1240-1243

In lab testing, sporicidal and IHP disinfectants were highly effective against *C. auris, C. glabrata and C. albicans*. Quats exhibited relatively poor activity against all of the *Candida* species

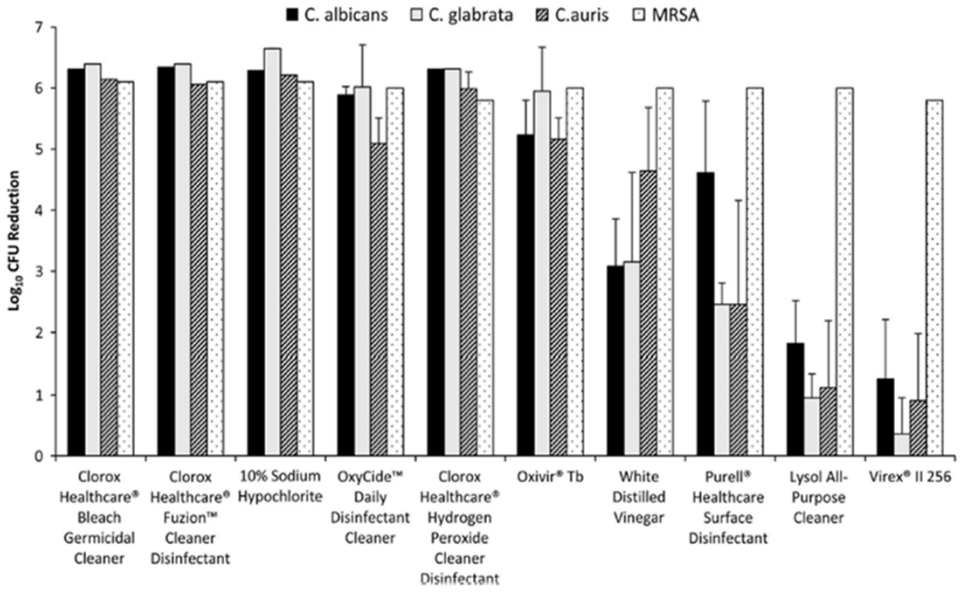


FIGURE 1. Mean log reductions for each of the disinfectants against the 3 *Candida* species and MRSA using the American Society for Testing and Materials (ASTM) Standard Quantitative Carrier Disk Test Method (ASTM E-2197-02).[7] Log reductions were calculated by subtracting viable organisms recovered after exposure to the disinfectants versus deionized water controls. Vinegar, Purell Healthcare Surface Disinfectant, and the 2 quaternary ammonium disinfectants were significantly less effective against the *Candida* species than against MRSA ($P \leq .02$). Error bars show standard error. MRSA, methicillin-resistant *Staphylococcus aureus*.

Efficacy of Disinfectants and Antiseptics against *Candida auris*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- ≥3 $\log_{10}$ reduction (*C. auris*, 1m, 5% FCS, QCT)
  - 0.20% peracetic acid
  - 2.4% glutaraldehyde
  - 0.65% hydrogen peroxide, 0.14% peroxyacetic acid
  - 0.5% Quat, 55% isopropyl alcohol
  - Disinfecting spray (58% ethanol, 0.1% QUAT)
  - 28.7% isopropyl alcohol, 27.3% ethyl alcohol, 0.61% QAC
  - 0.07% o-phenylphenol, 0.06% p-tertiary amylphenol
  - 70% isopropyl alcohol
  - ~5,250 ppm chlorine
  - Ethanol hand rub (70% ethanol)
  - Accelerated hydrogen peroxide, 1.4%
  - Accelerated hydrogen peroxide, 2%

Efficacy of Disinfectants and Antiseptics against *Candida auris*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- ≤3 $\log_{10}$ (most <2 $\log_{10}$) reduction (*C. auris*, 1m, 5% FCS, QCT)
  - 0.55% OPA
  - 3% hydrogen peroxide
  - Quat, (0.085% QACs)
  - 10% povidone-iodine
  - ~1,050 ppm chlorine
  - 2% Chlorhexidine gluconate-CHG
  - 4% CHG
  - 0.5% triclosan
  - 1% CHG, 61% ethyl alcohol
  - 1% chloroxylenol

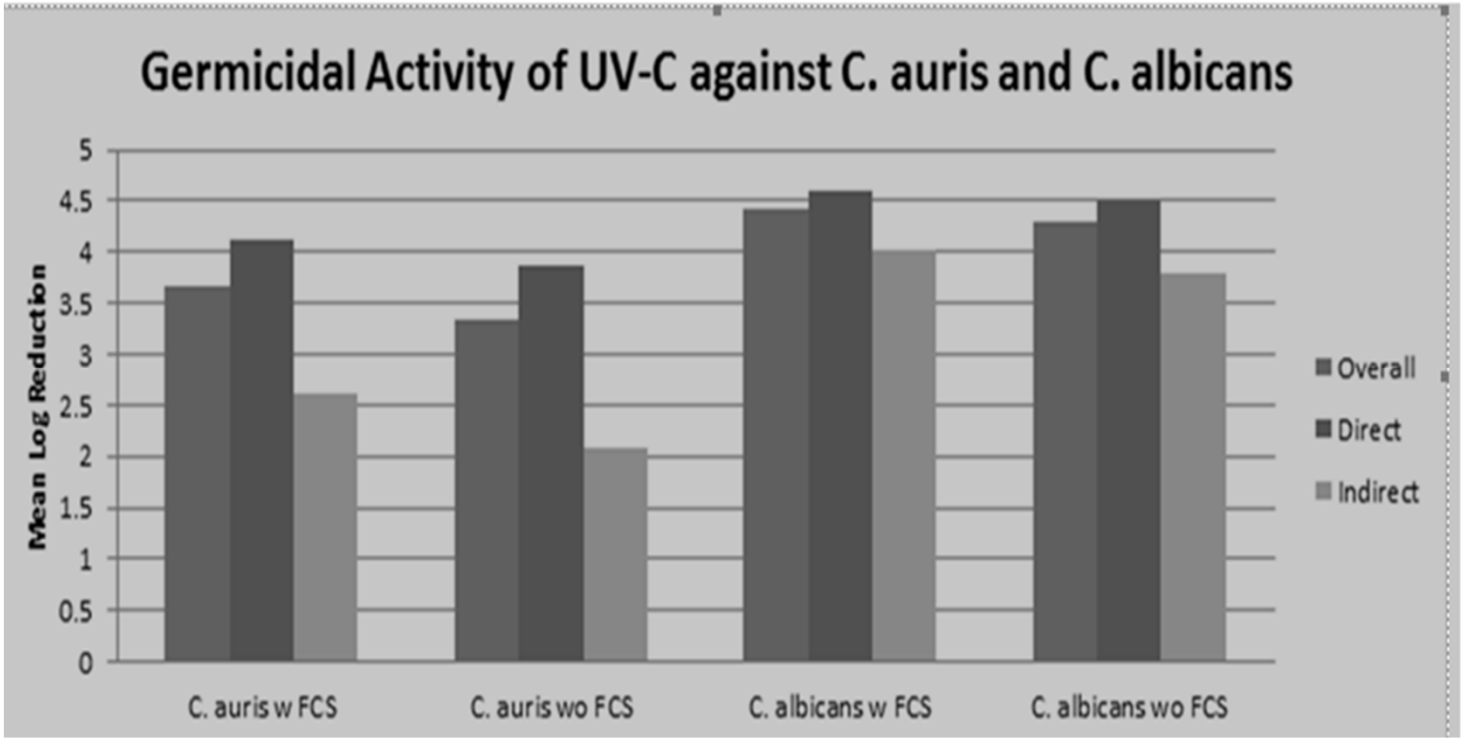
Efficacy of Disinfectants and Antiseptics against Carbapenem-Resistant *Enterobacteriacae*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- ≥3 $\log_{10}$ reduction (CRE, 1m, 5% FCS, QCT)
  - 0.20% peracetic acid
  - 2.4% glutaraldehyde
  - 0.5% Quat, 55% isopropyl alcohol
  - 58% ethanol, 0.1% QUAT
  - 28.7% isopropyl alcohol, 27.3% ethyl alcohol, 0.61% QAC
  - 0.07% o-phenylphenol, 0.06% p-tertiary amylphenol
  - ~5,250 ppm chlorine
  - 70% isopropyl alcohol
  - Ethanol hand rub (70% ethanol)
  - 0.65% hydrogen peroxide, 0.15% peroxyacetic acid
  - Accelerated hydrogen peroxide, 1.4% and 2.0%
  - Quat, (0.085% QACs; not *K. pneumoniae*)

Germicidal Activity of UV-C Against *C. auris* and *C. albicans*

UNC Hospitals, 2017



Very good inactivation of *Candida auris* by UV. Used Tru-D bacteria cycle (17-19 minute cycle, 12,000µWs/cm^2).

ALL “TOUCHABLE” (HAND CONTACT) SURFACES SHOULD BE WIPED WITH DISINFECTANT

“High touch” objects only recently defined (no significant differences in microbial contamination of different surfaces) and “high risk” objects not epidemiologically defined. Cleaning and disinfecting is one-step with disinfectant-detergent. No pre-cleaning necessary unless spill or gross contamination.

Evaluation of Hospital Floors as a Potential Source of Pathogen Dissemination

Koganti et al. ICHE 2016. 37:1374; Deshpande et al. AJIC 2017. 45:336.

- Effective disinfection of contaminated surfaces is essential to prevent transmission of epidemiologically-important pathogens
- Efforts to improve disinfection focuses on touched surfaces
- Although floors contaminated, limited attention because not frequently touched
- Floors are a potential source of transmission because often contacted by objects that are then touched by hands (e.g., shoes, socks)
- Non-slip socks contaminated with MRSA, VRE (Mahida, J Hosp Infect. 2016;94:273

Evaluation of Hospital Floors as a Potential Source of Pathogen Dissemination Using a Nonpathogenic Virus

Koganti et al. ICHE 2016. 37:1374



FIGURE 1. Illustration of high-touch surfaces sampled. Star, surfaces less than or equal to 3 feet from the center of the bed; square, surfaces more than 3 feet from the center of the bed; circle, personal items.

Recovery of Nonpathogenic Viruses from Surfaces and Patients on Days 1, 2, and 3 After Inoculation of Floor Near Bed

Koganti et al. ICHE 2016. 37:1374

Variable	Day 1 (% Positive)	Day 2 (% Positive)	Day 3 (% Positive)
Patient Hands	40	63	43
Patient Footwear	100	100	86
High-touch surface <3ft	58	62	77
High-touch surface >3ft	40	68	34
Personal items	50	44	50
Adjacent room floor	NA	100	80
Adjacent room environment	NA	40	11
Nursing station	53	47	63
Portable equipment	33	23	100

Surfaces <3ft included bedrail, call button, telephone, tray table, etc; surfaces >3ft included side table, chair, IV pole, etc; personal-cell phones, books, clothing, wheelchairs; nurses station included computer keyboard, mouse, etc

Recovery of Nonpathogenic Viruses from Surfaces and Patients on Days 1, 2, and 3 After Inoculation of Floor Near Bed

Koganti et al. ICHE 2016. 37:1374

- Found that a nonpathogenic virus inoculated onto floors in hospital rooms disseminated rapidly to the footwear and hands of patients and to high-touch surfaces in the room
- The virus was also frequently found on high-touch surfaces in adjacent rooms and nursing stations
- Contamination in adjacent rooms in the nursing station suggest HCP contributed to dissemination after acquiring the virus during contact with surfaces or patients
- Studies needed to determine if floors are source of transmission

Evaluation of Hospital Floors as a Potential Source of Pathogen Dissemination

Deshpande et al. AJIC 2017. 45:336.

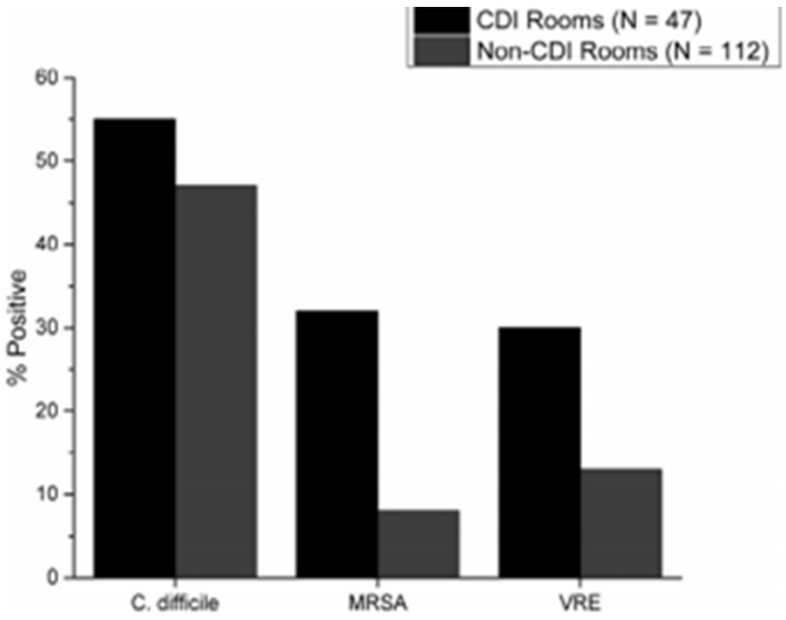
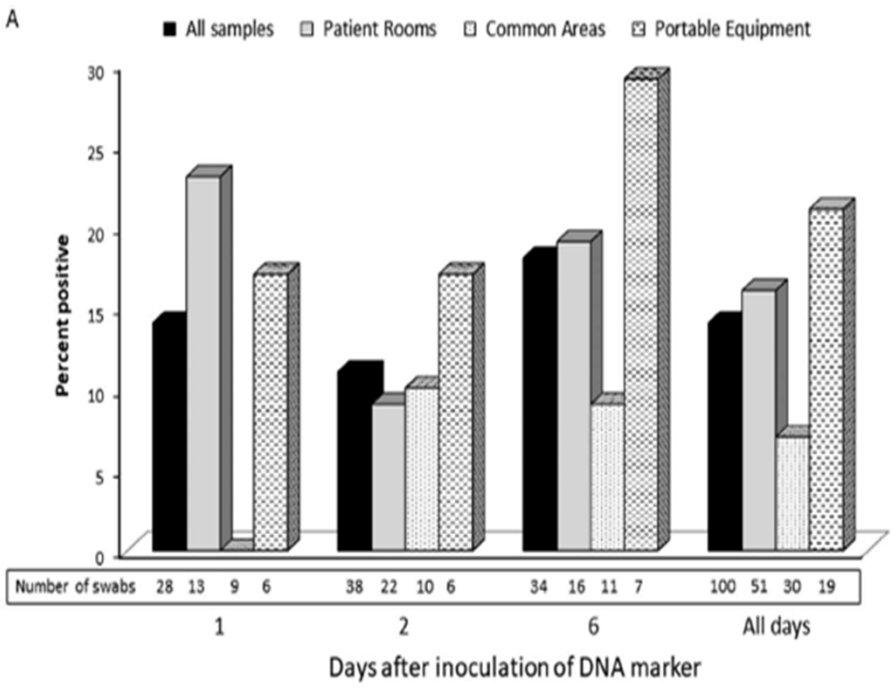


Fig 1. Recovery of *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant enterococci from floors in patient rooms from 5 hospitals in northeast Ohio.

- 318 floors sites sampled in 159 rooms
- *C. difficile* most frequently isolated
- MRSA and VRE isolated more frequently from CDI rooms
- 41% (100) had objects (personal-clothing, phone chargers; medical-BP cuff, call button) in contact with floor
- Of 31 objects on floor, 18% MRSA, 6% VRE, 3% Cd bare/glove cultures positive
- Demonstrates potential for indirect transfer of pathogens to hands from fomites on floor

Potential Vector for Dissemination of Pathogens in an ICU

John et al. ICHE 2017;38:1247-1249



- A DNA marker inoculated onto shared portable equipment in SICU (Doppler ultrasound) and MICU (electrocardiogram) disseminated widely to surfaces in patient rooms and provider work areas and to other types of portable equipment
- Results demonstrate the potential for contaminated portable equipment to serve as a vector for dissemination of pathogens

CDC Guideline for Disinfection and Sterilization

Rutala, Weber, HICPAC. November 2008. www.cdc.gov

Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008

William A. Rutala, Ph.D., M.P.H.[1,2], David J. Weber, M.D., M.P.H.[1,2], and the Healthcare Infection Control Practices Advisory Committee (HICPAC)[3]

It appears that not only is disinfectant use important but how often is important

Daily disinfection vs clean when soiled

Daily Disinfection of High-Touch Surfaces

Kundrapu et al. ICHE 2012;33:1039

Daily disinfection of high-touch surfaces (vs cleaned when soiled) with sporicidal disinfectant (PA) in rooms of patients with CDI and MRSA reduced acquisition of pathogens on hands after contact with surfaces and of hands caring for the patient

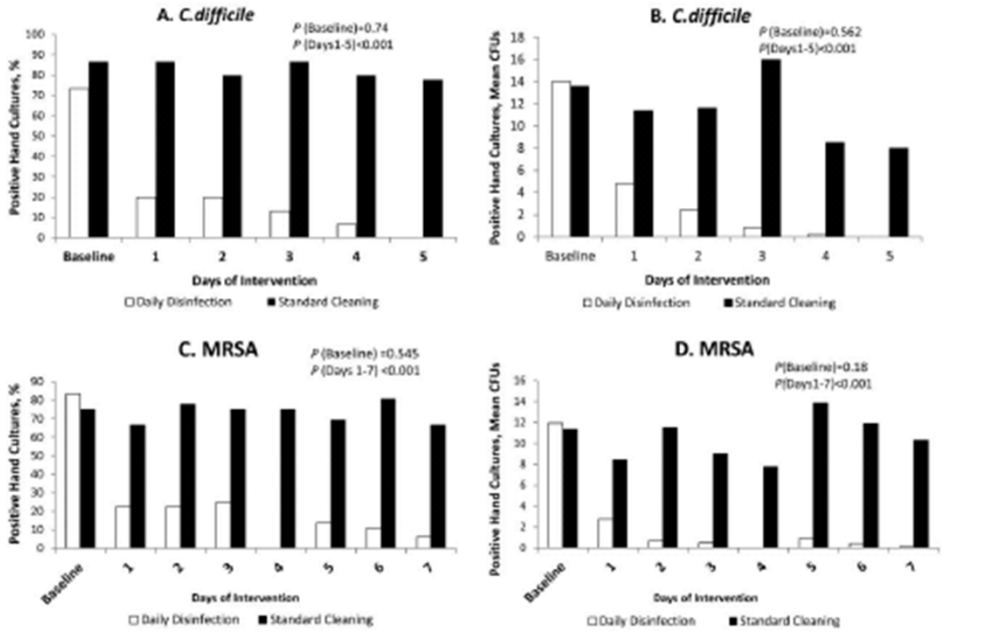


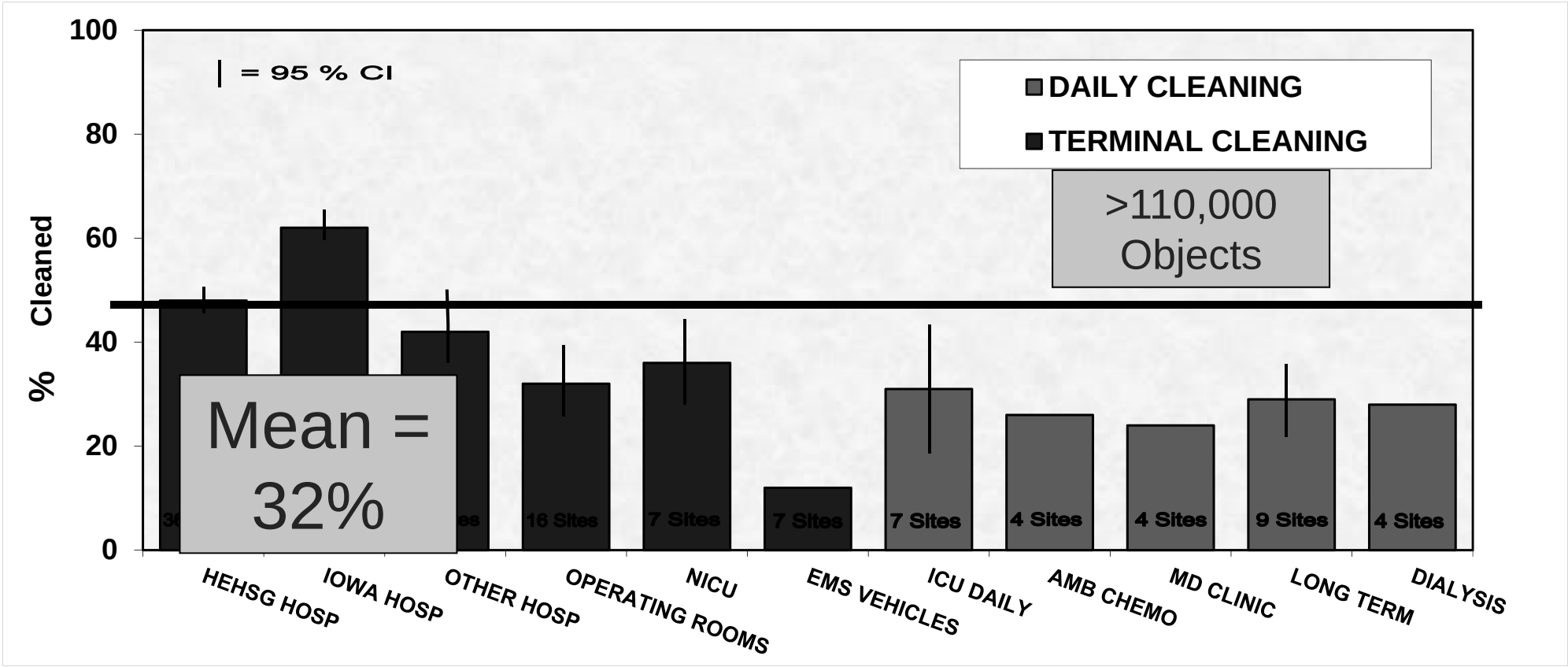
FIGURE 1. Effect of daily disinfection of high-touch environmental surfaces on acquisition of *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* (MRSA) on gloved hands of investigators after contact with the surfaces. *A*, Percentage of positive *C. difficile* cultures; *B*, mean number of *C. difficile* colony-forming units acquired; *C*, percentage of positive MRSA cultures; *D*, mean number of MRSA colony-forming units acquired.

ENVIRONMENTAL CONTAMINATION LEADS TO HAIs

- There is increasing evidence to support the contribution of the environment to disease transmission
- This supports comprehensive disinfecting regimens (goal is not sterilization) to reduce the risk of acquiring a pathogen from the healthcare environment/equipment

Thoroughness of Environmental Cleaning

Carling et al. ECCMID, Milan, Italy, May 2011



MONITORING THE EFFECTIVENESS OF CLEANING

Cooper et al. AJIC 2007;35:338

- Visual assessment-not a reliable indicator of surface cleanliness
- ATP bioluminescence-measures organic debris (each unit has own reading scale, <250-500 RLU)
- Microbiological methods-<2.5CFUs/cm^2-pass; can be costly and pathogen specific
- Fluorescent marker-transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light (applied by IP unbeknown to EVS, after EVS cleaning, markings are reassessed)

DAZO Solution (AKA – Goo)



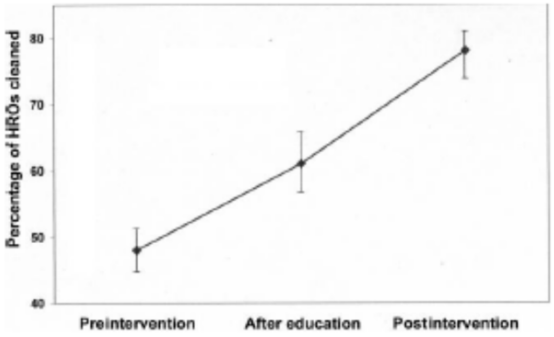
TARGET ENHANCED

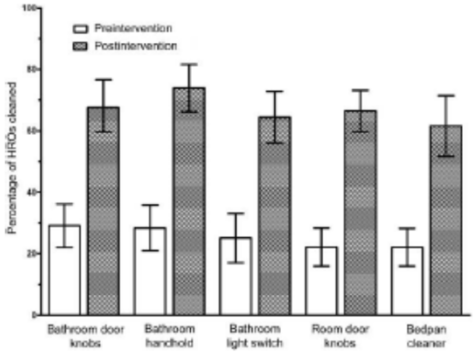


TERMINAL ROOM CLEANING: DEMONSTRATION OF IMPROVED CLEANING

- Evaluated cleaning before and after an intervention to improve cleaning
- 36 US acute care hospitals
- Assessed cleaning using a fluorescent dye
- Interventions
  - Increased education of environmental service workers
  - Feedback to environmental service workers

†Regularly change “dotted” items to prevent targeting objects



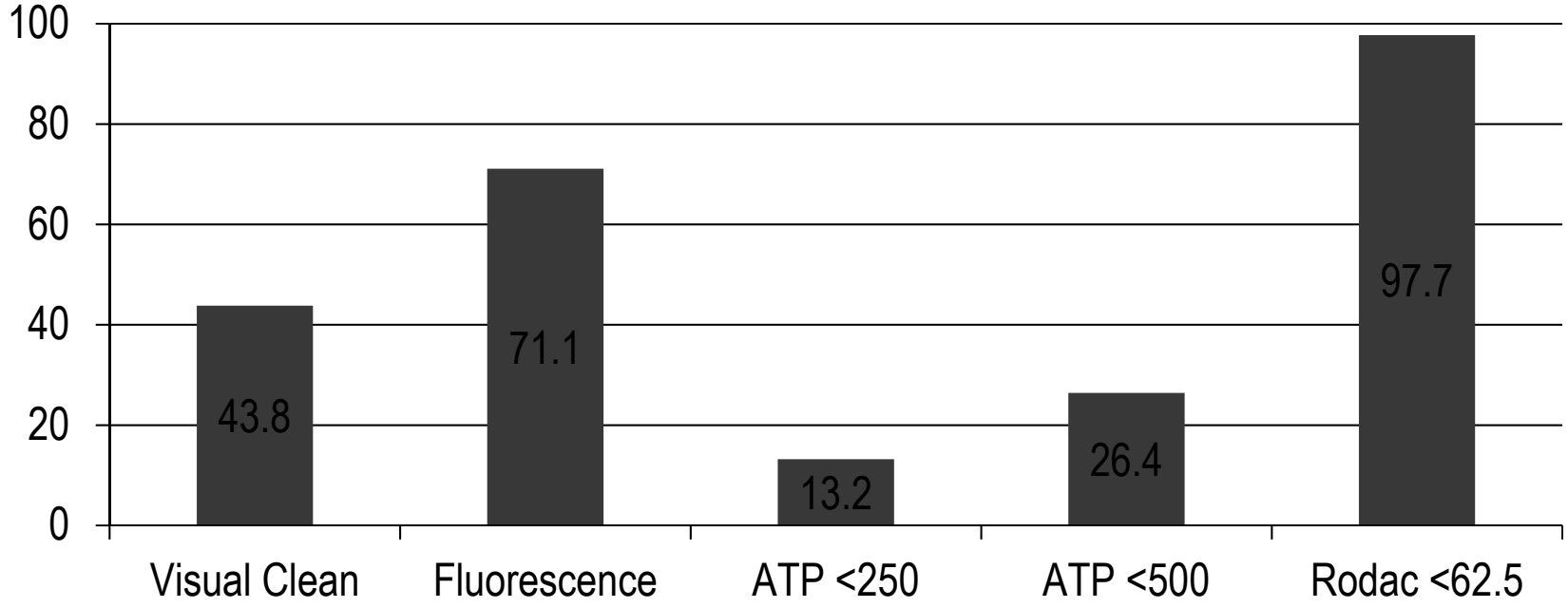


Carling PC, et al. ICHE 2008;29:1035-41

Percentage of Surfaces Clean by Different Measurement Methods

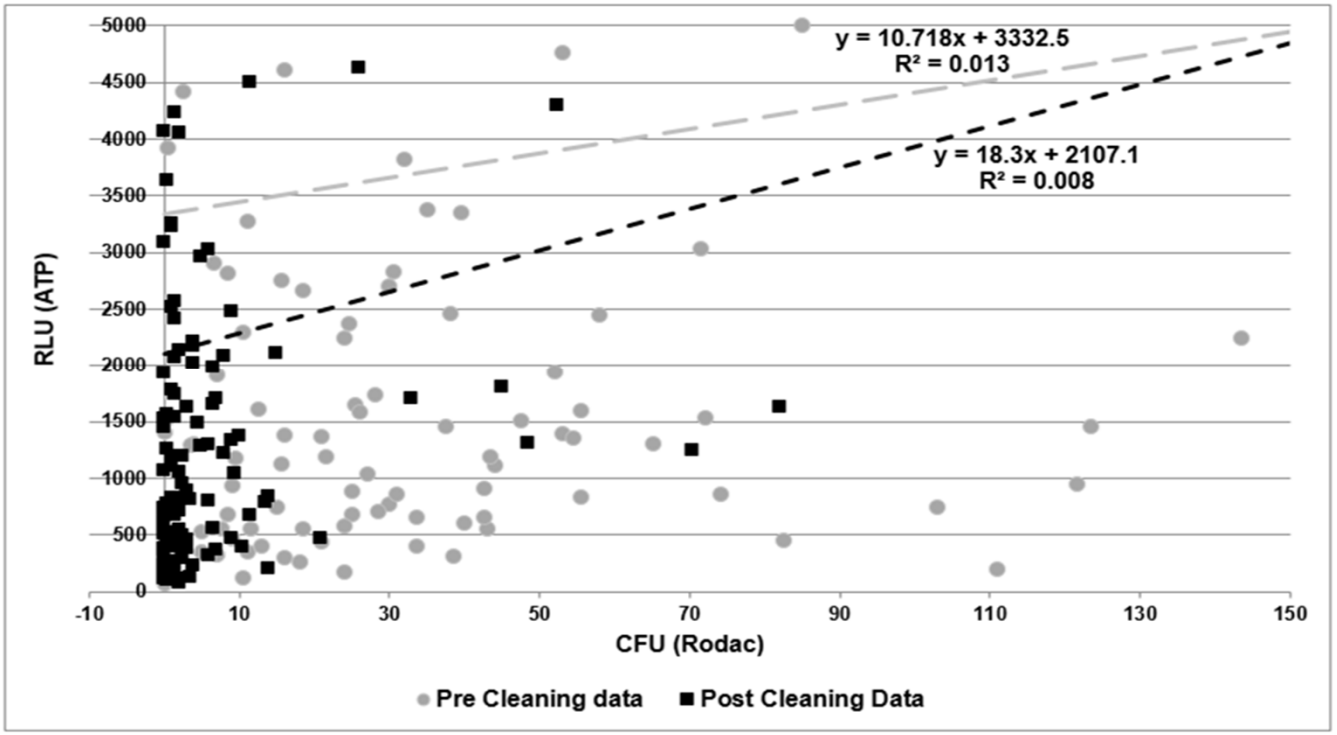
Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017.

Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP



Scatterplot of ATP Levels (less than 5000 RLUs) and Standard Aerobic Counts (CFU/Rodac)

Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017



There was no statistical correlation between ATP levels and standard aerobic plate counts.

Future Methods to Ensure Thoroughness

Future May Have Methods to Ensure Thoroughness



These interventions (effective surface disinfection, thoroughness indicators) not enough to achieve consistent and high rates of cleaning/disinfection

No Touch

(supplements but do not replace surface cleaning/disinfection)

“NO TOUCH” APPROACHES TO ROOM DECONTAMINATION

(will not discuss technology with limited data)

Rutala, Weber. Infect Control Hosp Epidemiol. 2013;41:S36-S41







This technology (“no touch”-UV/HP) should be used (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients on Contact Precautions).

New Technologies for Room/Surface Decontamination

Assessment Parameters

Weber, Rutala et al. Am J Infect Control. 2016;44:e77-e84.

- Safe
- Microbicidal
- Reduction of HAIs
- Cost-effective

Selection of a UV or HP Device

Weber, Rutala et al. Am J Infect Control. 2016;44:e77-e84.

- Since different UV and hydrogen peroxide systems vary substantially, infection preventionists should review the peer-reviewed literature and choose only devices with demonstrated bactericidal capability as assessed by carrier tests and/or the ability to disinfect actual patient rooms
- Ideally, one would select a device that has demonstrated bactericidal capability and the ability to reduce HAIs

Enhanced Disinfection Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Infection

Rutala, Kanamori, Gergen et al. ID Week 2017; Andersen et al. Lancet 2017

	Standard Method		Enhanced method	
	Quat	Quat/UV	Bleach	Bleach/UV
EIP (mean CFU per room)[a]	60.8	3.4	11.7	6.3
Reduction (%)		94	81	90
Colonization/Infection (rate)[a]	2.3	1.5	1.9	2.2
Reduction (%)		35	17	4

All enhanced disinfection technologies were significantly superior to Quat alone in reducing EIPs. Comparing the best strategy with the worst strategy (i.e., Quat vs Quat/UV) revealed that a reduction of 94% in EIP (60.8 vs 3.4) led to a 35% decrease in colonization/infection (2.3% vs 1.5%). Our data demonstrated that a decrease in room contamination was associated with a decrease in patient colonization/infection. First study which quantitatively described the entire pathway whereby improved disinfection decreases microbial contamination which in-turn reduced patient colonization/infection.

Back to the Basics of Disinfection

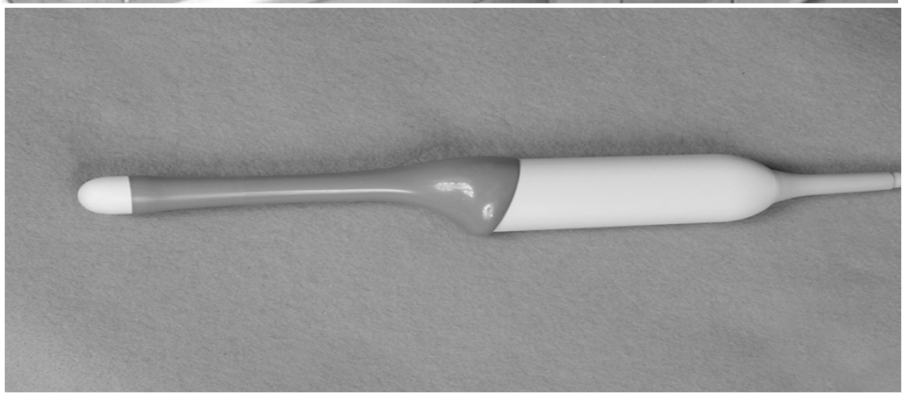
- Overview of disinfection
- Low-level disinfection
  - Role of environment in disease transmission
  - Products and practices for surface disinfection
    - New issues
      - Inactivation of emerging pathogens (e.g., CRE, *C. auris*)
  - Technologies for terminal room decontamination (not including technologies with limited data)
- High-level disinfection
  - Reprocessing channeled scopes
  - Shift from HLD to sterilization
  - HPV

Semicritical Items

Semicritical Medical Devices

Rutala et al. AJIC 2016;44:e47





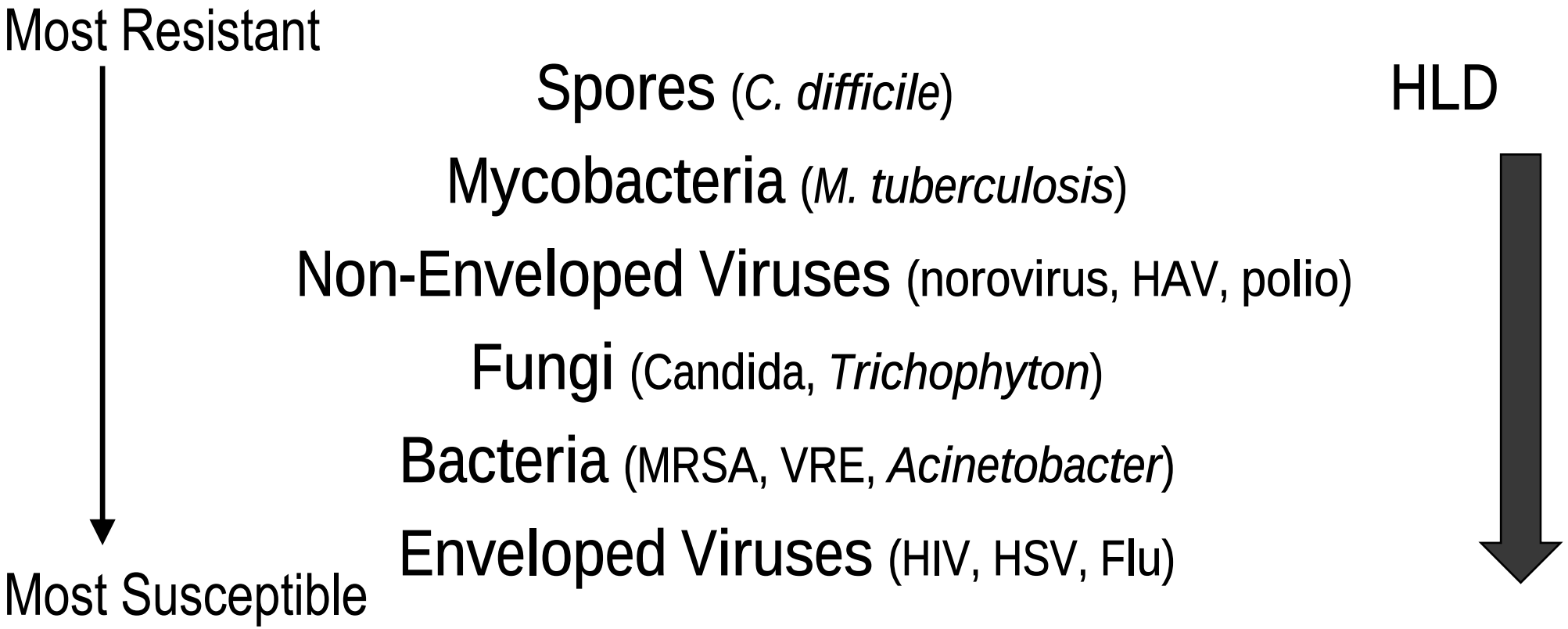
- Semicritical
  - Transmission: direct contact
  - Control measure: high-level disinfection
  - Endoscopes top ECRI list of 10 technology hazards, >100 outbreaks (GI, bronchoscopes)
    - 0 margin of safety
      - Microbial load, 10^7-10^{10}
      - Complexity
      - Biofilm
  - Other semicritical devices, rare outbreaks
    - ENT scopes, endocavitary probes (prostate, vaginal, TEE), laryngoscopes, cystoscopes
    - Reduced microbial load, less complex

Semicritical Items

- Endoscopes
- Respiratory therapy equipment
- Anesthesia equipment
- Endocavitary probes
- Tonometers
- Diaphragm fitting rings

Microbiological Disinfectant Hierarchy

Rutala WA, Weber DJ, HICPAC. www.cdc.gov



High-Level Disinfection of "Semicritical Objects"

Exposure Time ≥ 8m-45m (US), 20°C

Germicide	Concentration
Glutaraldehyde	≥ 2.0%
Ortho-phthalaldehyde	0.55%
Hydrogen peroxide*	7.5%
Hydrogen peroxide and peracetic acid*	1.0%/0.08%
Hydrogen peroxide and peracetic acid*	7.5%/0.23%
Hypochlorite (free chlorine)*	650-675 ppm
Accelerated hydrogen peroxide	2.0%
Peracetic acid	0.2%
Glut and isopropanol	3.4%/26%
Glut and phenol/phenate**	1.21%/1.93%

*May cause cosmetic and functional damage; **efficacy not verified

Transmission of Infection by Endoscopy

Kovaleva et al. Clin Microbiol Rev 2013. 26:231-254

Scope	Outbreaks	Micro (primary)	Pts Contaminated	Pts Infected	Cause (primary)
Upper GI	19	Pa, *H. pylori*, *Salmonella*	169	56	Cleaning/Dis-infection (C/D)
Sigmoid/Colonoscopy	5	*Salmonella*, HCV	14	6	Cleaning/Dis-infection
ERCP	23	*P. aeruginosa* (Pa)	152	89	C/D, water bottle, AER
Bronchoscopy	51	Pa, Mtb, Mycobacteria	778	98	C/D, AER, water
Totals	98		1113	249	

Based on outbreak data, if eliminated deficiencies associated with cleaning, disinfection, AER, contaminated water and drying would eliminate about 85% of the outbreaks.

Preventable Tragedies: Superbugs and How Ineffective Monitoring of Medical Device Safety Fail Patients

Minority Staff Report, January 13, 2016, Patty Murray, Ranking Member

- In January 2015, after several outbreaks of serious infections, Senator Murray initiated an investigation to determine the extent of duodenoscope-linked infections
- Between 2012 and spring 2015, closed-channel duodenoscopes were linked to at least 25 different incidents of antibiotic-resistant infections that sickened at least 250 patients worldwide
- None of the manufacturers of the “closed-channel” duodenoscopes had sufficient data to show that duodenoscopes could be cleaned reliably between uses

RECENT ENDOSCOPY-RELATED OUTBREAKS OF MRDO WITHOUT REPROCESSING BREACHES

Rutala WA et al. Manuscript in preparation

MDRO	Scope	No.	Recovered From Scope	Molecular Link	Reference
P. aeruginosa (VIM-2)	Duodenoscope	22	Yes, under forceps elevator	Yes	Verfaillie CJ, 2015
E. coli (AmpC)	Duodenoscope	35	Yes (2 scopes)	Yes	Wendorf, 2015
K. pneumoniae (OXA)	Duodenoscope	12	No	Yes	Kola A, 2015
E. coli (NDM-CRE)	Duodenoscope	39	Yes	Yes	Epstein L, 2015
K. pneumoniae	Duodenoscope	15	No	Yes	Kim S, 2016
K. pneumoniae	Duodenoscope	34	Yes	Yes	Marsh J, 2015
E. coli	Duodenoscope	3	No	Unknown	Smith Z, 2015
K. pneumoniae	Duodenoscope	13	Yes	Yes	Carbonne A, 2010

Reprocesssing Failures Have Led to Patient Notifications and Bloodborne Pathogens Testing

Rutala WA, Weber DJ. Infect Control Hosp Epidemiol 2007;28:146-155

TABLE 1. Reprocessing Failures of Semicritical or Critical Medical Instruments Resulting in Patient Notification

Location or institution, year	Instrument involved	No. of persons exposed
Sacramento, CA, 2002	Endoscope	750
Toronto, ON, 2003	Endoscope	146
Seattle, WA, 2004	Endoscope	600
Sacramento, CA, 2004	Endoscope	1,331
San Francisco, CA, 2004	Endoscope	2,000
Long Island, NY, 2004	Endoscope	177
Charleston, NC, 2004	Endoscope	1,383
Toronto, ON, 2003	Prostate biopsy probe	900
Pittsburgh, PA, 2005	Endoscope	200
Leesburg, VA 2005	Endoscope	144
San Diego, CA, 2006	Endoscope	300
Augusta, ME, 2006	Prostate biopsy needle	481
Dept Veterans Affairs, 2006	Prostate biopsy equipment	2,075
San Diego, CA, 2006	Surgical instrument	82

NOTE. Modified from a presentation by Douglas Nelson, MD, at the 33rd Annual Conference and International Meeting of the Association for Professionals in Infection Control and Epidemiology: Tampa, Florida, 2006.

Because more outbreaks associated with endoscopes than any other reusable medical device, endoscopes top ECRI's list of 10 health technology hazards

If we eliminate the risk of disease transmission associated with endoscopes, will eliminate risk associated with all medical and surgical devices

GI Endoscopes: Shift from Disinfection to Sterilization

Rutala, Weber. JAMA 2014. 312:1405-1406

EDITORIAL

Editorials represent the opinions of the authors and *JAMA* and not those of the American Medical Association.

Gastrointestinal Endoscopes
A Need to Shift From Disinfection to Sterilization?

William A. Rutala, PhD, MPH; David J. Weber, MD, MPH

More than 10 million gastrointestinal endoscopic procedures are performed annually in the United States for diagnostic purposes, therapeutic interventions, or both.[1] Because gastrointestinal endoscopes contact mucosal surfaces, use of a contaminated endoscope may lead to patient-to-patient transmission of potential pathogens with a subsequent risk of infection.[1]

In this issue of *JAMA*, Epstein and colleagues[2] report findings from their investigation of a cluster of New Delhi metallo-β-lactamase (NDM)-producing *Escherichia coli* associated with gastrointestinal endoscopy that occurred from March 2013 to July 2013 in a single hospital in northeastern Illinois. During the 5-month period, 9 pa-

Related article page 1447

First, endoscopes are semicritical devices, which contact mucous membranes or nonintact skin, and require at least high-level disinfection.[3,4] High-level disinfection achieves complete elimination of all microorganisms, except for small numbers of bacterial spores. Because flexible gastrointestinal endoscopic instruments are heat labile, only high-level disinfection with chemical agents or low-temperature sterilization technologies are possible.[3] However, no low-temperature sterilization technology is US Food and Drug Administration (FDA)-cleared for gastrointestinal endoscopes such as duodenoscopes.

Second, more health care-associated outbreaks and clusters of infection have been linked to contaminated endoscopes than to any other medical device.[3,5] However, until now,

ENDOSCOPE REPROCESSING

CDC 2008: Multi-Society Guideline on Endoscope Reprocessing, 2017

- PRECLEAN-point-of-use (bedside) remove debris by wiping exterior and aspiration of detergent through air/water and biopsy channels; leak test
- CLEAN-mechanically cleaned with water and enzymatic cleaner
- HLD/STERILIZE-immerse scope and perfuse HLD/sterilant through all channels for exposure time (>2% glut at 20m at 20^{o}C). If AER used, review model-specific reprocessing protocols from both the endoscope and AER manufacturer
- RINSE-scope and channels rinsed with sterile water, filtered water, or tap water. Flush channels with alcohol and dry
- DRY-use forced air to dry insertion tube and channels
- STORE-hang in vertical position to facilitate drying; stored in a manner to protect from contamination

Endoscope Reprocessing Methods

Ofstead , Wetzler, Snyder, Horton, Gastro Nursing 2010; 33:204

Performed all 12 steps with only 1.4% of endoscopes using manual versus 75.4% of those processed using AER

TABLE 3. Documented Completion of Steps During Manual Cleaning With High-Level Disinfection Reprocessing

Observed Activity	Steps Completed (%) (n = 69)
Leak test performed in clear water	77
Disassemble endoscope completely	100
Brush all endoscope channels and components	43
Immerse endoscope completely in detergent	99
Immerse components completely in detergent	99
Flush endoscope with detergent	99
Rinse endoscope with water	96
Purge endoscope with air	84
Load and complete automated cycle for high-level disinfection	100
Flush endoscope with alcohol	86
Use forced air to dry endoscope	45
Wipe down external surfaces before hanging to dry	90

Microbial Surveillance of GI Endoscopes

Saliou et al. Endoscopy. 2016

Characteristics of Sample	Action Level (TCU>100/scope) or EIP
Gastroscope	26.6%
Colonoscope	33.7%
Duodenoscope	34.7%
Echo-endoscope	31.9%
AER	27.2%
Manual	39.3%
Age of endoscope <2 years	18.9%
Age of endoscope >2 years	38.8%

Visual Inspections of Colonoscopes and Gastroscopes

Ofstead et al. Am J Infect Control. 2017. 45:e26-e33

- All endoscopes (n=20) had visible irregularities (e.g., scratches)
- Researchers observed fluid (95%), discoloration, and debris in channels

Disinfection and Sterilization

WA Rutala, DJ Weber, and HICPAC, www.cdc.gov

EH Spaulding believed that how an object will be disinfected depended on the object's intended use (developed 1968).

CRITICAL - objects which enter normally sterile tissue or the vascular system or through which blood flows should be sterile.

SEMICRITICAL - objects that touch mucous membranes or skin that is not intact require a disinfection process (high-level disinfection [HLD]) that kills all microorganisms but high numbers of bacterial spores.

NONCRITICAL -objects that touch only intact skin require low-level disinfection (or non-germicidal detergent).

Disinfection and Sterilization

Rutala, Weber. Am J Infect Control. 2016;44:e1-e6; Rutala, Weber ICHE. 2015;36:643.

EH Spaulding believed that how an object will be disinfected depended on the object's intended use (modified).

CRITICAL - objects which directly or secondarily (i.e., via a mucous membrane such as duodenoscope, cystoscope, bronchoscope) enter normally sterile tissue or the vascular system or through which blood flows should be sterile.

SEMICRITICAL - objects that touch mucous membranes or skin that is not intact require a disinfection process (high-level disinfection [HLD]) that kills all microorganisms but high numbers of bacterial spores.

NONCRITICAL -objects that touch only intact skin require low-level disinfection (or non-germicidal detergent).

Other Issues

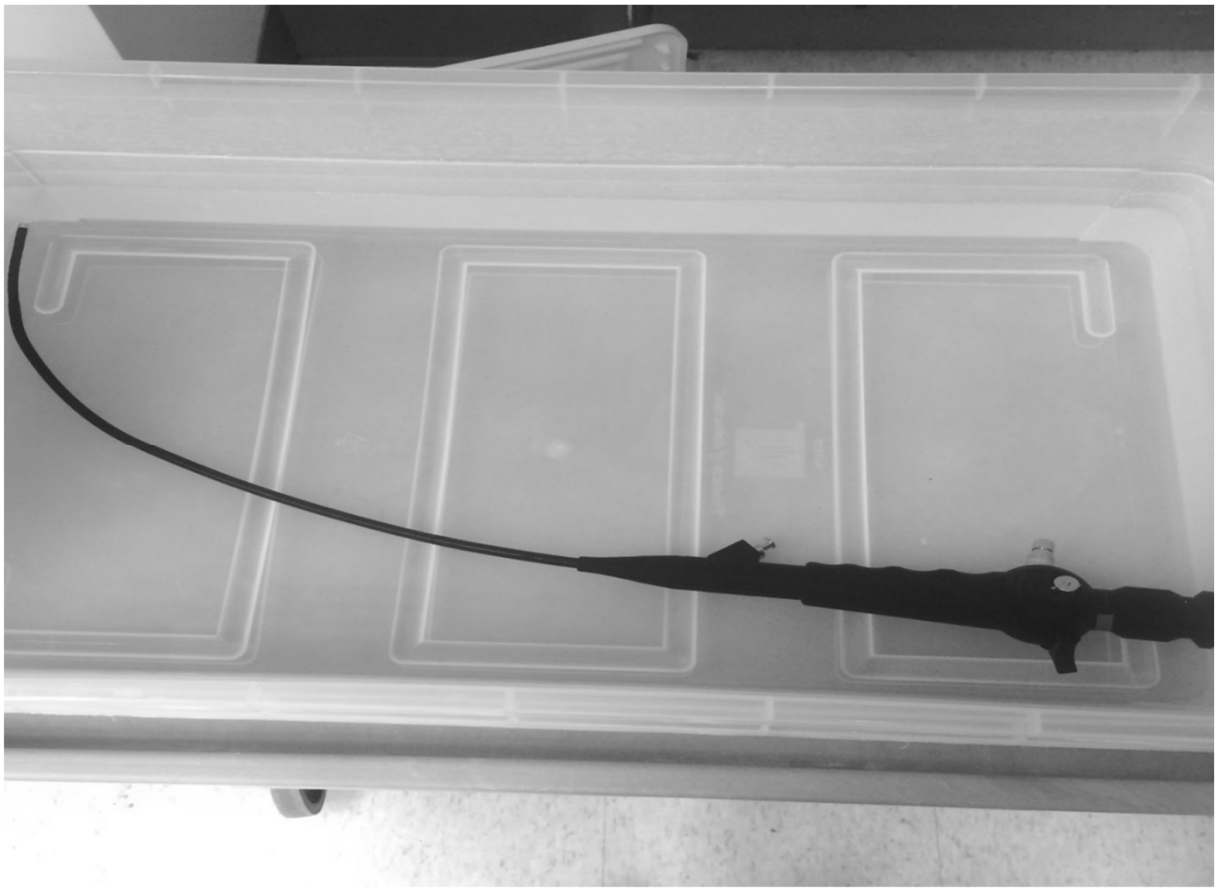
Storage of Semicritical Items

Rutala, Weber, SHEA Handbook, 2016. In press

- In 2011, TJC recommended that laryngoscope blades be packaged in a way that prevent recontamination
- Examples of compliant storage include, but not limited to, a peel pouch or a closed plastic bag
- Examples of non-compliant storage would include unwrapped blades in an anesthesia drawer as well as unwrapped blades on top of or within a code cart
- Packaging not only prevents recontamination but also distinguishes a processed from non-processed semicritical item such as a specula, endoscope, etc
- The use of a tagging system that separates processed from non-processed items minimizes the use of a semicritical item that has not been reprocessed, and minimizes unnecessary patient exposures and risk of disease transmission

Reprocessing Channeled Endoscopes

Cystoscope- “completely immerse” in HLD (J Urology 2008.180:588)



Reprocessing Channeled Endoscopes

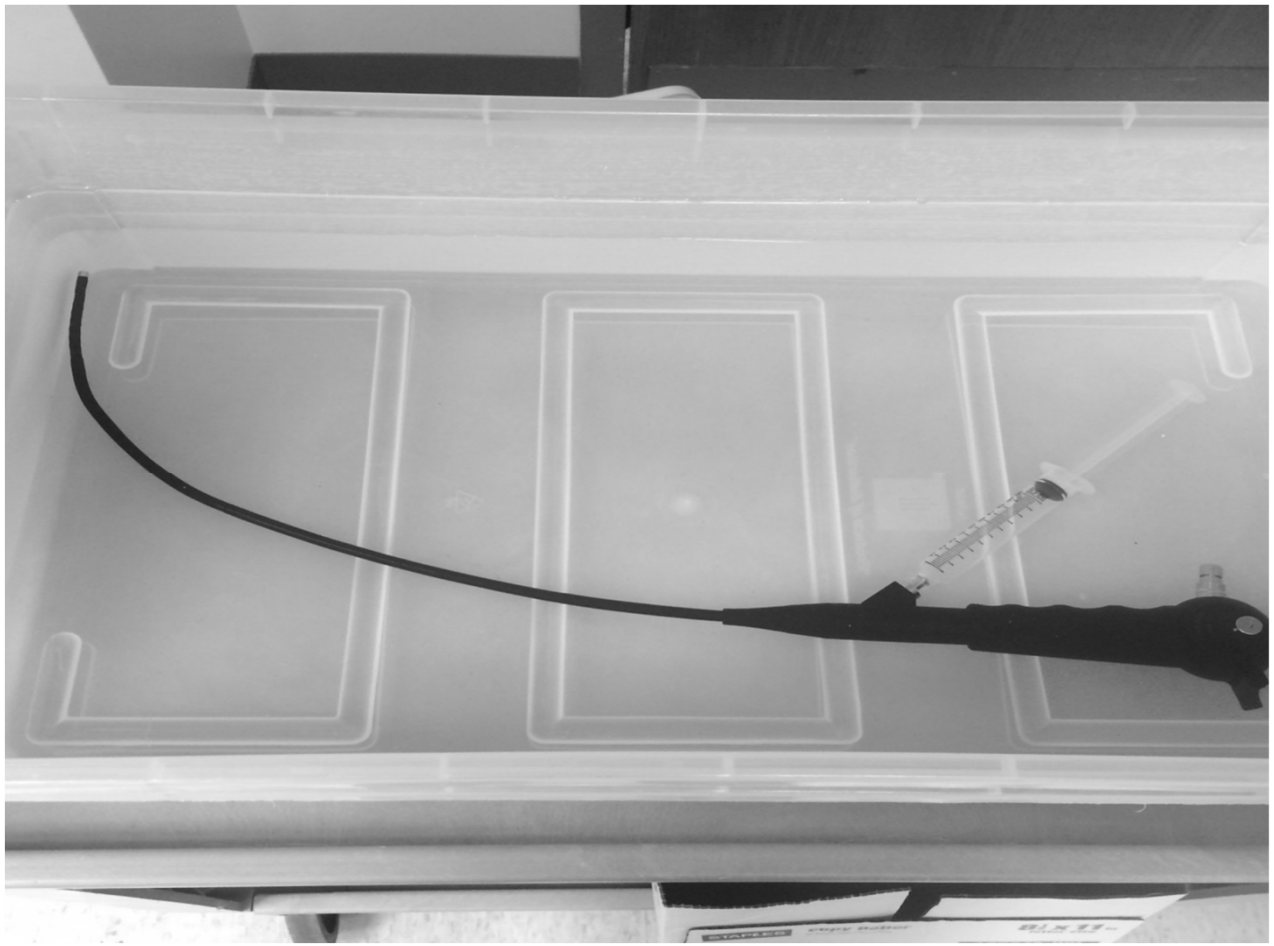
Rutala, Gergen, Bringhurst, Weber. ICHE. 2016;37:228-231

Exposure Method	CRE (*K. pneumoniae*) Inoculum before HLD (glutaraldehyde)	CRE (K. pneumoniae) Contamination after HLD
Passive HLD (immersed, not perfused)	$3.2x10^8$ $1.9x10^9$ $4.1x10^8$	$3.1x10^8$ $4.6x10^8$ $1.0x10^8$
Active HLD (perfused HLD into channel with syringe)	$3.0x10^8$ $9.2x10^8$ $8.4x10^8$	0 0 0

- Pathogens must have exposure to HLD for inactivation
- Immerse channeled flexible scope into HLD will not inactivate channel pathogens
- Completely immerse the endoscope in HLD and ensure all channels (e.g., hysteroscopes, cystoscopes) are perfused
- Air pressure in channel stronger than fluid pressure at fluid-air interface

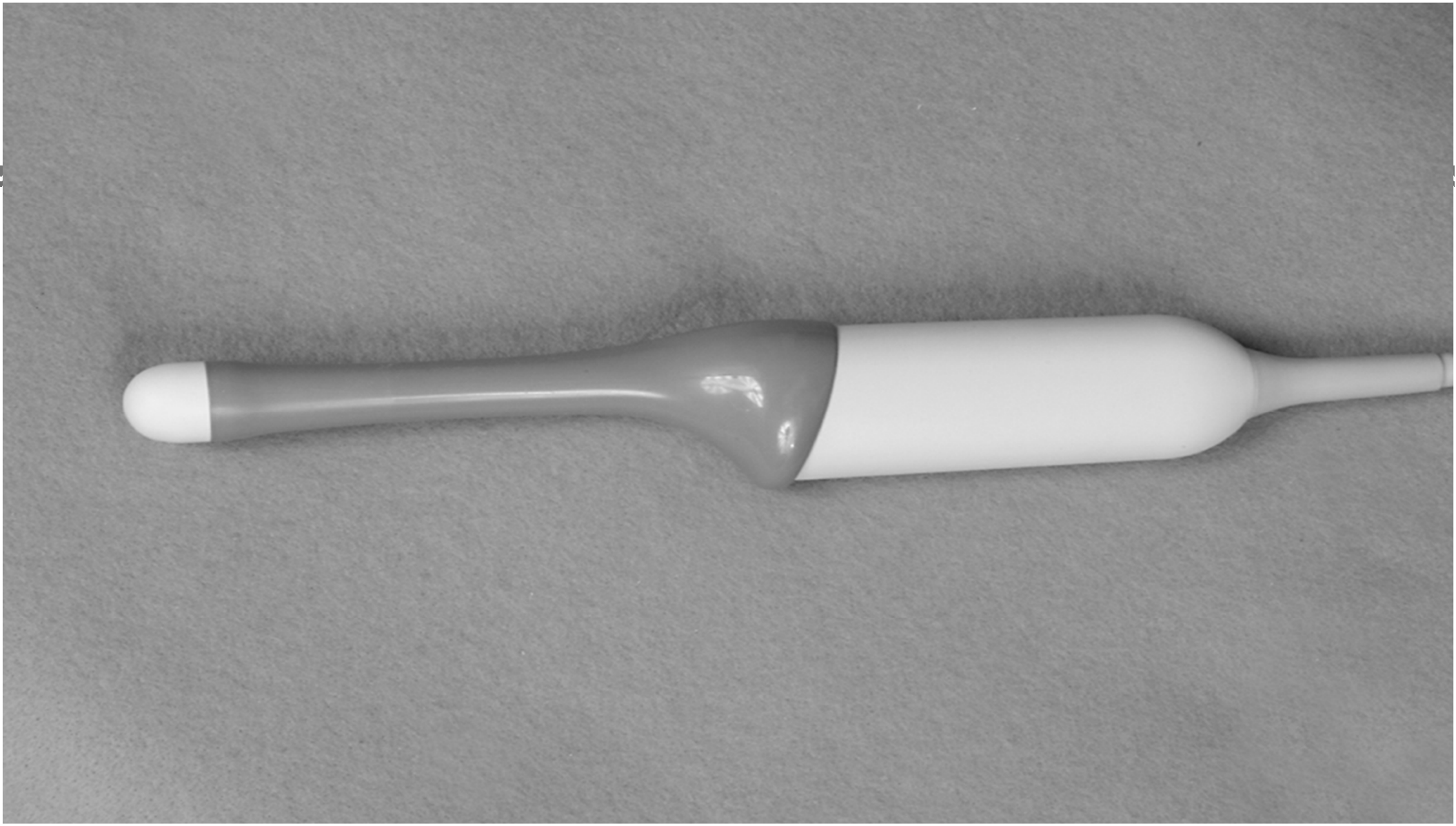
Reprocessing Channeled Endoscopes

Cystoscope-HLD perfused through lumen with syringe (luer locks onto port and syringe filled and emptied until no air exits in the scope nor air in barrel of syringe-syringe and lumen filled with HLD)



Summary

- High-level disinfection guidelines must be followed to prevent exposure to pathogens that may lead to infection (laryngoscopes, endocavitary probes)
- Ensure channeled scopes are perfused with HLD



Human Papillomavirus Contamination of Gynecologic Equipment

Gallay et al. Sex Transm Infect. 2016. 92:19-23

- Assess presence of HPV on equipment used in GYN practice
- Samples from fomites (glove box, lamp on GYN chair, gel tubes, colposcope, speculum) in 2 hospitals and 4 private practices
- Samples analyzed by real-time PCR
- 32 (18%) HPV-positive samples found
- Higher risk of HPV contamination in GYN private practices
- Colposcope had the highest risk of contamination
- Equipment and surfaces contaminated, need strategies to prevent contamination and transmission

ENDOSCOPE/ENDOCAVITARY PROBES REPROCESSING: CHALLENGES
Susceptibility of Human Papillomavirus
J Meyers et al. J Antimicrob Chemother, Epub Feb 2014

- Most common STD
- In one study, FDA-cleared HLD no effect on HPV
- Finding inconsistent with other small, non-enveloped viruses such as polio, rhino, echo
- Further investigation needed: test methods unclear; glycine; organic matter; comparison virus
- Conversation with CDC: validate and use HLD consistent with FDA-cleared instructions (no alterations)

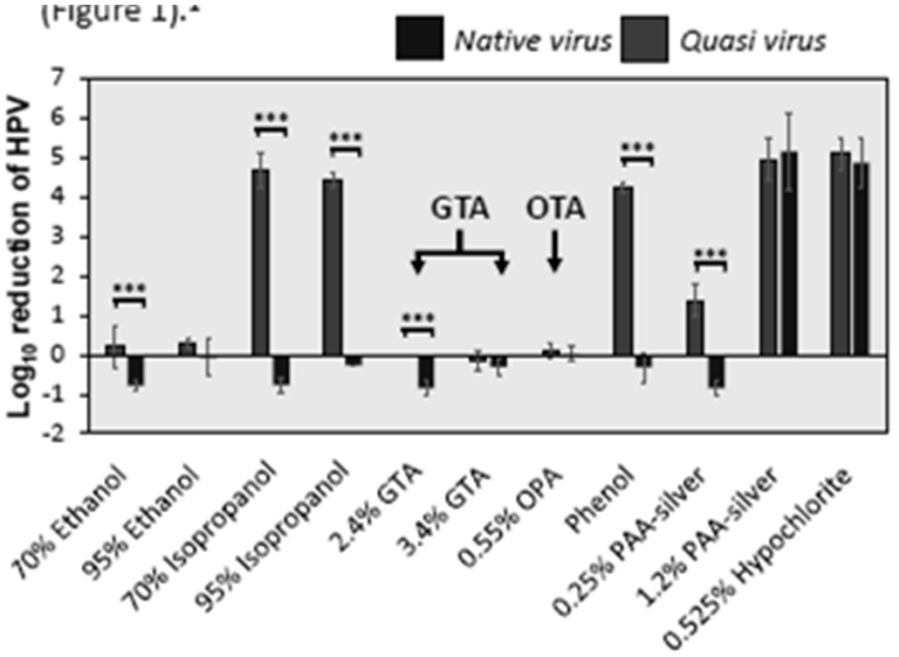


Figure 1: Susceptibility of HPV virions to clinical disinfectants. Both authentic virus and quasivirus were incubated with the indicated disinfectants for a contact time of 45 min. Disinfectants were neutralized and the virus was added to HaCaT cells for infection. Data shown are the averages of at least five independent experiments, with errors shown as the standard deviations of all experiments. **P<0.01; ***P<0.001.

Hydrogen Peroxide Mist

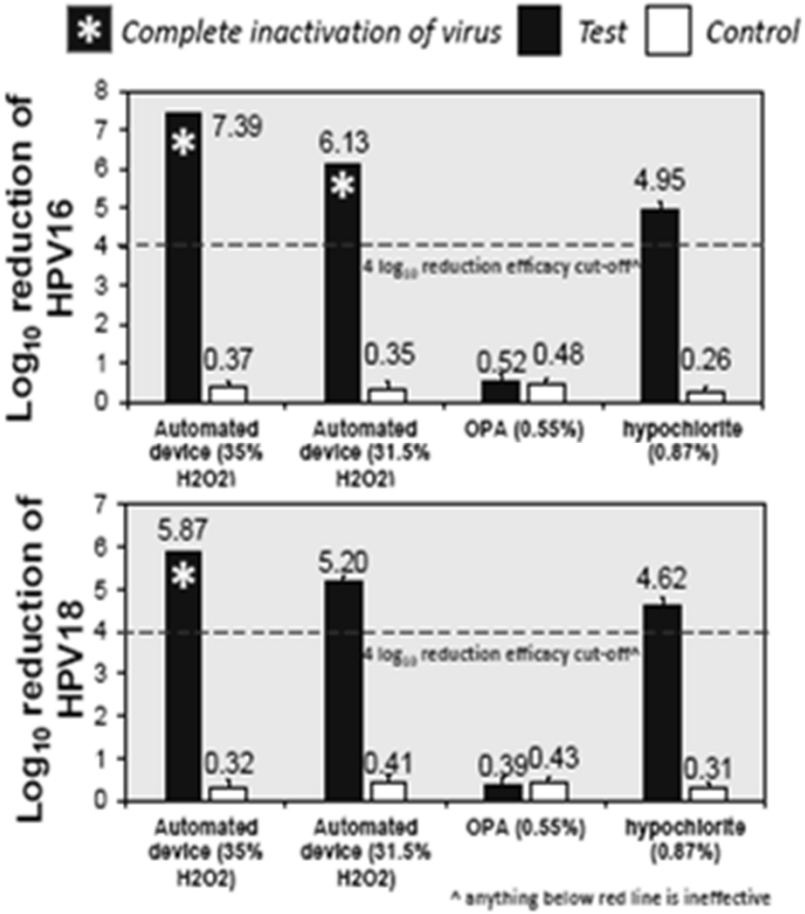
(uses HP mist to achieve HLD in 7m)





Efficacy of HP Mist Against HPV

Meyers C et al. SHEA Poster, 2015



- HLD widely used to reprocess semicritical items including endocavitary probes
- Tested OPA, hypochlorite and HP mist
- HP mist system and hypochlorite >4 log_{10} reduction, OPA achieved <1 log_{10} reduction

Effectiveness of HP Mist System in Inactivating Healthcare Pathogens on Probes

Rutala, Gergen, Sickbert-Bennett. ICHE 2016;37:613-614

TABLE 1. Proportion of Surface and Endocavitary Probes Positive After [redacted] System Processing According to the Presence or Absence of an Organic Challenge*

5% Fetal Calf Serum-FCS	Probes with vancomycin-Resistant *Enterococcus* (VRE), No./Total	Probes with CR *Klebsiella pneumoniae*, No./Total	Probes with *Mycobacterium terrae*, No./Total (mean $\log_{10}$ reduction and 95% CI)	Probes with *Clostridium difficile* spores, No./Total (mean $\log_{10}$ reductions and 95% CI)
Present	0/7	0/6	4/9 (5.19 [4.61–5.76])	3/6 (5.12 [4.42–5.83])
Absent	0/6	0/6	1/6 (4.62 [4.07–5.17])	1/9 (6.23 [6.02–6.43])

- Automated, closed system that uses HP mist for HLD of ultrasound probes
- >10^6 pathogens inoculated onto probe at 2-3 sites
- Inactivated bacteria and good but not complete kill of mycobacteria, spores
- Alternative to high-level disinfection by high-level disinfectants

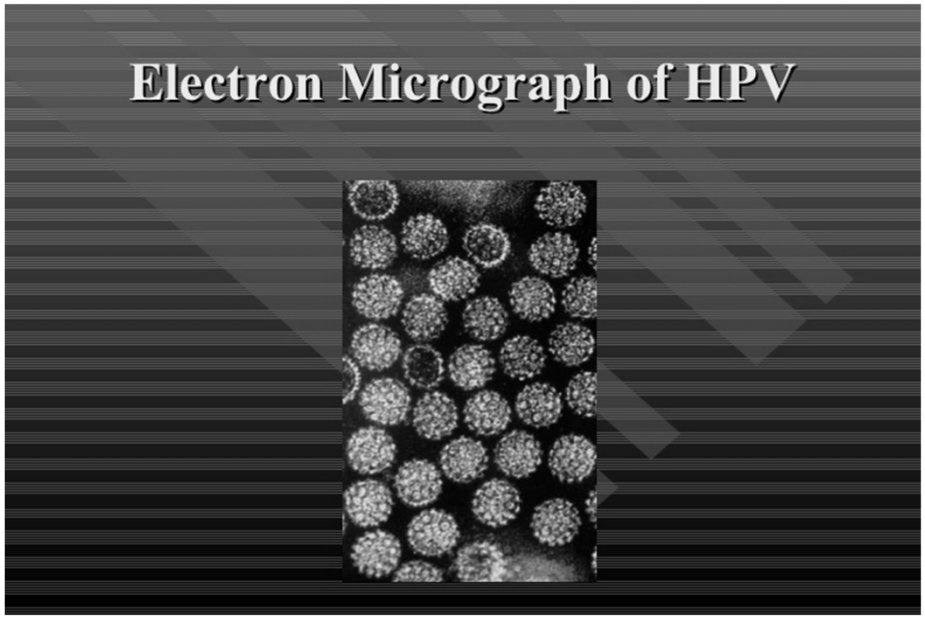
Effectiveness of Germicides Against HPV

(Dr. Carey Allen Moody, UNC and Duke UMC)

- Germicides
  - Aldehydes
    - Glutaraldehyde
    - Ortho-phthalaldehyde
  - Others
    - Phenolics
    - Ethanol
    - CHG-4%
    - Quats

- Germicides
  - Oxidizing agents
    - 1.5% and 2.0% accelerated HP
    - 0.525% sodium hypochlorite
    - 1% HP/0.08% peracetic acid
    - O.2% peracetic acid, 55^{o}C
    - 1000-1300ppm peracetic acid

What if HPV is Resistant to Aldehydes?



- If unlike all other non-enveloped viruses that are susceptible to aldehydes
- Upset the Spaulding classification scheme (HLD kill all viruses)
- If only oxidizing agents kill HPV (transition to PA or HP alone or combination)

Back to the Basics of Disinfection

- Overview of disinfection
- Low-level disinfection
  - Role of environment in disease transmission
  - Products and practices for surface disinfection
    - New issues
      - Inactivation of emerging pathogens (e.g., CRE, *C. auris*)
  - Technologies for terminal room decontamination (not including technologies with limited data)
- High-level disinfection
  - Reprocessing channeled scopes
  - Shift from HLD to sterilization
  - HPV

Back to the Basics of Disinfection
Summary

- Implement evidence-based practices for surface and instrument disinfection
  - Ensure use of safe and effective (against emerging pathogens such as *C. auris* and CRE) low-level disinfectants
  - Ensure thoroughness of cleaning (new thoroughness technology)
  - Use “no touch” room decontamination technology proven to reduce microbial contamination on surfaces and reduction of HAIs at terminal/discharge cleaning
  - Endoscope represent a nosocomial hazard. Urgent need to understand the gaps in endoscope reprocessing. Reprocessing guidelines must be followed to prevent exposure to pathogens that may lead to infection.

THANK YOU!
www.disinfectionandsterilization.org

