Disinfection and Sterilization
Current Issues, New Research and New Technology

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Disclosure: PDI, Kinnos, Ideate Medical

November 2025

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Disinfection and Sterilization
Current Issues, New Research and New Technology

- Fifteen articles/topics were selected for presentation as they represented current issues, new research and/or new technologies
  - PubMed data was searched for all studies on disinfection and sterilization in past 5 years
  - About 2,500 abstracts reviewed
- Most significant change to reduce infection risk-sterilization of endoscopes

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Disinfection and Sterilization

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

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

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**.

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Infection Control & Hospital Epidemiology (2025), 1–23
doi:10.1017/ice.2025.41

SHEA

SHEA Expert Guidance

Multisociety guidance for sterilization and high-level disinfection

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Abstract

SHEA, in partnership with ASGE, APIC, AAMI, AORN, HSPA, IDSA, SGNA, and The Joint Commission, developed this multisociety infection prevention guidance document for individuals and organizations that engage in sterilization or high-level disinfection (HLD). This document follows the *CDC Guideline for Disinfection and Sterilization in Healthcare Facilities*. This guidance is based on a synthesis of

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Infection Control & Hospital Epidemiology (2025), 1–23
doi:10.1017/ice.2025.41

SHEA

SHEA Expert Guidance

Multisociety guidance for sterilization and high-level disinfection

- SHEA, in partnership with ASGE, APIC, AORN, HSPA, IDSA, SGNA, TJC developed this multi-society infection prevention guidance document
- Based on synthesis of published scientific evidence, theoretical rationale, current practices, practical considerations, written group consensus, and consideration of potential harm
- Addresses 45 topics

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Mobile UVC Robotic Systems

Astrid et al Anti Resist IC. 2021; Russo et al Int J Env Res Pub Hlt 2021; Casini et al. Int J Env Res Publ Hlt 2023; Bratu at al. Sensors. 2024.

- Contaminated hospital environment is a reservoir for various pathogens
- May serve as a source of HAIs
- Conventional manual CD are not always sufficient to eliminate risk posed by contaminated surfaces
- Humans are a contributing factor
- UVC, now UVC robots developed to overcome shortcomings
- AI driven; microbial reductions > manual CD; huge potential but needs further development

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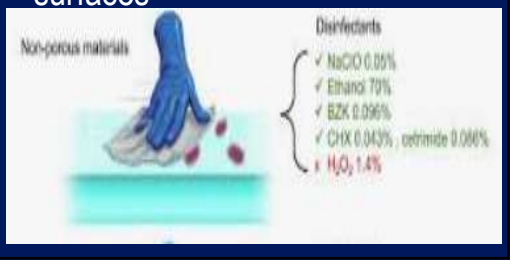
Efficacy of Disinfectants for Mpox Inactivation

(mpox outbreak highlights the need intervention-disinfection, transmission via surfaces)

Pitol et al. Environ Sci Technol 2024;58:19981

- Conducted on porous carriers (ceramic, wood); wiped in triplicate; 1 min contact
- NaOCl and ethanol effective

- Conducted on non-porous carriers (SS, glass, plastic, latex)
- 99.97% reduction except HP
- Use NaOCl or ethanol on clean surfaces



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Disposable Chlorine Dioxide Wipes

Tofanelli et al. Am J Otolaryngol 2020

- 320ppm chlorine dioxide
- Registered as HLD for manual application using wipes; 2 min at 20°C
- Per FDA, for processing endocavity transvaginal, transrectal and skin surface transducers only

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Rapid Environmental Contamination with *Candida auris* and MRDO Near Colonized Patients

Sansom et al. Clin Infect Dis 2024

- Environmental contamination is suspected to play an important role in *C. auris* and MDRO transmission
- Understanding how *C. auris* colonization contributes to environmental contamination is critical to inform infection prevention and outbreak response.
- This study measured time to environmental contamination to determine whether more cleaning/disinfection of high touch objects should be recommended to reduce transmission risk from *C. auris* and MDRO carriers

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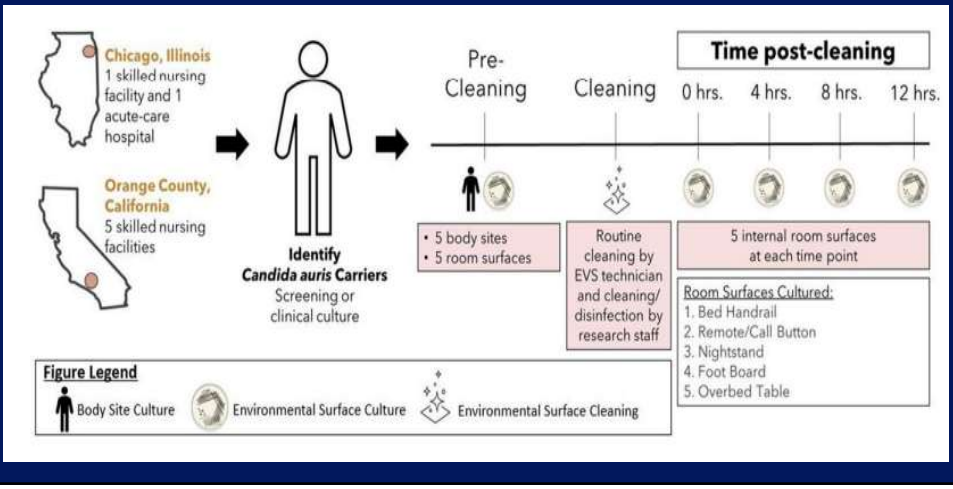
Rapid Environmental Contamination with *Candida auris* and MRDO Near Colonized Patients

Sansom et al. Clin Infect Dis 2024



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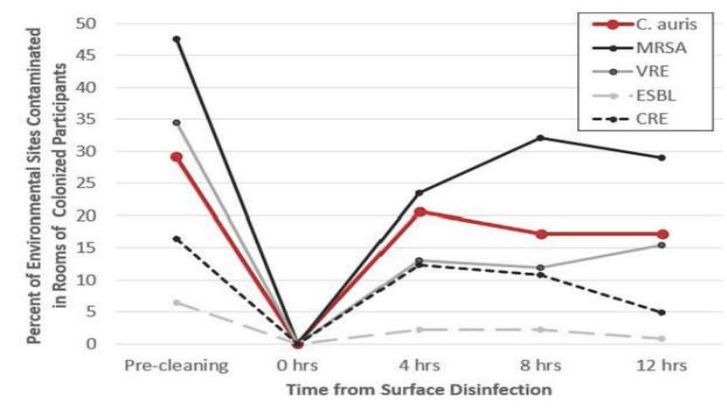
Rapid Environmental Contamination with *Candida auris* and MRDO Near Colonized Patients

Sansom et al. Clin Infect Dis 2024



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Susceptibility of *C. auris* and *C. albicans* to 21 germicides used in healthcare facilities

- Goal: Assess susceptibility of *C. auris* to germicides
- Methods: Disc-based quantitative carrier testing
- Results: All of the FDA-cleared high-level disinfectants have a registration claim >1 minute (e.g., 8–45 minutes). In summary, with the exception of a water-based QAC and a 1:50 dilution of sodium hypochlorite, our data demonstrate that most disinfectants (10 of 13, 77%) used in healthcare facilities are effective (>3-$\log_{10}$ reduction) against *C. auris*.

Rutala WA, et al. ICHE 2019;40:380-382

Germicide name	Manufacturer, Location	Active ingredient	Formulation Tested	Classification	*C. auris*[a]	*C. albicans*[a]
Purell Advanced instant hand sanitizer	GOJO, Akron, OH	70% ethanol	Undiluted	Antiseptic	4.0	2.5
Betadine solution	Purdue Products, Stamford, CT	10% povidone-iodine/1% iodine	Undiluted	Antiseptic	2.5	2.3
Medicated Soft 'N Sure	Steris, St. Louis, MO	0.5% triclosan	Undiluted	Antiseptic/Handwash	1.4	1.7
Soft Care Defend	Diversey, Charlotte, NC	1% chloroxylenol	Undiluted	Antiseptic/Handwash	2.8	3.9
Avagard	3M, St Paul, MN	1% chlorhexidine gluconate solution, 61% ethyl alcohol	Undiluted	Antiseptic/Surgical hand scrub	2.0	1.9
Scrub-Stat 2%	Ecolab, St Paul, MN	2% chlorhexidine gluconate solution	Undiluted	Antiseptic/Surgical hand scrub/handwash	1.6	2.8
Scrub-Stat 4%	Ecolab, St Paul, MN	4% chlorhexidine gluconate solution	Undiluted	Antiseptic/Surgical hand scrub/handwash	1.9	3.5
Isopropyl rubbing alcohol 70% USP	Medichoice, Mechanicsville, VA	70% isopropyl alcohol	Undiluted	Antiseptic/Disinfectant	3.8	4.1
Solution of hydrogen peroxide 3% USP	Medichoice, Mechanicsville, VA	3% hydrogen peroxide	Undiluted	Antiseptic	1.4	1.8
Austin's A-1 bleach 1:10	James Austin Co, Mars, PA	5.25% sodium hypochlorite (~6,100–6,700 ppm)	1:10 dilution	Disinfectant	4.1	4.0
Austin's A-1 bleach 1:50	James Austin Co, Mars, PA	5.25% sodium hypochlorite (~1,245 ppm)	1:50 dilution	Disinfectant	1.6	1.5
Vesphene IIse	Steris, St Louis, MO	9.09% o-phenylphenol, 7.66% p-tertiary amylphenol	1:128 dilution	Disinfectant	4.1	3.6
Hydrogen peroxide cleaner disinfectant	Clorox, Oakland, CA	1.4% hydrogen peroxide	Undiluted	Disinfectant	4.1	4.1
Lysol disinfectant spray	Reckitt Benckiser, Parsippany, NJ	58% ethanol, 0.1% QAC[b]	Undiluted	Disinfectant	3.8	4.1
A-456 II disinfectant cleaner	Ecolab, St Paul, MN	21.7% QAC[c]	1:256 dilution	Disinfectant	1.7	1.5
Super Sani-Cloth wipe	PDI, Orangeburg, NY	55% isopropyl alcohol, 0.5% QAC[d]	Undiluted[f]	Disinfectant	3.9	4.1
Prime Sani-Cloth wipe	PDI, Orangeburg, NY	28.7% isopropyl alcohol, 27.3% ethyl alcohol, 0.61% QAC[e]	Undiluted[f]	Disinfectant	4.1	4.1

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Infect Control Hosp Epidemiol. 2024 Jan;45(1):127-131. doi: 10.1017/ice.2023.157. Epub 2023 Aug 2.

Efficacy of 23 commonly used liquid disinfectants against *Candida auris* isolates from the 4 major clades

Muhammed F Haq [1], Basya S Pearlmutter [1], Jennifer L Cadnum [1], Curtis J Donskey [2 3]

Affiliations + expand

PMID: 37528766 DOI: 10.1017/ice.2023.157

Abstract

We tested the effectiveness of 23 disinfectants used in healthcare facilities against isolates from the 4 major clades of *Candida auris*. Sporicidal disinfectants were consistently effective, whereas quaternary-ammonium disinfectants had limited activity. Quaternary-ammonium-alcohol and hydrogen-peroxide-based disinfectants varied in effectiveness against *C. auris*.

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- Clades-distinct genetic lineages, I common
- Clade III and clade IV might have reduced effectiveness compared to clade II (initially recommended for standard testing)
- Chlorine-based disinfectants and PA consistently reduced all strains
- Most iHP reduced all test strains (>5log)
- 2 of 4 Quat with alcohol >5log
- None of Quat only achieved >5log
- Quat-alcohol, iHP varied effectiveness
- Sporicidal disinfectants effective

Table 2. Mean (SE) Log_{10} Reductions in *Candida auris* and *Candida albicans* for the 23 Tested Disinfectants

Product	Clade II	Clade I	Clade IV	Clade III	*Candida albicans*[a]
Chlorine-based disinfectants					
Clorox Healthcare bleach germicidal cleaner	5.72 (0.00)	5.87 (0.00)	≥6.00 (0.00)	≥6.00 (0.00)	5.10 (0.00)
Clorox germicidal bleach wipe	5.72 (0.00)	5.49 (0.00)	5.75 (0.00)	≥6.00 (0.00)	5.25 (0.00)
Clorox Dispatch Hospital cleaner disinfectant	5.72 (0.00)	5.25 (0.00)	5.35 (0.00)	5.72 (0.00)	5.67 (0.00)
PDI Sani-Cloth bleach germicidal disposable wipe	5.98 (0.00)	5.91 (0.00)	≥6.00 (0.00)	≥6.00 (0.00)	5.67 (0.00)
Artemis BioSolutions Defender disinfectant	6.00 (0.00)	5.20 (0.00)	5.4 (0.00)	5.4 (0.00)	6.00 (0.00)
Peracetic acid-based disinfectant					
EcoLab OxyCide daily disinfectant	5.3 (0.22)	5.30 (0.00)	5.42 (0.00)	5.46 (0.00)	5.9 (0.04)
Improved hydrogen peroxide					
Clorox Healthcare hydrogen-peroxide cleaner disinfectant	5.22 (0.00)	5.89 (0.00)	5.10 (0.00)	5.01 (0.00)	5.10 (0.00)
Diversey Oxivir TB	5.34 (0.00)	5.89 (0.00)	5.10 (0.00)	5.01 (0.00)	5.10 (0.00)
Diversey Alpha HP multisurface cleaner	4.02 (0.29)	1.48 (0.23)	0.00 (0.09)	0.17 (0.24)	0.96 (0.24)
PDI Sani-Hypercide	≥6.00 (0.00)	5.89 (0.00)	5.10 (0.00)	5.01 (0.00)	5.67 (0.00)
Quaternary-ammonium compound					
Diversey Virex II 256	2.50 (0.20)	0.13 (0.10)	0.10 (0.11)	0.00 (0.03)	0.33 (0.05)
Diversey Virex Plus	2.50 (0.26)	0.06 (0.59)	0.00 (0.11)	0.00 (0.17)	0.00 (0.12)
Kinzua Shield Foam	3.56 (0.17)	3.89 (0.36)	1.62 (0.42)	1.98 (0.04)	4.22 (0.31)
Diversey Crew nonacid disinfectant	1.17 (0.24)	0.16 (0.06)	0.00 (0.18)	0.41 (0.16)	0.88 (0.15)
Kinzua TB	5.22 (0.00)	5.26 (0.23)	1.93 (0.49)	3.78 (0.31)	4.39 (0.72)
Kinzua Shield Ultra	0.40 (0.34)	0.91 (0.24)	0.00 (0.20)	1.33 (0.16)	0.00 (0.16)
Diversey Crew NA SC	0.79 (0.14)	0.66 (0.03)	0.00 (0.29)	0.71 (0.17)	0.53 (0.27)
Diversey Crew Restroom Floor & Surface SC	1.35 (0.15)	4.50 (0.29)	2.15 (0.23)	3.25 (0.19)	4.74 (0.22)
Quaternary-ammonium plus alcohol					
PDI Sani-Cloth germicidal wipes	5.30 (0.00)	5.74 (0.00)	≥6.00 (0.00)	≥6.00 (0.00)	5.66 (0.00)
Kinzua KE 15 Citrus surface disinfectant	5.30 (0.00)	5.87 (0.00)	≥6.00 (0.00)	≥6.00 (0.00)	5.10 (0.00)
Metrex CaviWipes[b]	3.55 (0.32)	2.98 (0.06)	1.95 (0.24)	1.84 (0.02)	4.75 (0.27)
Metrex CaviCide spray[b]	5.63 (0.14)	4.06 (0.28)	3.04 (0.56)	2.10 (0.14)	5.25 (0.00)

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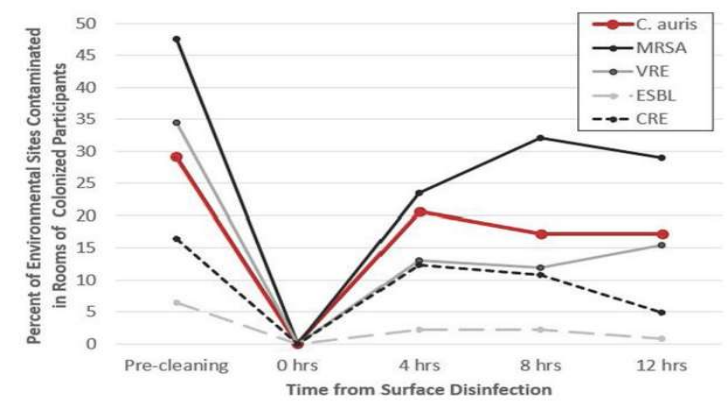
Rapid Environmental Contamination with *Candida auris* and MRDO Near Colonized Patients

Sansom et al. Clin Infect Dis 2024



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Continuous Room Decontamination Technologies for Disinfection of the Healthcare Environment

Weber, Rutala et al. AJIC. 2019;47:A72; Rutala et al. ICHE 2019; Weber D, Rutala W. AJIC 2013;41:S31

- Visible light disinfection through LEDs
- Dry/dilute hydrogen peroxide; hydroxyl radicals, free reactive oxygen
- Self-disinfecting surfaces (e.g., heavy metals-copper, silver)
- Far UV 222 nm
- Bipolar ionization
- Multijet cold air plasma
- Continuously active disinfectant (CAD) or persistent disinfectant that provides continuous disinfection action
  - Allows continued disinfection and may eliminate the problem of recontamination
  - Patients, staff and visitors can remain in the room

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Antimicrobial Stewardship & Healthcare Epidemiology (2024), **4**, e123, 1–3
doi:10.1017/ash.2024.388

SHEA

Concise Communication

A novel approach for safe and automated implementation of far ultraviolet-C light decontamination in clinical areas

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Abstract

A novel wall-mounted far ultraviolet-C (UV-C) light technology providing automated delivery of far UV-C only when people are not present reduced methicillin-resistant *Staphylococcus aureus* in a patient room and equipment room. The safety feature that discontinues far UV-C output when people are detected was effective in preventing far UV-C exposure.

(Received 7 February 2024; accepted 30 May 2024)

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Far UV-C 222

Continuous decontamination of air and surfaces

- Filters block >230nm
- Placed on wall
- Kill microbes (3 $\log_{10}$ reduction in 45m) in air and on surfaces when within 2-3m
- Safe for occupied areas
- Proposed as continuous, safe decontamination for air and surface contamination in occupied spaces
- Long-term safety needs to be investigated

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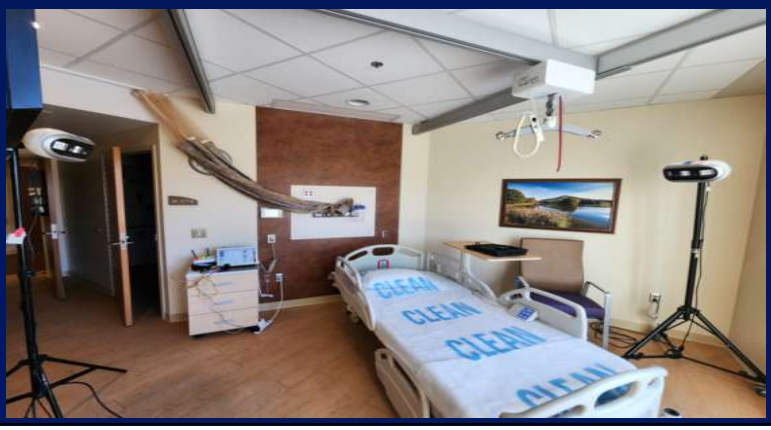
Far Ultraviolet-C

Memic et al. Antimicrob Steward Healthcare Epidemiol. 2024

- Pictures of a patient room with 2 Far UVC devices positioned at opposite sides of the room on each side of the bed. Motion detector that discontinues Far UVC output when people in the room, which preventing exposure.



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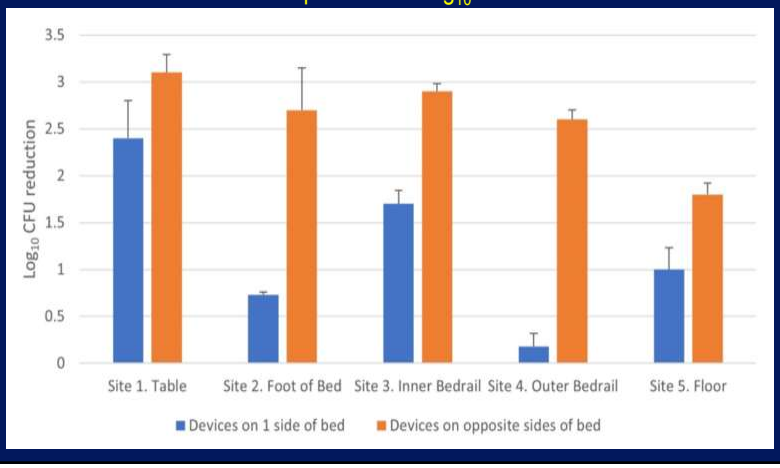
Far Ultraviolet-C

Memic et al. Antimicrob Steward Healthcare Epidemiol. 2024

- Reductions in MRSA after 45m of exposure ~2.5 log_{10} reduction



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Disinfectants kill microbes when applied to a surface but no sustained microbicidal activity

Persistent disinfectants

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Continuously Active Disinfectant Inactivates SARS-CoV-2 and Human Coronavirus 229E two days after the Disinfectant Was Applied and Following Wear Exposures

Rutala et al. Infect Control Hosp Epidemiol. 2023;44:507-509

A novel disinfectant studied using an EPA protocol (wears/re-inoculations) demonstrated excellent continuous antiviral activity following a 48h period of wear and abrasion exposures with reinoculations. Reduction >4.5-$\log_{10}$ were achieved within a minute contact time for a human coronavirus, 229E, and SARS-CoV-2.

Table 1. Inactivation of SARS-CoV-2 and the Human Coronavirus 229E by a Continuously Active Disinfectant Following a 48-Hour Period of Wear and Abrasion Exposures

Carrier Treatment with Wears and Reinoculations	HCoV 229E Mean Viral Recovery per Carrier ($\log_{10}$ ± S.D.)	SARS-CoV-2 Mean Viral Recovery per Carrier ($\log_{10}$ ± S.D.)	HCoV 229E $\log_{10}$ Reduction	SARS-CoV-2 $\log_{10}$ Reduction
Control (sterile NP water, n=3)	6.00 ± 0.25	5.72 ± 0.08	NA	NA
Continuously acting disinfectant (n=3)	≤1.50 ± 0.00	≤1.50 ± 0.00	≥4.50	≥4.22

Notes: Contact time = 1 minute; NA = not applicable.

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Enhanced Disinfection Reduces HAIs

Browne et al. Lancet. 2024

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Enhanced Disinfection (UVC) Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Inf

Anderson et al. Lancet 2017;289:805; Rutala et al. ICHE 2018;39:1118

	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.

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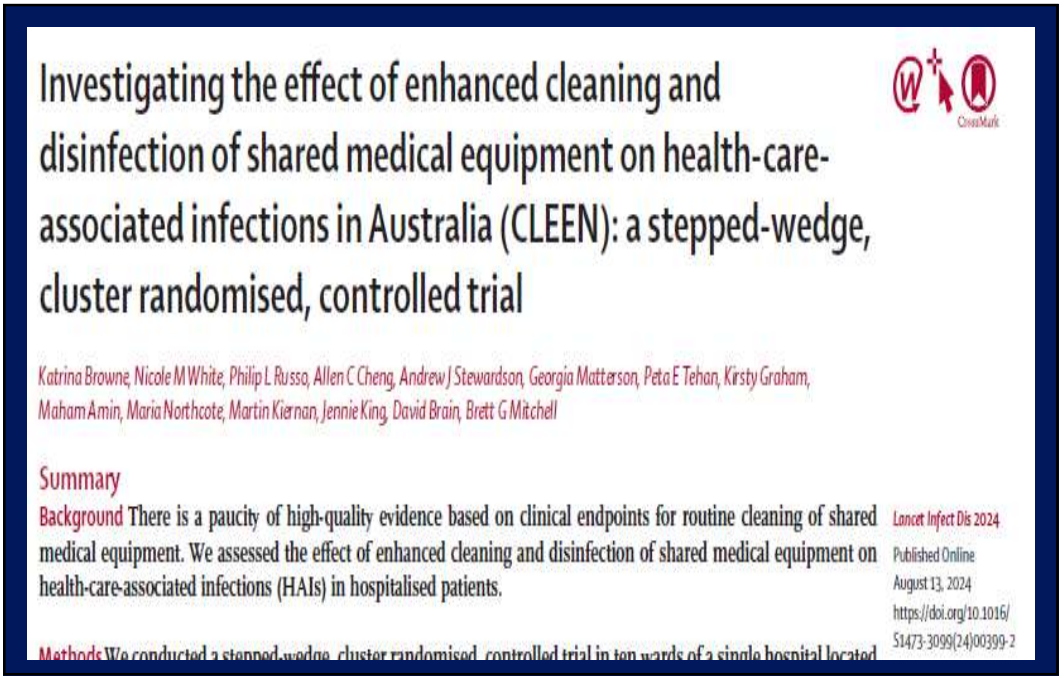

Investigating the effect of enhanced cleaning and disinfection of shared medical equipment on health-care-associated infections in Australia (CLEEN): a stepped-wedge, cluster randomised, controlled trial

Katrina Browne, Nicole M White, Philip L Russo, Allen C Cheng, Andrew J Stewardson, Georgia Matterson, Peta E Tehan, Kirsty Graham, Maham Amin, Maria Northcote, Martin Kiernan, Jennie King, David Brain, Brett G Mitchell

Summary

Background There is a paucity of high-quality evidence based on clinical endpoints for routine cleaning of shared medical equipment. We assessed the effect of enhanced cleaning and disinfection of shared medical equipment on health-care-associated infections (HAIs) in hospitalised patients.

Methods We conducted a stepped-wedge, cluster randomised, controlled trial in ten wards of a single hospital located

Lancet Infect Dis 2024
Published Online
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https://doi.org/10.1016/
S1473-3099(24)00399-2

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Enhanced Disinfection of Shared Medical Equipment Reduces HAIs

Browne et al. Lancet. 2024

- Cluster randomized, controlled trial in ten ward, single hospital in Australia
- Each cluster, 2 randomly allocated wards (March-November 2023)
- Control phase, no change to CD (no requirement for cleaning staff; responsibility of HCWs to CD after use)
- Intervention phase, CD bundle included additional 3h per weekday for dedicated CD of noncritical, shared medical equipment (BP, pumps, infusion drip stands) by 21 dedicated CD staff
- Primary outcome HAIs as assessed by fortnightly point prevalence survey

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Enhanced CD of Shared Medical Equipment

Browne et al. Lancet 2024

- Clinell universal and sporicidal wipes
- Dual detergent-disinfectant wipes, GAMA Healthcare
- 1-h training session with 21 dedicated cleaning staff
- Cleaning thoroughness <50% refresher training
- Fluorescent marker gel, randomized list of 12 items for each audit
- 1786 shared equip audited. CD increased from ≥18% to ≥57%
- No policy changes, such as screening, isolation or outbreaks
- Hand hygiene compliance, colonization pressure-no change

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Enhanced Cleaning/Disinfection (CD) of Shared Medical Equipment

Browne et al. Lancet 2024

- Intervention reduced HAIs

	Control			Intervention		
	Patients	HAIs	HAI prevalence, % (95% CI)	Patients	HAIs	HAI prevalence, % (95% CI)
1	189	23	12·2% (7·5–16·8)	359	37	10·3% (7·1–13·5)
2	276	58	21·0% (16·2–25·8)	275	32	11·6% (7·9–15·4)
3	82	9	11·0% (4·2–17·7)	393	36	9·2% (6·3–12·0)
4*	314	37	11·8% (8·2–15·4)	278	29	10·4% (6·8–14·0)
5	161	24	14·9% (9·4–20·4)	314	48	15·3% (11·3–19·3)
6	401	60	15·0% (11·5–18·5)	73	11	15·1% (6·9–23·2)
7	91	18	19·8% (11·6–28·0)	430	44	10·2% (7·4–13·1)
8	340	54	15·9% (12·0–19·8)	65	12	18·5% (9·0–27·9)
9	321	96	29·9% (24·9–34·9)	160	32	20·0% (13·8–26·2)
10	322	54	16·8% (12·7–20·9)	161	20	12·4% (7·3–17·5)
All wards	2497†	433	17·3% (15·9–18·8)	2508	301	12·0% (10·7–13·3)

HAI=health-care-associated infection. *Ward 4 was relocated in the last week of the study to a new area in the hospital. The ward and patients on the ward were excluded from the final 2 weeks of the study. †Three patients had two separate admissions each, and are therefore counted twice here.

Table 2: Unadjusted prevalence of HAIs in control and intervention phases by ward

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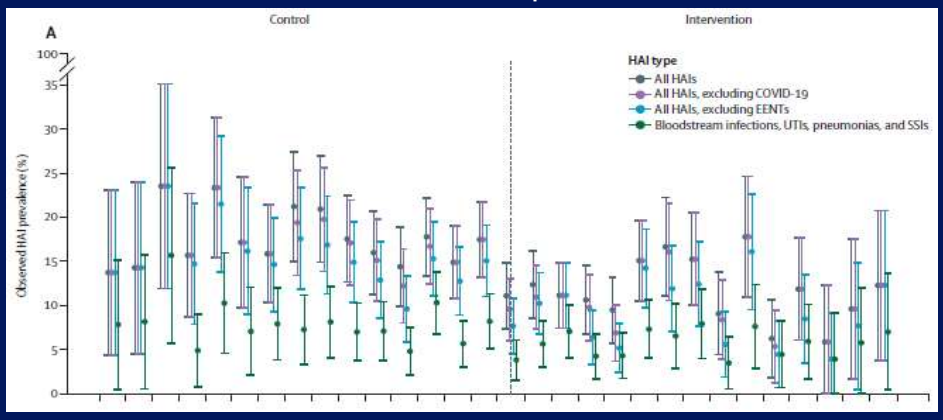
Enhanced CD of Shared Medical Equipment

Browne et al. Lancet 2024

- HAIs in intervention and control phase

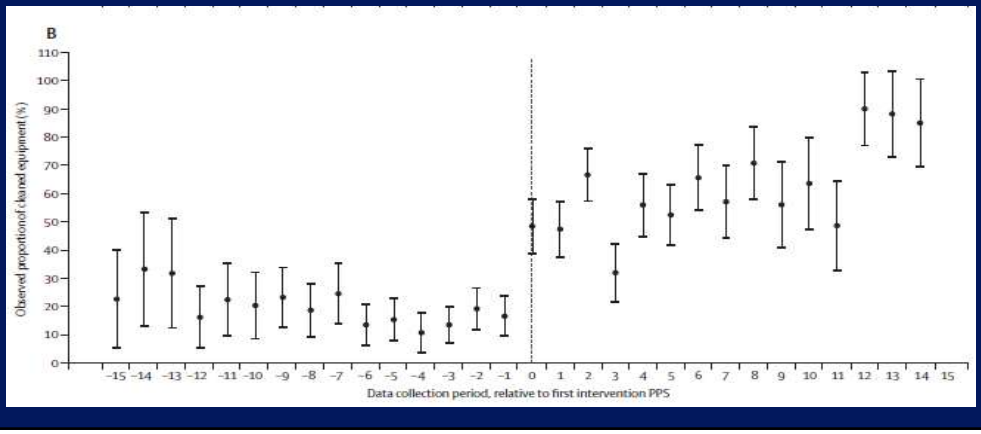


29

Enhanced CD of Shared Medical Equipment

Browne et al. Lancet 2024

- Proportion of cleaned equipment in intervention and control phase



30

Enhanced CD of Shared Medical Equipment

Browne et al. Lancet 2024

Conclusions

- The prevalence of HAIs was reduced from 14.9% to 9.8% when CD of shared equipment was initiated
- Supports the role of CD shared medical equipment as a key intervention strategy
- Might be due to reduced burden of infectious pathogens

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Am J Infect Control. 2020 Aug; 48(8): 951–954.
Published online 2020 Jun 6. doi: 10.1016/j.ajic.2020.06.002
PMCID: PMC7275188
PMID: 32522608

Evaluation of an electrostatic spray disinfectant technology for rapid decontamination of portable equipment and large open areas in the era of SARS-CoV-2

Jennifer L. Cadnum, BS,[a] Annette L. Jencson, CIC,[a] Scott H. Livingston, MD,[b] Daniel F. Li, BS,[a] Sarah N. Redmond, BS,[b] Basya Pearlmutter, BS,[a] Brigid M. Wilson, PhD,[c] and Curtis J. Donskey, MD[b,c,*]

Author information ▸ Copyright and License information Disclaimer

Abstract

Go to:

In the setting of the coronavirus disease 2019 pandemic, efficient methods are needed to decontaminate shared portable devices and large open areas such as waiting rooms. We found that wheelchairs, portable equipment, and waiting room chairs were frequently contaminated with potential pathogens. After minimal manual precleaning of areas with visible soiling, application of a dilute sodium hypochlorite disinfectant using an electrostatic sprayer provided rapid and effective decontamination and eliminated the benign virus bacteriophage MS2 from inoculated surfaces.

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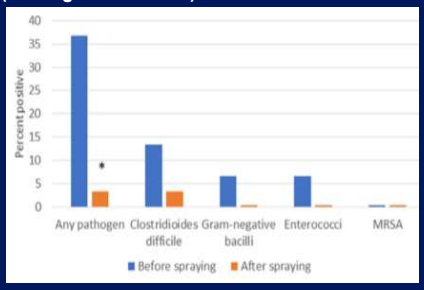
Efficacy of Disinfectant Electrostatic Spray (positively charged droplets attracted to negatively charged surfaces or microbes) in Reducing Pathogen Contamination

Cadnum et al. AJIC 2020

Picture of electrostatic sprayer
(0.25% sodium hypochlorite)

Efficacy of disinfectant spray
(waiting room chairs)



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UVC vs Electrostatic Sprayer (0.25% NaOCl) for Adjunctive Room Decontamination

Carlisle MG, Rutala WA…Donskey CJ. ICHE. 2022. doi:10.1017/ice.2022.132

ES Sprayer and UVC similarly effective in reducing pathogen contamination on floors and high-touch surfaces

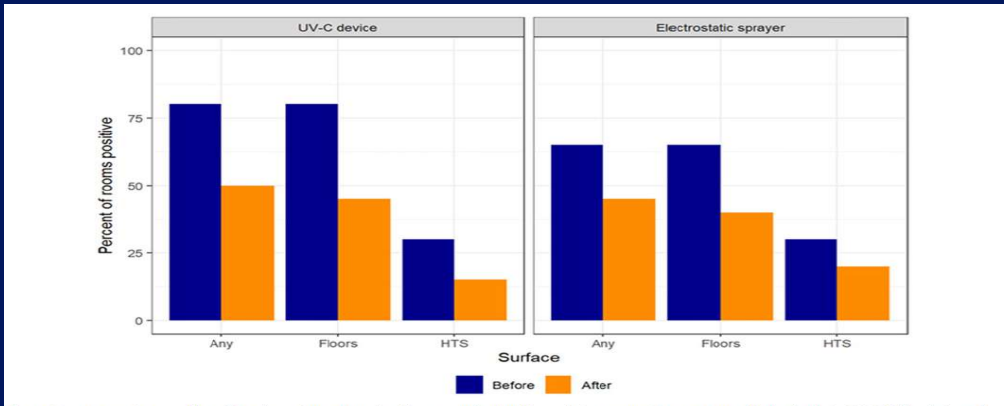

Fig. 1. Percentages of rooms with positive cultures for 1 or more healthcare-associated pathogens before versus after treatment with the ultraviolet-C (UV-C) light device or the electrostatic sprayer. Note. HTS, high-touch surface.

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Summary of Electrostatic Sprayer Issues Include

- Optimal **droplet size is between 40-70u**; what is the droplet size of the proposed unit
- **Spray patterns** vary tremendously across vendors and even across products from a single vendor
- EPA demands that all surfaces being disinfected be thoroughly **wetted for the contact time** of the **specific disinfectant**
- Person applying the disinfectant may need to wear full PPE because of inhalation concerns
- Electrostatic sprayer does not replace the initial cleaning and disinfecting that EVS performs
- Cadnum/Donskey study used sporicidal disinfectant alone with no pre-cleaning or wiping
- Electrostatic sprayers might be most useful for items and areas that are not amenable to standard cleaning and disinfection (Cadnum/Donskey)
- Effectiveness on soft surfaces?
- Considerations for purchase include: coverage requirements, weight of loaded device; ease of handling; **effective distance; particulate size; and disinfectant safety**
- Electrostatic sprayers are promoted as a "get in" and "get out" time saving technology
- How many seconds per square foot with a sprayer to properly treat the surface
- Equipment can be easily misused (must prevent misuse and consider sprayer, time allotted to perform, disinfectant, surface [soft v hard], space/area to disinfect, level of cleaning prior to application, user training)

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Wipes

Cotton, Disposable, Microfiber, Cellulose-Based, Nonwoven Spunlace

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Contact time and disinfectant formulation significantly impact the efficacies of disinfectant towelettes against *Candida auris* on hard, non-porous surfaces

Maxwell G. Voorn[1], Alyssa M. Kelley[1], Gurpreet K. Chaggar[1], Xiaobao Li[2], Peter J. Teska[2] & Haley F. Oliver[1]✉

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Disinfectant Towelettes Used

Voorn et al. 2023. Scientific Reports

Table 1 Description of disinfectant towelettes

Disinfectant Products[a]	Active Ingredients[b]	Dilution at Use	Label Contact Time[d]
HP1	0.5% hydrogen peroxide	RTU[c]	1 min
QAC1	0.25% n-Alkyl (68% C_{12}, 32% C_{14}) dimethyl ethylbenzyl ammonium chlorides, 0.25% n-Alkyl (60% C_{14}, 30% C_{16}, 5% C_{12}, 5% C_{18}) dimethyl benzyl ammonium chlorides, 55% isopropyl alcohol)	RTU	2 min
QAC2	0.125% n-Alkyl (68% C_{12}, 32% C_{14}) dimethyl ethylbenzyl ammonium chlorides, 0.125% n-Alkyl (60% C_{14}, 30% C_{16}, 5% C_{12}, 5% C_{18}) dimethyl benzyl ammonium chlorides	RTU	3 min
QAC3	0.14% n-Alkyl (68% C_{12}, 32% C_{14}) dimethyl ethylbenzyl ammonium chlorides), 0.14% n-Alkyl (60% C_{14}, 30% C_{16}, 5% C_{12}, 5% C_{18}) dimethyl benzyl ammonium chlorides	RTU	3 min
QAC4	Octyl decyl dimethyl ammonium chloride, dioctyl dimethyl ammonium chloride, didecyl dimethyl ammonium chloride, n-Alkyl (50% C_{14}, 40% C_{12}, 10% C_{16}) dimethyl benzyl ammonium chloride (848 ppm active at 1:256 use-dilution)	1:256	10 min

[a] Abbreviated naming scheme for commercially available EPA-registered disinfectants used in this study;

[b] Concentrations of active ingredients at use-dilution;

[c] Ready-to-use;

[d] Recommended label contact time for standard use.

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Disinfectant Towelettes Vary in their Fungicidal Efficacies Against *C. auris*

Voorn et al. Scientific Reports. 2023

HP and QAC1 exhibited significantly higher fungal (*C. auris*) mean reductions

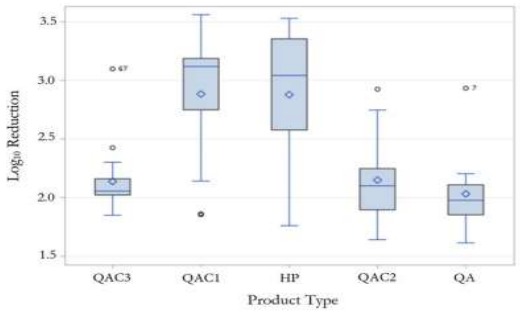

Figure 2. Mean $\log_{10}$ reductions for each product type against *C. auris* regardless of contact time. HP had the highest variability among products tested followed closely by QAC1. HP and QAC1 had significantly higher levels of fungicidal disinfect efficacies compared to QAC2, QAC3, and QAC-alcohol; ($\alpha = 0.05$). ◇ Mean, — Median, ⊥ Q1-1.5 IQR, T Q3 + 1.5IQR, ○ Outlier.

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Disinfectant Towelettes and Contact Time

After one minute disinfection is achieved. No significant difference in disinfectant efficacy between 1 and 10m

Voorn et al. Scientific Reports. 2023

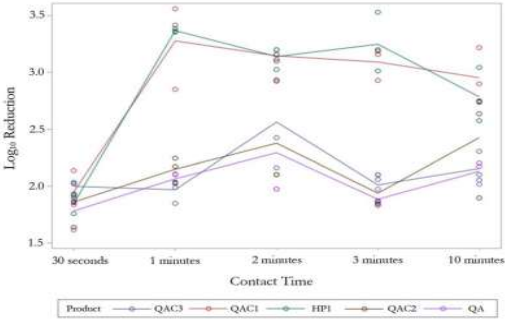
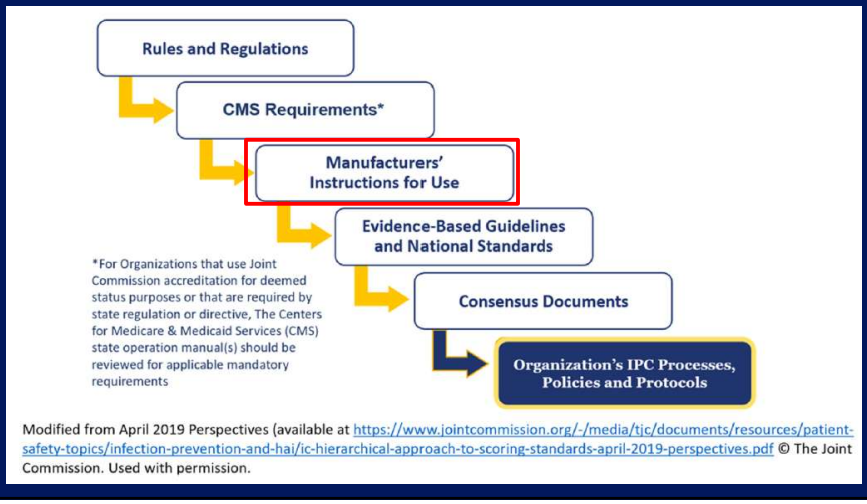


Figure 4. Interaction plot showing the relationship between contact time i.e., 30 s, one-min, two-min, three-min, and 10-min for each product (HP, QAC1, QAC2, QAC3, and QA) and mean $\log_{10}$ reductions against *C. auris*.

40

Approach for Assessing Compliance Infection Prevention and Control Requirements

S. Garcia-Houchins / American Journal of Infection Control 51 (2023) 1182–1184



Modified from April 2019 Perspectives (available at https://www.jointcommission.org/-/media/tjc/documents/resources/patient-safety-topics/infection-prevention-and-hai/ic-hierarchical-approach-to-scoring-standards-april-2019-perspectives.pdf © The Joint Commission. Used with permission.

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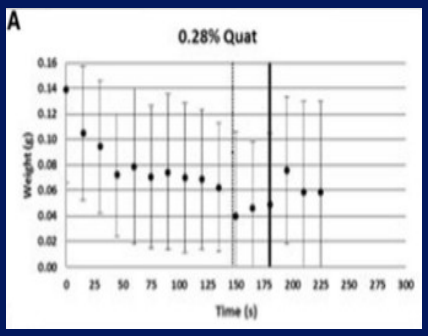
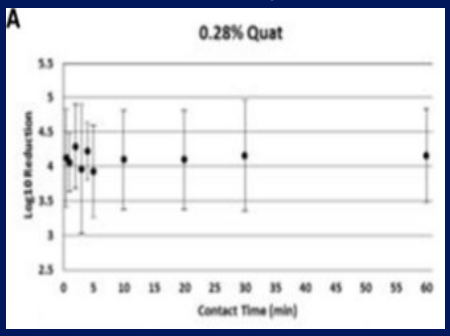
Bactericidal (*S. aureus*) Efficacy of EPA-Registered Towelettes

West, Teska, Oliver, AJIC, 2019

- Drying time curve based on surface wetness; bold-contact time (180s); dashed-dry (~145s)



- Wet time is not crucial for complete disinfection (wet or dry ~4 $\log_{10}$ reduction); 30s for $\log_{10}$ reduction



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Dry Biofilms on Healthcare Surfaces

Examples of "Dry" Biofilms Recovered from Surfaces

Ledwoch et al. J Hosp Infect 2018;100:e47-e56

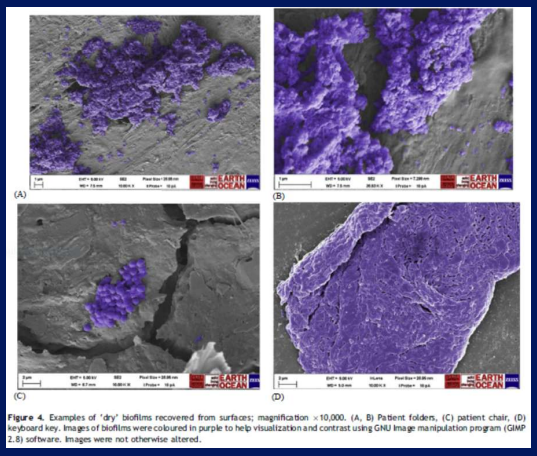

Figure 4. Examples of 'dry' biofilms recovered from surfaces; magnification ×10,000. (A, B) Patient folders, (C) patient chair, (D) keyboard key. Images of biofilms were coloured in purple to help visualization and contrast using GNU Image manipulation program (GIMP 2.8) software. Images were not otherwise altered.

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Biofilms on Instruments and Environmental Surfaces

Alfa, AJIC 2019. 47:A39

- Three types of biofilm-represent various types of microbial reservoirs that may act as sources of microbes
  - Traditional hydrated biofilm (water content 90%)
  - Build-up biofilm—occurs in endoscope channels
  - Dry surface biofilm-heterogenous accumulation of organisms and other material in a dry matrix (water content 61%)
    - ◆Raises questions about the inactivation of microbes with a dry surface biofilm by currently used cleaning/disinfecting methods
    - ◆Viable as well as viable non-culturable bacteria that exist in a matrix extra-cellular glycoconjugate, protein and DNA

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Dry Surface Biofilms

Key Points

Ledwoch et al, Br J Hosp Med 2022; Schapira et al. JHI 2024

- Dry surface biofilms are widespread on dry environmental surfaces in healthcare settings (as high as 96% of surfaces)
- Dry surface biofilms can harbor bacterial pathogens including MDROs
- Dry surface biofilms cannot be detected by routine wet swabbing
- Dry surface biofilms are less susceptible to disinfection
- Bacterial pathogens in dry surface biofilms are transferable by direct and indirect contact (gloves) following cleaning/disinfection
- Role dry surface biofilms play in HAIs is unclear

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Other Issues

- Can probiotics (principle of competitive exclusion, beneficial bacteria replace pathogens) trigger a paradigm shift. Requires further research. Denkel et al. Anti Resist IC 2024.
- Novel color additive in disinfectant wipes improves the thoroughness of CD (reduction in surface bioburden). Oremade et al. AJIC. 2024.
- Electrolyzed water (EW) generated on-site as a disinfectant (hypochlorous acid). Effect of EW on pathogens requires further investigation. Krishnan et al. Gerodont 2023.

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Disinfection and Sterilization

Current Issues, New Research and New Technology

- AI driven decontamination and continuous room decontamination (Far UV 220nm with motion detectors) offer huge potential
- Enhanced disinfection of shared medical equipment reduced HAIs
  - An additional 3h per workday for dedicated CD of shared medical equipment by 21 dedicated CD staff
- Biofilms are less susceptible to disinfectants (oxidizing agents more effective)

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Infect Control Hosp Epidemiol. 2025 Jan 27:1-3. doi: 10.1017/ice.2024.236. Online ahead of print.

Evaluation of a new technology for terminal sterilization of flexible endoscopes using hydrogen peroxide gas plasma

Martin M Varghese [1], Samir Memic [1], Maria M Torres-Teran [1], Jennifer L Cadnum [1], William A Rutala [2], Curtis J Donskey [1 3 4]

Affiliations + expand

PMID: 39865764 DOI: 10.1017/ice.2024.236

Abstract

In laboratory testing, a novel hydrogen peroxide gas plasma endoscope sterilizer consistently reduced vegetative organisms, but not bacterial spores, to undetectable levels in the presence of high organism load (≥6.5 $\log_{10}$) and organic material and salts. These findings highlight the importance of meticulous cleaning of endoscopes prior to sterilization.

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Why Shift from HLD to Sterilization

Rutala, Weber. AJIC 2023;51:A96-A106

Many reasons sterilization is superior to standard HLD in reducing the risk of microbial contamination and infection to include:

- Comply with Spaulding classification scheme
- Evidence-based recommendation as more than 150 outbreaks
- No margin of safety associated with HLD (10^{10} microbes vs $\geq 10^{6}$ C and HLD)
- Sterilization can improve outcomes as it can be validated (BI) and provides a SAL
- Some HLD are relatively resistant to atypical mycobacteria
- No toxicity or anaphylactic reaction
- HLD is a complex process and prone to errors and challenges (1.4% compliance)
- HLD items unpackage; terminal sterilization items packaged, prevent contamination

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Background

- Contaminated endoscopes have been linked to more infections than any other medical/surgical device in healthcare
- Evidence from outbreaks and contamination studies after HLD has compelled the FDA and professional organizations (e.g., AORN, AAMI) to promote a transition from HLD to sterilization

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Background

- The aim of this study is to evaluate the effectiveness of a new hydrogen peroxide gas plasma endoscope sterilizer that recently received FDA 510k clearance
- We tested the hypothesis that the effectiveness of the sterilizer would be reduced in the presence of organic material and/or salt that might be present in the setting of suboptimal manual cleaning

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SteroScope

- The hydrogen peroxide gas plasma sterilizer is designed for terminal sterilization of flexible endoscopes with as many as 8 internal channels
- The endoscope is placed inside a container that interfaces with the sterilizer and subsequently provides a sterile storage container.

SteroScope and container

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SteroScope

- It uses a pressure differential in each internal channel and single-use channel connector to rapidly diffuse VHP to endoscope channels

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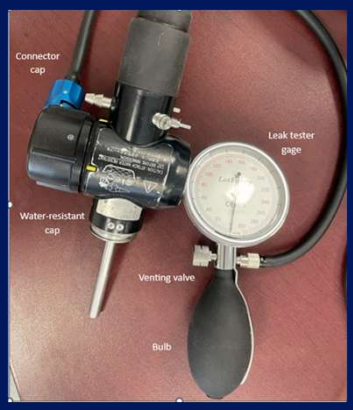
SteroScope

- Sterilization occurs after manual cleaning and drying with filtered forced air for ≥10 minutes
- Cycle: 44 minutes total with 2 injections of hydrogen peroxide gas plasma 16 minutes apart
- The water-resistant cap must be removed from video endoscopes
- Leak test is done to ensure that there is no leak which could cause fluid invasion



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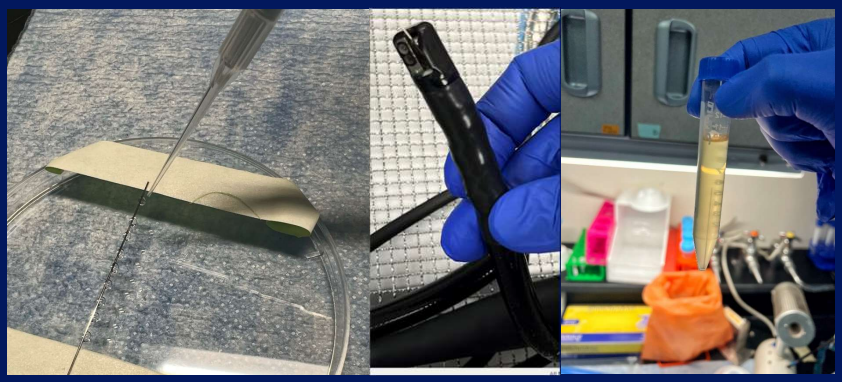
Objective

- Evaluated the effectiveness of the sterilizer against spores and vegetative organisms with and without organic material and salt to simulate a worst-case scenario with inadequate cleaning
- Evaluated the efficacy of the endoscope sterilizer against spore-forming and vegetative organisms using three methods

55

Method 1. Inoculated steel wires placed inside elevator channel



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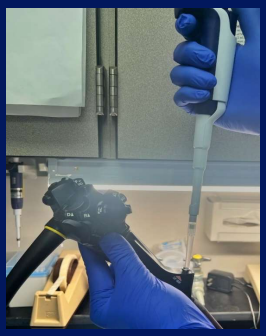
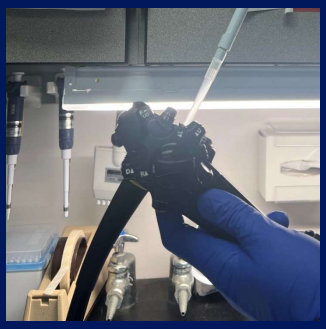
Method 2. Inoculation into the elevator recess and instrument channel with 5% serum





Flush with ~100 mL of sterile water to allow the inoculum to reach the center of the channel

Molloy-Simard V. Elevating the standard of endoscope processing: Terminal sterilization of duodenoscopes using a hydrogen peroxide–ozone sterilizer. AJIC 2019;47:243 - 250

57

Method 3. Inoculation throughout the lumen using a brush

- Brush inserted into the biopsy port to the distal tip of the endoscope
- With brush in place, immerse the distal tip of the duodenoscope in 20 mL of test organism suspension
- Elevator mechanism articulated 3 times
- Brush withdrawn from the biopsy port
- Process repeated 3 times
- Soil: 5% serum or ATS-2015

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Test organisms

- Vegetative organisms
  - *Escherichia coli*, vancomycin-resistant *Enterococcus faecium* (VRE), *Candida auris*
  - Soil included for all tests
  - Inoculum: 8 to 9 $\log_{10}$ CFU
- Spores
  - *Bacillus atrophaeus*, *Clostridioides difficile*, *Clostridium sporogenes*
  - Inoculum: 6 to 9.7 $\log_{10}$ CFU

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Test Soils

- 5% fetal calf serum
- RPMI 1640 with ~0.65% salt and 10% fetal calf serum
- Artificial Test Soil (ATS)-2015
  - Intended to simulate a “worst case” challenge
  - Salt base with mucin, insoluble cellulose fiber, reconstituted dried egg yolk, and 20% sterile sheep blood

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Results
Vegetative Organisms

- For each test method and for all 3 test organisms, (*E. coli, E. faecium, C. auris*) no organisms were recovered after sterilization
- Inoculum: 7.9 to 9.1 $\log_{10}$ CFU
- Soil: 5% serum, ATS-2015, and RPMI

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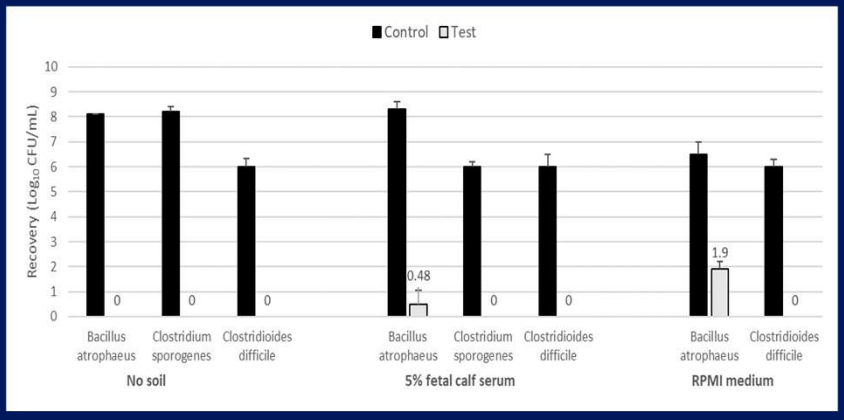
Inoculated steel wires

No spores recovered from wires in absence of soil. In presence of soil, no spores were recovered when inoculum ≤6.2 $\log_{10}$ CFU but low levels of spores recovered when ≥6.5 $\log_{10}$ CFU recovered from control endoscopes.



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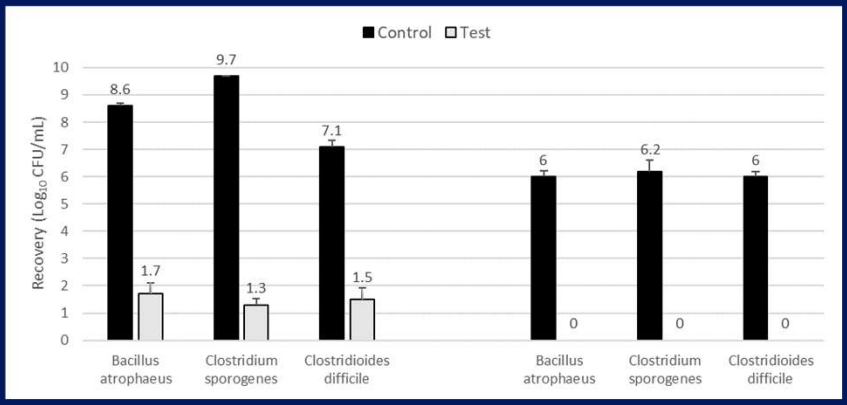
Inoculation of the elevator recess and instrument channel with 5% serum

~6 log_{10} or greater reduction of spores with 5% serum



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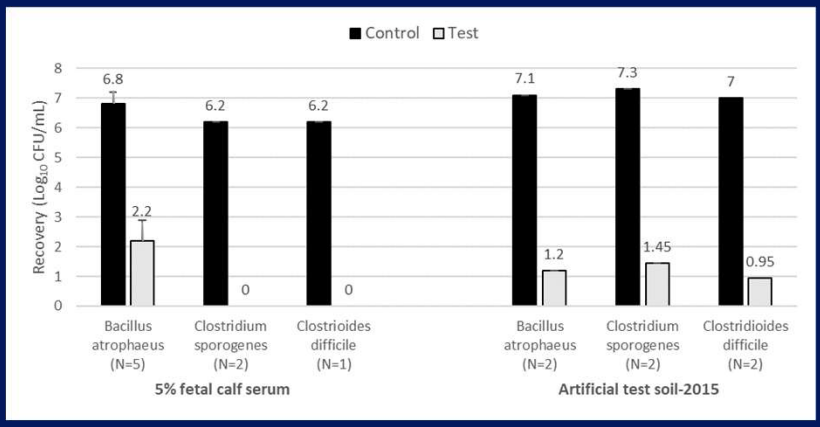
Inoculation throughout the lumen using a brush

~6 log_{10} reduction of spores in most tests



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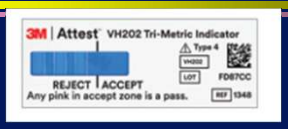
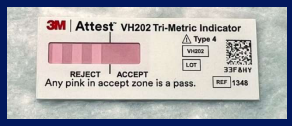
Chemical and Biological Indicators

- 3M Attest Vaporized Hydrogen Peroxide Type 4 Tri-Metric Chemical Indicators
  - All indicated appropriate exposure time, temperature, and amount of hydrogen peroxide
- 3M Attest Super Rapid Vaporized Hydrogen Peroxide Biological Indicators (24 min)
  - All with no surviving *G. stearothermophilus* spores





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FDA-Clearance for Endoscope Sterilization

Requires evidence that half-cycle eliminated 6 $\log_{10}$ CFU of *G. stearothermophilus* spores with no soil and a full cycle eliminated 6 $\log_{10}$ CFU of spores in simulated-use testing with soil

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The SteroScope Sterilization Technology System is indicated for the terminal sterilization of cleaned reusable flexible endoscopes with up to 8 internal lumens with lumen dimensions of:
ID of 1.0 mm or larger and a length of 3580 mm or shorter
and
ID of 1.2 mm or larger and a length of 4095 mm or shorter

These dimensions capture 99% of the flexible endoscopes in the marketplace.

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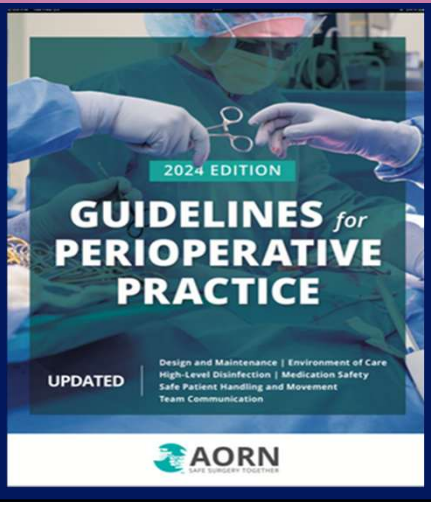
Sterilize reusable flexible endoscopes that are manufacturer validated for sterilization when possible. *[Recommendation]*



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With the infection risk that endoscopes present to the patient, sterilization is the preferred method of microbial inactivation and the only option for instruments to be used in "critical" uses entering sterile body cavities, tissues, or vascular spaces. Sterilization continues to be recommended for endoscopes. Terminal sterilization is also required for all endoscope accessories that penetrate the mucosa, such as biopsy forceps, sphincterotomes, etc. When sterilization is required, most endoscopes require low temperature sterilization. Compatibility with low-temperature sterilization processes varies with endoscope make and model. Compatible processes can include ethylene oxide (EO), hydrogen

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34. Instead of HLD, should certain semi-critical devices preferentially be sterilized?

Recommendation:

1. When sterilization technologies are shown to be effective in clinical settings and cycle specifications are validated and included in the MIFU, facilities should begin developing an institutional process for converting from HLD to sterilization for semi-critical reusable medical devices that are associated with a high risk of transmission of infection to patients.

Infection Control & Hospital Epidemiology (2025), **46**, 561–583
doi:10.1017/ice.2025.41

SHEA

SHEA Expert Guidance

Multisociety guidance for sterilization and high-level disinfection

Erica S. Shenoy MD, PhD[1,*], David J. Weber MD, MPH[2,*], Kathleen McMullen MPH, CIC[3], Zachary Rubin MD[4], Priya Sampathkumar MD[5], Joshua K. Schaffzin MD, PhD[6], Emily Sickbert-Bennett PhD, MS, CIC[2], Laraine Washer MD[7], Deborah S. Yokoe MD, MPH[8], Audrey H. Calderwood MD, MS[9], Raymond Chinn MD[10], Michelle Day RN, MSN, CGRN[11], Sylvia Garcia-Houchins RN, MBA, CIC[12], Waleed Javaid MD, MBA, MS[13], Susan Klacik BS[14], Erin Kyle DNP, RN, CNOR[15], Rekha K. Murthy MD[16], Amber Wood MSN, RN, CNOR, CIC[15] and William A. Rutala PhD, MPH, CIC[2]

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Abstract

SHEA, in partnership with ASGE, APIC, AAMI, AORN, HSPA, IDSA, SGNA, and The Joint Commission, developed this multisociety

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Why Shift from HLD to Sterilization

Rutala Weber, JAMA 2014; 312:1405-1406; Rutala, Weber. AJIC 2023;51:A96-A106

- National/international guidelines recommend sterilization for lumened endoscopic devices (AORN; AAMI)
- FDA has recommended sterilization for bronchoscopes rather than HLD when feasible (FDA, 2021)
- FDA has recommended sterilization for duodenoscopes (FDA Panel, 2015)
- FDA has precluded use of HLD for certain urologic endoscopes due to HLD failure…FDA recommends sterilization (FDA, 2022)
- FDA has promoted innovation to enhance safety (e.g., use of fully disposable, sterile duodenoscopes) (FDA, 2022)

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Summary

- The sterilizer consistently reduced vegetative organisms to undetectable levels even under "worst case" conditions including high organism load (>10^9) and presence of organic material and salts
- The technology consistently eliminated 6 to 6.2 $\log_{10}$ CFU of spores in the presence of soils/salts
- These findings highlight the importance of meticulous cleaning of endoscopes prior to use of the sterilizer
- The endoscope sterilizer is a promising technology that provides one means to transition from HLD to sterilization of endoscopes

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THANK YOU!
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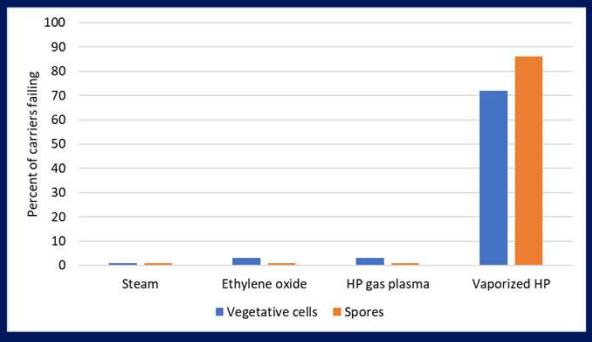
Low-temperature sterilization technologies sometimes fail in the presence of salt and serum simulating inadequate cleaning



Soil: fetal calf serum and .29%-.65% salt

Rutala WA. Comparative evaluation of the microbicidal activity of low temperature sterilization technologies to steam sterilization. ICHE 2020.

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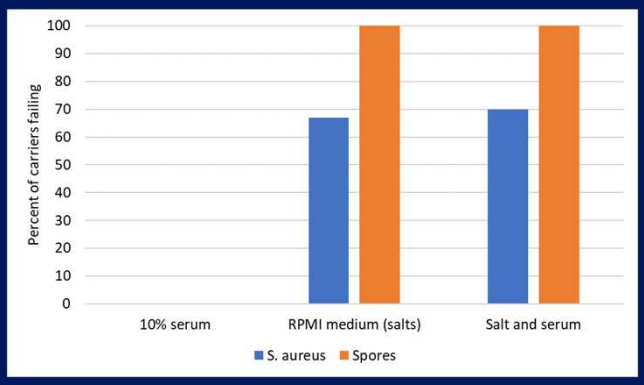
Salt was the principal factor interfering with efficacy



Rutala WA. Comparative evaluation of the microbicidal activity of low temperature sterilization technologies to steam sterilization. ICHE 2020.

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FDA requirements for sterilization validation

- Test: sterilization half-cycle with a challenge of 10^6 CFU of a highly resistant organism (bacterial spores) placed at the cold spot (worse-case location) of the device
- Validation does not require the use of an organic/inorganic soil

Food and Drug Administration. Guidance on Premarket Notification (510 (k)) submission for sterilizers intended for use in health care facilities. March, 1993.

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Contact Time Has Limited Efficacy of Disinfectant Towellettes

Kelley et al. Antimicrobial Resist and IC, 2023

No difference in efficacy at contact time at 1m compared with 2, 3, and 10m

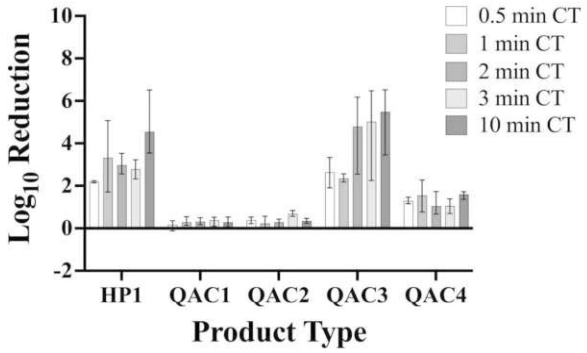

Fig. 3 Efficacy of Disinfectant Towelette Products Against *Paeruginosa* Mean $\log_{10}$ reduction of *P. aeruginosa* achieved by each disinfectant towelette product type at each contact time tested. Bars indicate minimum and maximum values measured

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