# The Pros and Cons of Alternative Disinfection Technologies for Room Decontamination

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# Conflict Of Interest Disclosure

- An inventor of AsepticSure®
- Chief Medical Officer of Medizone International Inc.
- Shareholder of Medizone International Inc

# Objectives

- At the end of this presentation I hope you:
  - Will be able to describe the two types of UV lamp technologies, their characteristics and efficacy
  - Will be able to describe the basis for the hydrogen peroxide vapor and mist technologies and their efficacy
  - Will be able to describe how effective ozone based methods are as a space disinfection technology
  - Understand the synergy of combining ozone and hydrogen peroxide as a novel high level disinfection technology for health care spaces and other applications
  - Will know what to look for in *in vitro, in vivo* and clinical studies of the new technologies for room decontamination and disinfection

# Agenda

- The characteristics of an ideal room disinfection system
- Quality of Evidence
- Ultraviolet light
- Hydrogen peroxide
- Ozone
- Ozone and Hydrogen Peroxide Synergy

# What I Cannot Cover Today

- Formaldehyde fogging
- Aerosolization of surface cleaning agents
- Chlorine dioxide
- Detailed cost estimates of all technologies
- Most of the data presented is about bacteria and bacterial spores
  - With apologies to the viruses and fungi in the room!

# The Problem

- Too many healthcare infections
- Needless suffering and mortality
- Despite innovations and best efforts
- Environment a major source and reservoir
- We need to find a transformational technology!
- Just cleaning where the “dots are” is not good enough!

# Characteristics of the Ideal Room Disinfection System

- ✓ Highest possible kill of all relevant organisms especially *C. difficile* spores
- ✓ Fast
- ✓ Simple to perform
- ✓ Cost effective
- ✓ Can be safely deployed
- ✓ No environmental residues
- ✓ Reduces incidence of healthcare infections
- ✓ High quality supportive scientific evidence

# Quality of Evidence Concerning H2O2, UV, O3

- Can be very mixed so read it critically
- Peer reviewed literature best
- *in vitro* studies
  - Using test chambers etc
  - Bacteria or other organisms on various materials
    - Steel discs/coupons
    - Fabric, carpet, plastics, various building finishes
  - Good controls with many replicates
  - Quantitative Carrier Tests (QCT) Protocol by Springthorpe and Sattar et al
  - Use of a soil load
  - Each organism brings unique challenges

# *in vivo* Testing

- In hospital rooms, laboratories, various field locations
  - Random assignment of rooms/spaces
  - No over lap of methods, “wash out times”
  - Detailed surface culture protocol with large number of samples
    - Highly standardized, with different methods
  - Supplemented with microbe loaded coupons in standard locations in the room
  - Always use spores of spore forming pathogens
    - eg *C. difficile, Bacillus spp, Geobacillus spp*. etc.

# Interpreting Results

- Want to see expression of data as log10 kill (or log10 survivor)
  - Kill =starting inoculum-survivors
    - Expressed as log10 kill
  - Use geometric means for large number of samples
  - Need dozens of replicates under any one set of conditions especially for *in vitro* testing
- Surface swabs
  - Typically expressed as cfu/cm2
    - Typically see 10's to 100's cfu/cm2
    - Count specific pathogens
    - Or count all heterotrophic bacteria on the surface

# Clinical Studies

- Before and after studies citing reductions in infections
  - Rates of HAI vary significantly over time
  - Be cautious in the interpretation of these results
- Prefer randomized and multicenter design ideally
  - Difficult to do and costly
  - Combined with surface cultures and loaded coupons and clinical outcomes to make a comprehensive evaluation

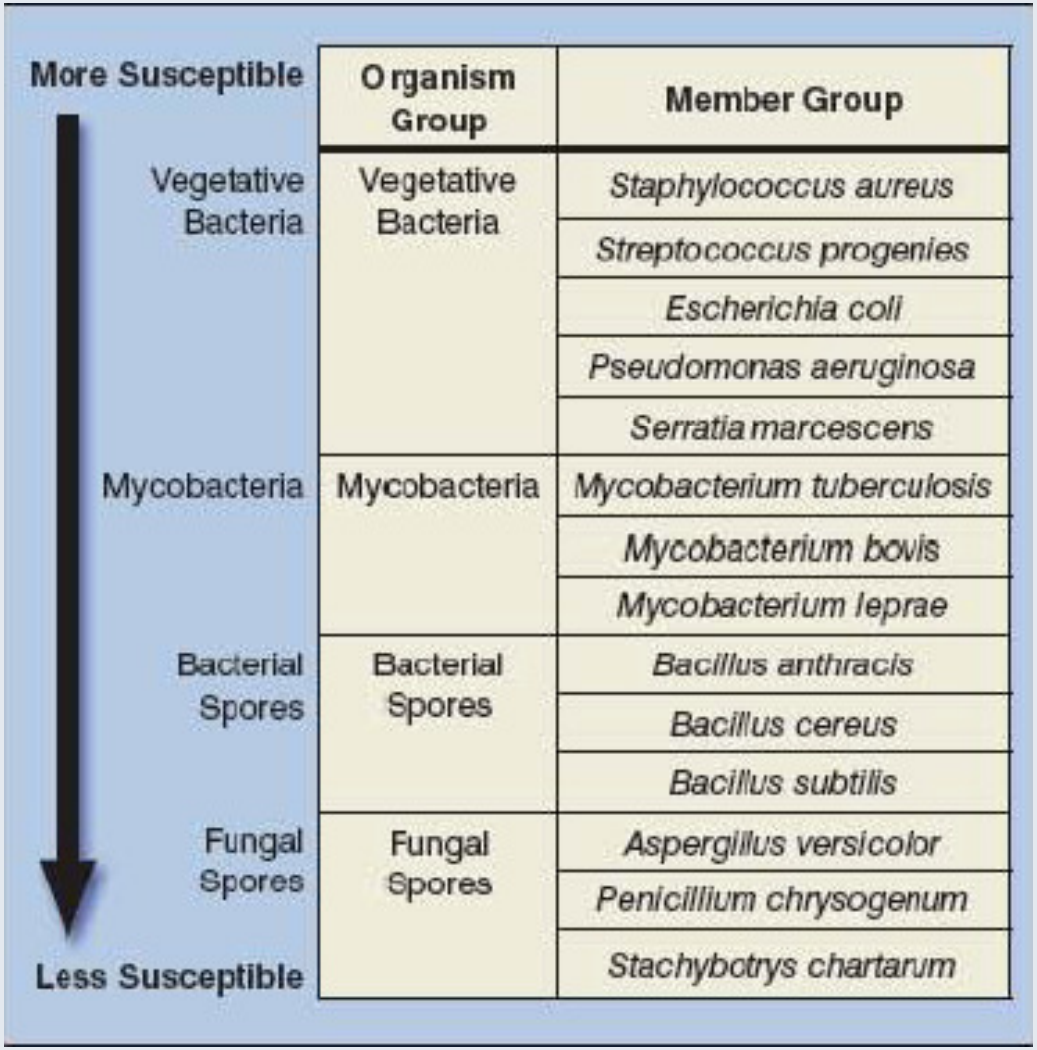
# A Bit of Physics About UV Light

- Ultraviolet germicidal irradiation (UVGI)
- Wavelength shorter than that of visible light
  - UVA 400 nm to 315 nm
  - UVB 315 nm to 280 nm
  - UVC 280 nm to 200 nm
- The entire UV spectrum can kill or inactivate many different microorganisms
- UVC energy provides the most germicidal
- 265 nm optimum wavelength

# Susceptibility to UV Light

- Susceptibility to UV irradiation varies by species
- Also upon other conditions:
  - Eg  air, water, temperature, flow rates, etc
- Microbial susceptibility is very variable
- Design of UV light systems not that standardized
- No consensus guidelines for design

# Susceptibility of Organisms to UVC




| Organism Group | Member Group |
|---|---|
| Vegetative Bacteria | *Staphylococcus aureus* |
| | *Streptococcus progenies* |
| | *Escherichia coli* |
| | *Pseudomonas aeruginosa* |
| | *Serratia marcescens* |
| Mycobacteria | *Mycobacterium tuberculosis* |
| | *Mycobacterium bovis* |
| | *Mycobacterium leprae* |
| Bacterial Spores | *Bacillus anthracis* |
| | *Bacillus cereus* |
| | *Bacillus subtilis* |
| Fungal Spores | *Aspergillus versicolor* |
| | *Penicillium chrysogenum* |
| | *Stachybotrys chartarum* |

From Martin SB et al . ASHRE Journal. August 2008

# Mercury Vapor Lamps

- In mercury vapor lamps, the mercury vapor is excited to create UV-C
- Create UV at 253.7 nm.
- This is close to the average peak DNA absorbed at 260-265 nm.
- Mercury lamps produce continuous UV light

# Xenon Vapor Lamps

- Pulsing a xenon UV lamp PX-UV
- Results in a flash of light with a broad spectrum from 200 nm to 320 nm
- Millisecond pulses
- More UV-C wavelengths are produced
- High intensity of the fast pulses may give PX-UV better disinfection efficacy?

# Tru-D Unit by Lumalier

From ECRI Health Devices May 2011

# Mercury UV System Tru-D

- An automated mobile UV-C unit
- Tru-D; by Lumalier
- Shown to produce a 3 log10 kill of vegetative bacteria
  - MRSA, VRE, and *A. baumannii*
- 2.4-log10 kill of *C. difficile* seeded onto Formica surfaces in experimentally contaminated patient room

Rutala WA, Gergen MF, Weber DJ. Room decontamination with UV radiation. *Infect Control Hosp Epidemiol* 2010;31:1025–1029.

# Tru-D

- Tru-D, Lumalier studied in reducing environmental contamination with vegetative bacteria
- Measured using aerobic colony counts and *C. difficile* inoculated onto stainless steel carrier disks
  - Boyce JM et al. *Infect Control Hosp Epidemiol* 2011;32:737–742

# Tru-D

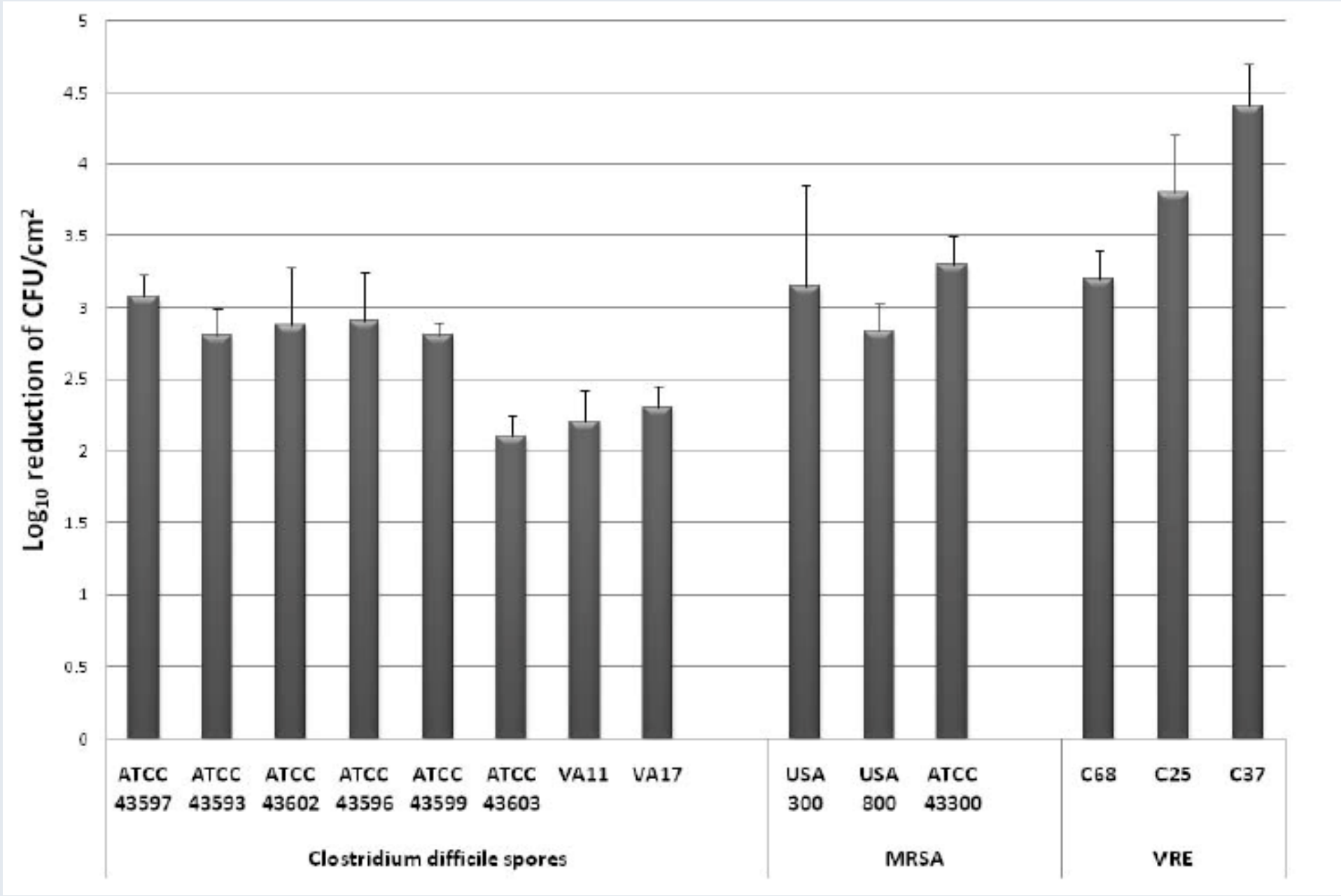
- Room decontamination with the Tru-D UV system
- Reductions in aerobic bacteria on 5 high-touch surfaces.
- Mean *C. difficile* log10 reductions ranged from 1.8 to 2.9 when cycle times of 34.2–100.1 minutes were used.
- Surfaces in direct line of sight were significantly more likely to yield negative culture results after UV decontamination than before decontamination
  - Boyce JM et al. *Infect Control Hosp Epidemiol* 2011;32:737–742

# Tru-D

- On inoculated surfaces
- Reflected dose of 22,000 µWs/cm2 for 45 minutes
- Kill of *C. difficile* spores and MRSA by >2-3 log10 colony forming units (CFU)/cm2
- Kill of VRE by >3-4 log10 CFU/cm2

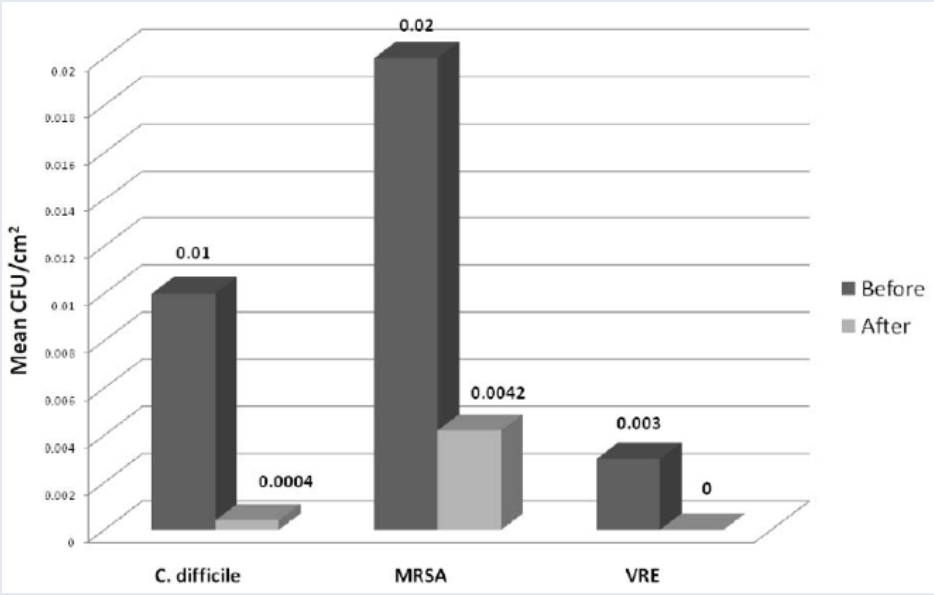
- Same level of kill of MRSA and VRE was achieved in 20 minutes at a reflected dose of 12,000 µWs/cm2,
- But killing of *C. difficile* spores was reduced significantly.
  - Nerandzic MM. *BMC Infect Dis* 2010;10:197.

# Tru-D Log10 Bacterial Kill




From Nerandzic MM et al. *BMC Infect Dis* 2010;10:197

# Tru-D Surface Swabs




- High touch surfaces of a bathroom
  - 60,000 $cm^2$
  - *C. difficile* spores
    - Before: 600 spores
    - After: 24 spores
  - MRSA bacteria
    - Before: 1,200
    - After: 240
  - VRE bacteria
    - Before: 180
    - After: 0

From Nerandzic MM et al. *BMC Infect Dis* 2010;10:197

# Xenex


Pulsed xenon UV light

From: www.xenex.com

# XENEX *in vitro* Lab Study

| Organism | Control (cfu) | Log10 Kill | |
|---|---|---|---|
| | | 480 sec (8 min) | 720 sec (12 min) |
| **MRSA** | $1.23 \times 10^5$ | 5.01 | n/a |
| **VRE** | $2.75 \times 10^4$ | 4.44 | n/a |
| ***C. difficile*** | $3.33 \times 10^5$ | 4.52 | 5.52 |

- ***C. difficile*** **was 1 meter from lamp, MRSA and VRE 2 meters from lamp.**
- ***C. difficile*** **9 samples, MRSA & VRE 4 samples.**
- **"The experiment was conducted at an independent microbial testing laboratory"**
- **Modified from: Stibich M.** ***Abstract presented at SHEA/Fifth Decennial Meeting 2010***

# Xenex Study at MD Anderson

- January to March 2010 at MD Anderson Cancer Center, Houston Tx
- 12 rooms extensively surface cultured at discharge for VRE isolation
- Isolation clean with germicide x 30 mins.
- 3 x 4 min exposures to Xenex lamp
- Cultures taken before cleaning, after cleaning and using the Xenex lamp

*Stibich et al. Infect Control Hosp Epidemiol* 2011;32(3)

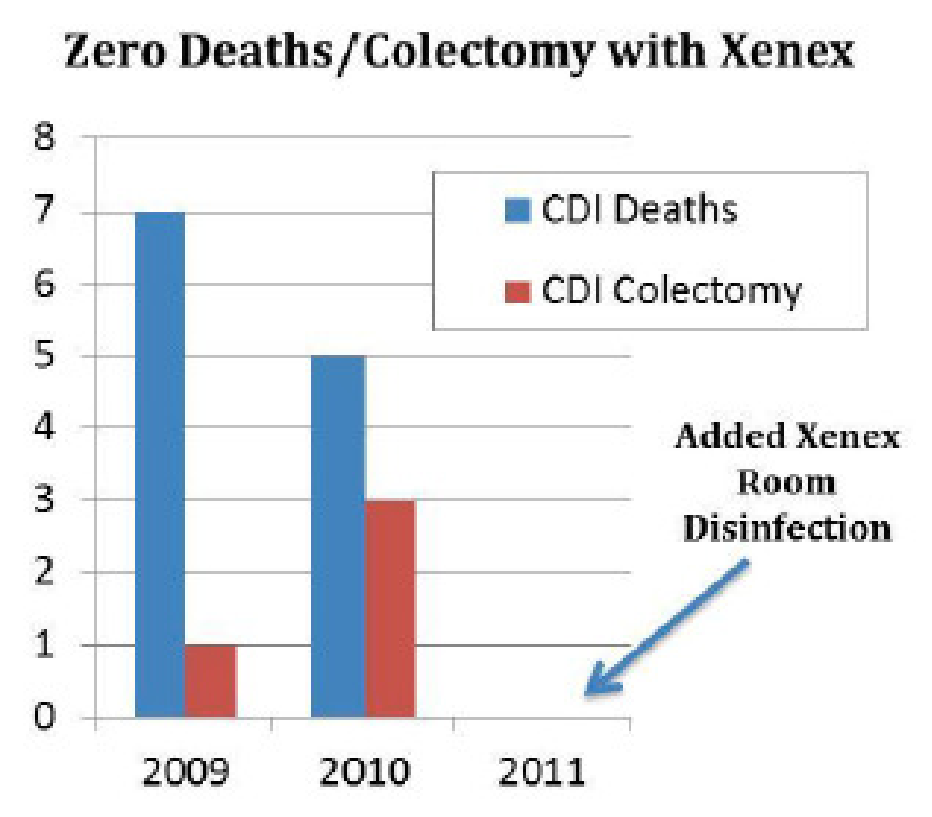
# XENEX

TABLE 2. Impact of Standard Cleaning and Pulsed-Xenon Ultraviolet (PX-UV) Disinfection on Room Bacterial Heterotrophic Plate Count (HPC)

| Room status | No. of samples | HPC mean, CFU/cm$^2$ | *z* | *P* |
|---|---|---|---|---|
| Comparison 1 | | | 2.638 | .0083 |
| Before cleaning | 73 | 33.0 | | |
| After standard terminal cleaning | 91 | 27.4 | | |
| Comparison 2 | | | 6.430 | <.0001 |
| Before cleaning | 73 | 33.0 | | |
| After PX-UV treatment | 75 | 1.2 | | |
| Comparison 3 | | | 4.309 | <.0001 |
| After standard terminal cleaning | 91 | 27.4 | | |
| After PX-UV treatment | 75 | 1.2 | | |

*Stibich et al. Infect Control Hosp Epidemiol* 2011;32(3)

# Xenex Cooley Dickinson Hospital Study




- 140 bed acute hospital, Northampton MA
- January-September 2011 Xenex used
- Uncontrolled observational study
  - 2x7 min in room
  - 1x7 min in bathroom
- Pre-cleaned with chlorine bleach (SOP throughout)
- CDI Rates
  - 2009: not stated
  - 2010: 0.95/1000 PtDay
  - 2008-2010 Q1-3: 0.98/1000 PtDay
  - 2011 (Q1-3): 0.32/1000 PtDay

Levin J et al. IDSA 2011 Abstract

# UV Light Summary

| Property | UV-C Light | Xenon Pulse Light |
|---|---|---|
| Source | Mercury bulb | Xenon bulb |
| Exposure time | 20-100 min | 8-12 mins over 2-3 doses |
| Vegetative bacterial kill | 3-4 log | 4-5 log |
| C. difficile spore kill | 2-3 log | 4-5 log (limited data) |
| Risks | UV exposure | UV exposure |
| Toxicities/By Products | Mercury vapor | None |
| Controlled Clinical Trials | Yes | None yet |
| Costs | $124,500 capital<br>$1,600 for lamps (9000 h) | ??<br>Lamps x 3-4 months |
| Other | Line of sight effect | Scant data,<br>line of sight effect |

# H2O2 Technologies

- Bioquell
  - 30% H2O2 solution
  - H2O2 vapor
- Glosair (ASP)
  - 5-6% H2O2 solution
  - ASP (J&J) acquired Sterinis in 2009
  - H2O2 mist/aerosol
- VHP (Steris)
  - 35% H2O2 solution
  - H2O2 vapor

# Steris VHP 1000 ED System

From: www.steris.com

# BioQuell Q-10


www.bioquell.com

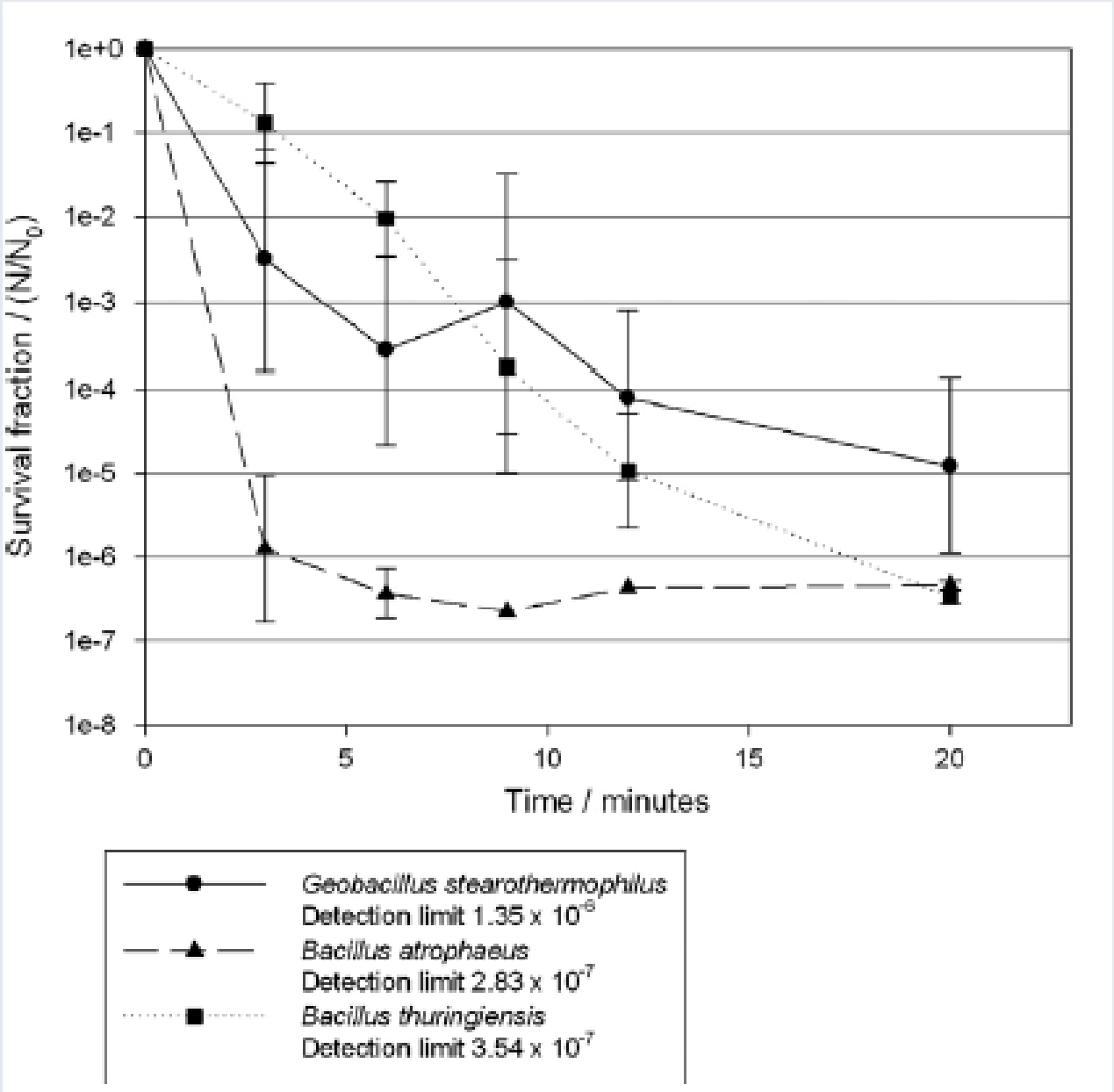
# Glosair (ASP)

**Glosair 600**

**Glosair 400**

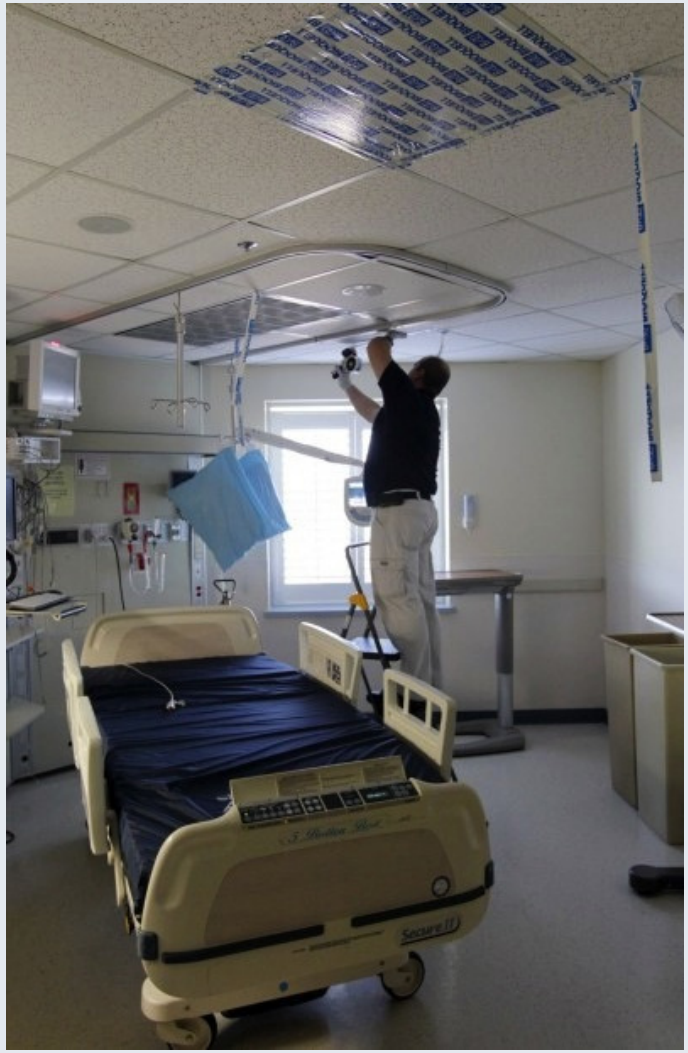
www.aspjj.com

# VHP (Steris) Against Aerobic Spores




*Pottage T. Appl. Environ. Microbiol.* 2012, 78(12):4169.

# Sealing Ducts in a Room



Jim Doyle in www.stltoday.com/business/article published August 15, 2010

# Bioquell Efficacy for CDI

- HPV decontamination of 5 high-incidence CDI wards followed by hospital-wide decontamination of rooms vacated by patients with *C. difficile* infection (CDI)
- 25.6% of cultures from surfaces before HPV decontamination yielded *C. difficile*
- compared with 0 cultures of samples obtained after HPV decontamination ($P < .001$)

*Boyce et al. Infect Control Hosp Epidemiol* 2008; 29:723–729

# Bioquell and CDI Cont'd

- During 9 month intervention period
- On the 5 high incidence wards rates of CDI dropped from 2.28 vs 1.28 cases per 1,000 patient-days ($P<.047$)
- Hospital wide incidence fell from 1.89 vs 0.88 cases per 1,000 patient-days ($P < .047$) during the high incidence months pre and post intervention.

*Boyce et al. Infect Control Hosp Epidemiol* 2008; 29:723–729

# Bioquell and MRSA

- 74% of 359 swabs taken before cleaning yielded MRSA
- After cleaning, all areas remained contaminated, with 66% of 124 swabs yielding MRSA.
- After treatment of 6 rooms with HPV (Bioquell) only 1 of 85 (1.2%) swabs showed MRSA
  - note smaller sample size after exposure however
- 5 hour cycle time
- 500 ppm H2O2 (high)
  - French GL et al. Journal of Hospital Infection (2004) 57, 31–37

# Sterinis Trial (becomes Glosair)

- Teaching hospital in Zonguldak, Turkey
- Steel discs inoculated and placed in many locations in patient rooms 53m3
- MRSA and *A. baumannii*
- Applied Sterinis HP Mist
- 2.5 hr cycles
  - Piskin N et al. Am J Infect Control. 2011 Nov;39(9):757-62

**Table 4.** Comparison of the activity of the DMHP system according to presence or absence of a barrier

| | Reduction in initial contamination, Mean (±SD), $log_{10}$ cfu | | |
|---|---|---|---|
| | In absence of a barrier | In presence of a barrier | *P* value |
| Pure MRSA suspension carrying disks | 4.70 ± 0.0 | 3.52 ± 1.82 | .059 |
| Pure Acinetobacter suspension carrying disks | 4.67 ± 0.0 | 3.79 ± 1.35 | .059 |
| Serum containing MRSA suspension carrying disks | 4.45 ± 0.63 | 1.49 ± 1.86 | .003 |
| Serum containing Acinetobacter suspension carrying disks | 4.44 ± 0.0 | 2.92 ± 1.75 | .01 |

*SD*, standard deviation.

# H2O2 (Sterinis) vs Bleach

## In vitro

TABLE 1. Comparison of the In Vitro Activity of Sodium Hypochlorite and Hydrogen Peroxide Against *Clostridium difficile* Spores, According to the Material Used as a Spore Carrier

| Disinfection method | Reduction in initial contamination, mean (±SD), $\log_{10}$ cfu | |
|---|---|---|
| | Vinyl polychloride | Laminate |
| 0.5% Sodium hypochlorite solution | 4.18 ± 0.33 | 4.47 ± 0.32 |
| Hydrogen peroxide–silver cation dry-mist | 4.19 ± 0.86 | 4.17 ± 0.74 |

## In vivo

- *C. difficile* terminal clean rooms
- 0.5% bleach x 10 min x 16 rooms
  - 24% to 12% room contamination reduction (50%)
- Sterinis x 1.5-2 hr x 15 rooms
  - 19% to 2% room contamination reduction (91%)

Barbut et al. *Infect Control Hosp Epidemiol* 2009; 30:507-514 (Paris)

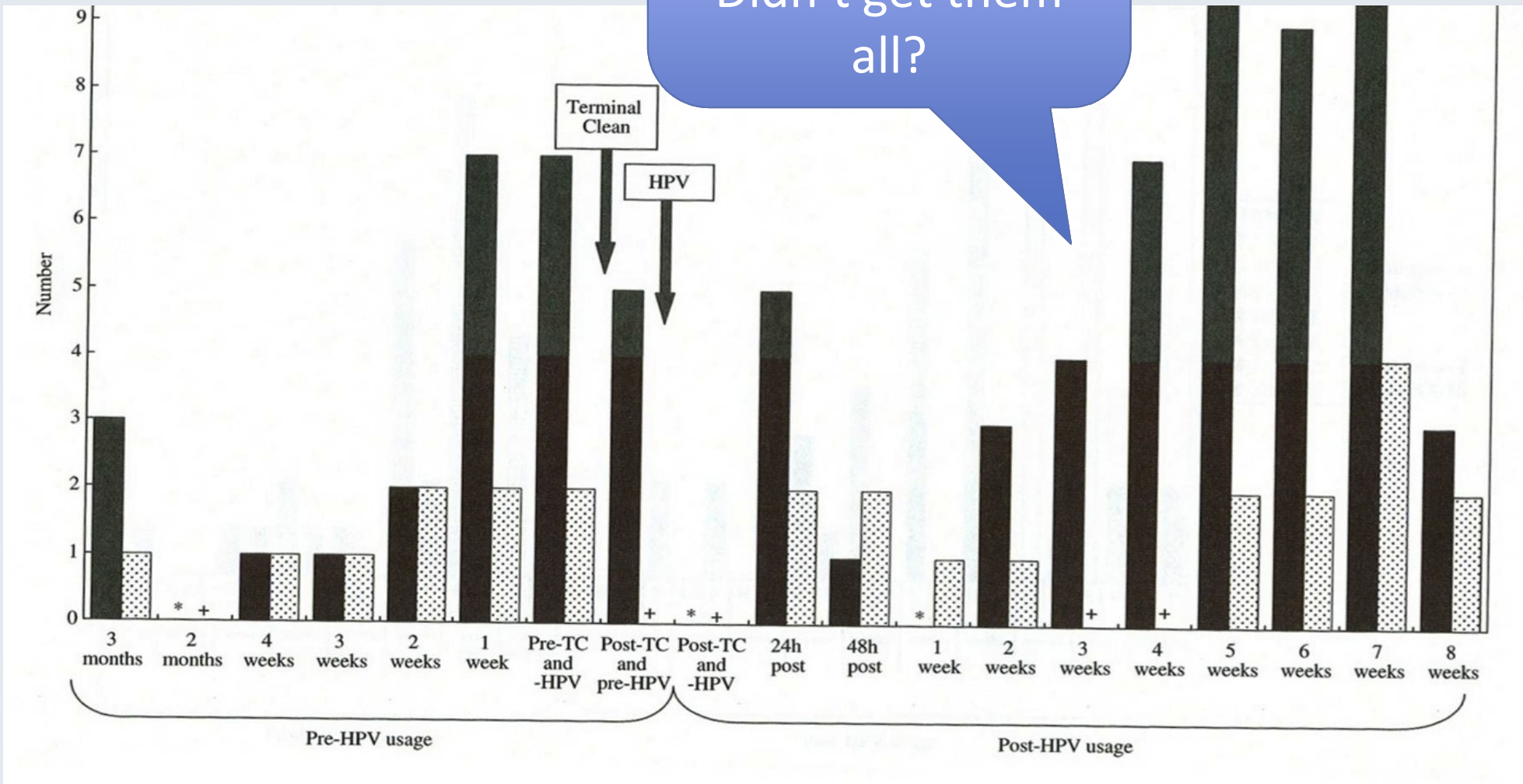
# Tru-D vs Bioquell "Head to Head"

- 500 bed hospital
  - 15 patient rooms at random from 8 wards
- 5 high touch surfaces cultured for ACC
- Steel discs loaded with $10^6$ *C. difficile* spores placed in 5 areas close to high touch surfaces
- BI's with $10^4$ and $10^6$ *G. stearothermophilus*

- Results
- HPV (Bioquell)
  - 93% ACC negative
  - 6 log10 *C. difficile* kill
  - 99-100% BI's killed
  - 2.5-3 hr cycles
- UV-C (TRU-D)
  - 52% ACC negative
  - <2 log10 *C. difficile* kill
  - 0-22% % BI's killed
  - 0.6-1.7 hr cycles

*Havell et al. Infect Control Hosp Epidemiol* May 2012;33(5):507-512

Rapid MRSA regrowth after HPV.
Didn't get them all?




Hardy K et al. J Hosp Infect 2007;66:360-368

# Comparison of H2O2 Systems

| Parameter | Glosair (ASP) | VHP ( Steris) | BioQuell |
|---|---|---|---|
| H2O2 % | 5-6% | 35% | 35% |
| Dispersion | Dry Mist/Aerosol | Vapor | Vapor |
| Final Conc H2O2 | 50-80 ppm | ~500 ppm | ~500 ppm |
| Cycle Time | ~2-3 hr | 2-8 hrs | ≥2 hr, up to 5 hr |
| *C. difficile* log10 kill | 2-3 log | *NPD for *C. difficile*.<br>5-6 log for Bacillus | *6 log for C. difficile*.<br>6 log for Bacillus |
| Controlled Clinical Trials | Some small | ? | Yes |
| Cost | $65,000?<br>$50 per room | ? | $44,000 capital<br>Cost per room? |
| | | | |

*NPD= No Published Data

# Ozone Actions

- The first ozone disinfection experiment was conducted in France in 1886
- de Meritens demonstrated that diluted ozonized air could sterilize polluted water
- Ozone gas (O3) with a molecular weight of 48
- Highly reactive with a large excess of energy (~143 KJ/mol) and a high level of oxidizing power
- Marked tropism for extracting electrons from other molecules and simultaneously releasing one of its own oxygen atoms in the process.

# Pure O3 as Antibacterial

**Table 1.** Bacterial susceptibility to ozone gas

| | ATCC # | Log $_{10}$ reduction in cfu's | |
|---|---|---|---|
| | | Wet sample | Dry sample |
| Gram-positive bacteria | | | |
| *Bacillus cereus* | 11778 | > 3.1 | > 3.1 |
| *Bacillus spizizenii* | 6633 | > 3.2 | > 3.2 |
| *Clostridium difficile* | 43593 | > 4.0 | > 4.0 |
| MRSA | Clinical isolates | > 3.0 | > 3.0 |
| Methicillin-sensitive *Staphylococcus aureus* | Clinical isolates | > 2.5 | > 2.5 |
| *Propionibacterium acnes* | 11827 | ≥ 4 | ≥ 4 |
| *Streptococcus pyogenes* | 12384 | ≥ 4 | ≥ 4 |
| Gram-negative bacteria | | | |
| *Acinetobacter baumannii* | 19606 | ≥ 4 | ≥ 4 |
| *Enterococcus faecalis* | 51299 | > 3 | > 3 |
| *Escherichia coli* | 25922 | > 3.1 | > 3.1 |
| *Haemophilus influenzae* | 19418 | ≥ 4 | ≥ 4 |
| *Klebsiella pneumoniae* | 10031 | ≥ 4 | ≥ 4 |
| *Legionella pneumophila* | 33152 | ≥ 4 | ≥ 4 |
| *Pseudomonas aeruginosa* | 27853 | ≥ 4 | ≥ 4 |
| Acid-fast bacteria | | | |
| *Mycobacterium smegmatis* | 14468 | > 2.7 | > 2.7 |

Sharma & Hudson. Am J Infect Control 2008;36:559-63. Viroforce

# Ozone & Hydrogen Peroxide in Biological Systems

- Antibodies have been shown to have catalytic activity that produces **BOTH $H_2O_2$ AND $O_3$**
  - BUT the amount produced of each is so low that neither could kill any microorganism
- Trioxidane ($H_2O_3$) has been detected as the extremely reactive intermediary molecule of this reaction
- Trioxidane is lethal to organisms in minute amounts!

Nyffeler, Wentworth & Lerner et al. Angewandte Chemie 2004, from Scripps Research Institute and Oxford University

# What Can be Learned From Mother Nature!

- Medizone experiments that led to synergy
- Goals:
  - To study the antimicrobial effects of ozone gas **and** of hydrogen peroxide vapour
  - Against common **healthcare** and **food borne** pathogens
  - And to document the **synergy of ozone AND hydrogen peroxide** as rapid means to achieve a high level of disinfection in full sized rooms

# Hydrogen Peroxide ***OR*** Ozone

**Hydrogen Peroxide**

- Used alone at 1-3%
- Resulted in < 1 $\log_{10}$ bacterial kill with up to 60 minute exposures
- Certainly not sporocidal

**Ozone**

- Used alone at 30-200 PPM
- Resulted in < 1 $\log_{10}$ bacterial kill with up to 90 minutes exposures
- At 500-800 PPM for 90 mins see kill of 6 $\log_{10}$

# The Science of Synergy

$O_3$

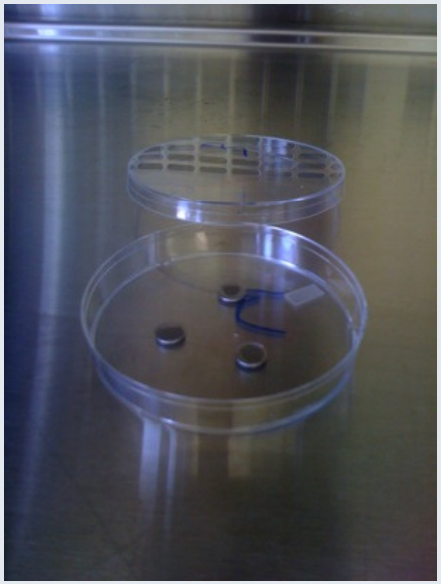
+

$H_2O_2$

$H_2O_3$

No Kill → >6 $\log_{10}$ Kill

# Our Microbiology Techniques



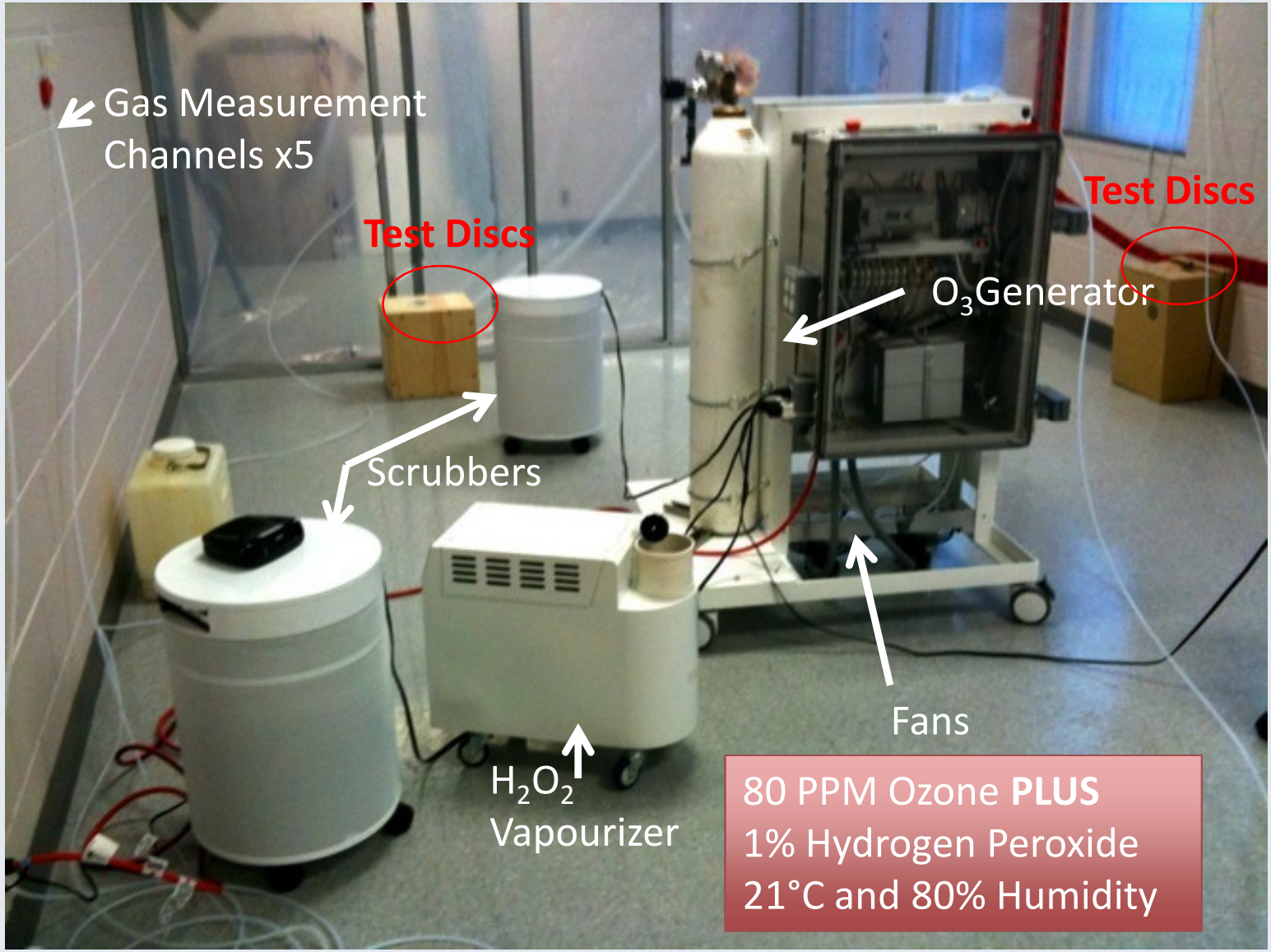

1 cm stainless steel disks as the bacteria & spore carriers

The quantitative carrier test (QCT-2) standard used or modified

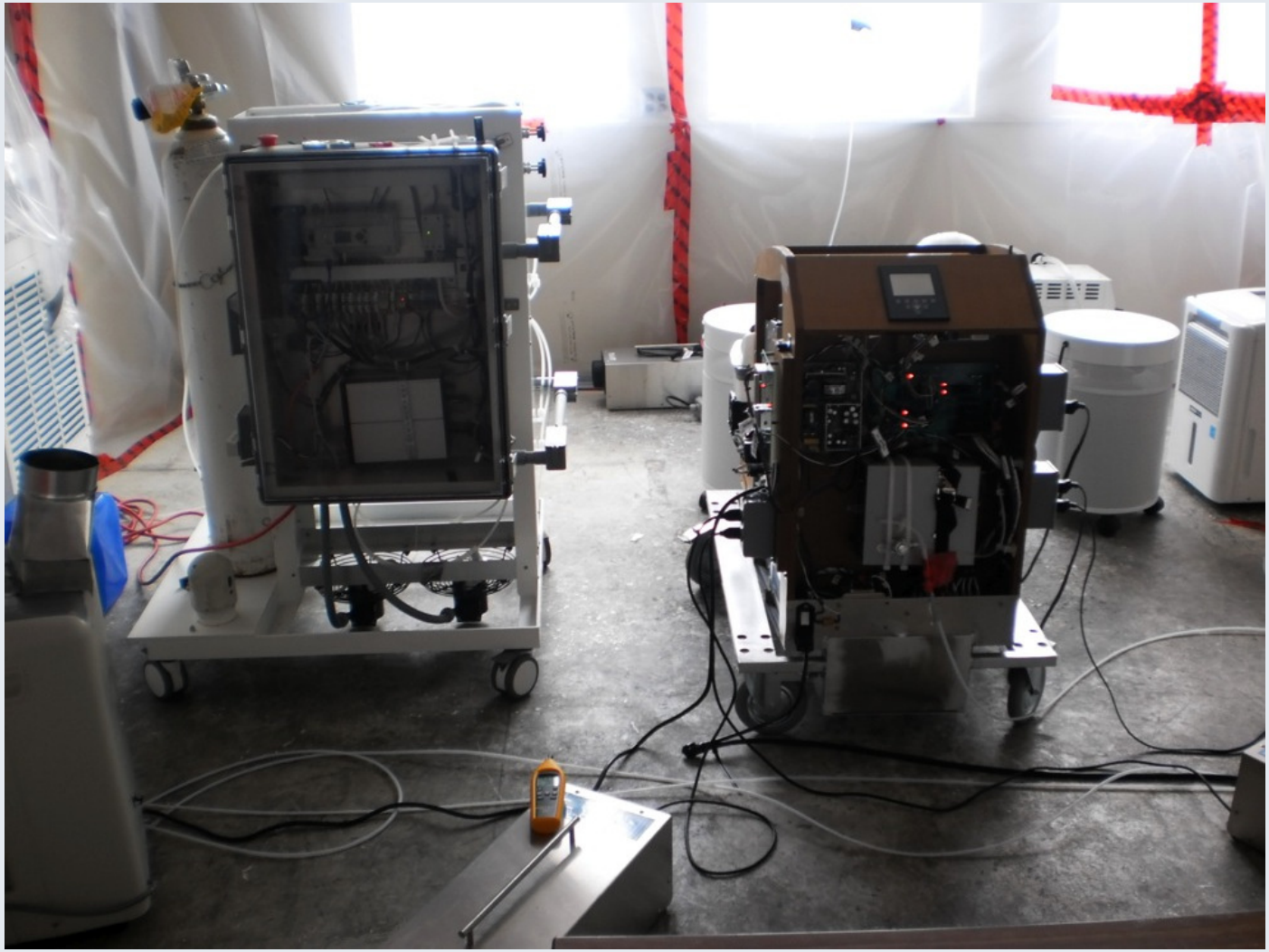
# *In vitro* Testing System

- Polycarbonate chamber
- Fully instrumented to measure conditions
- Computer controlled and recorded results
- Used MRSA as test organism initially to define optimal conditions

# *In vivo* Testing System



# Frankenstein and Woody



# The Results

| Organism | Ozone (PPM) | H2O2 (%) | Exposure (min) | Microbial Kill ($Log_{10}$) |
|---|---|---|---|---|
| MRSA | 80 | 1 | 15 | 6.3 |
| VRE | 80 | 1 | 15 | 6.2 |
| *E. coli* | 80 | 1 | 15 | 6.5 |
| *S. typhimurium* | 80 | 1 | 15 | 6.1 |
| *P. aeruginosa* | 80 | 1 | 15 | 6.0 |
| *L. monocytogenes* | 80 | 1 | 15 | 6.3 |
| *C. difficile spores* | 80 | 1 | 15-30 | 6.1 |
| *B. subtilis spores* | 80 | 1 | 30 | 6.1 |
| *Mycobacterium terrae* | 80 | 1 | 30 | 6.2 |

# Testing Materials

- AsepticSure system also effective on:
  - Stainless steel
  - Plastic from toilet seats
  - Laminate
  - Carpeting
  - Cotton or synthetic cloth
  - With and without organic soil load

# Summary of AsepticSure

- **First ever** use of **ozone and hydrogen** peroxide for high level disinfection of clinical spaces and surfaces
- Capitalizes upon **HUGE synergy** between ozone and hydrogen peroxide producing **trioxidane**
- Very **fast**
- **Broad** spectrum
- Consistent **high level** disinfection (6 $\log_{10}$=sterilization)
- **Penetrating** gas goes everywhere
- **Low doses** of ozone and hydrogen peroxide reduces costs, risks and damage to infrastructure
- Technology proven to be very **robust** and **reliable**
- Capital Cost~ $95,000 + ~$10-20 per room

# Am J Inf Control 2011;39:873-9

## Effectiveness of a novel ozone-based system for the rapid high-level disinfection of health care spaces and surfaces

Dick Zoutman, MD, FRCPC,[a] Michael Shannon, MD, MSc,[b,c] and Arkady Mandel, MD, PhD, DSc[c]
Kingston and Ottawa, Ontario, Canada

***Background:*** Vapor-based fumigant systems for disinfection of health care surfaces and spaces is an evolving technology. A new system (AsepticSure) uses an ozone-based process to create a highly reactive oxidative vapor with broad and high-level antimicrobial properties.

***Methods:*** Ozone gas at 50-500 ppm was combined with 3% hydrogen peroxide vapor in a test chamber and upscaled in rooms measuring 82 $m^3$ and 90 $m^3$ in area. Test organisms included methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococcus, *Escherichia coli*, *Pseudomonas aeruginosa*, *Clostridium difficile*, and *Bacillus subtilis* spores dried onto steel discs or cotton gauze pads.

***Results:*** The combination of 80-ppm ozone with 1% hydrogen peroxide vapor achieved a very high level of disinfection, with a $\geq 6$ $\log_{10}$ reduction in the bacteria and spores tested on steel discs and MRSA tested on cotton gauze during a 30- to 90-minute exposure. The entire system was scalable such that it achieved the same high level of disinfection in both the 81-$m^3$ and 90-$m^3$ rooms in 60-90 minutes.

***Conclusion:*** The ozone hydrogen peroxide vapor system provides a very high level of disinfection of steel and gauze surfaces against health care-associated bacterial pathogens. The system is an advanced oxidative process providing a rapid and effective means of disinfecting health care surfaces and spaces.

***Key Words:*** Ozonation; hydrogen peroxide; fumigation.

# AsepticSure

# Bed Bugs!

# AsepticSure and Bed Bugs

- Collaboration with Department of Entomology, Purdue University
- 100% kill of all stages of beg bugs including the very hard to kill eggs
- Higher concentration of ozone & H2O2 required (180 ppm and 3%)
- And longer exposure time of up to 24 hours.

# Characteristics of the Ideal Room Disinfection System

- ✓ Highest possible kill of all relevant organisms especially *C. difficile* spores
- ✓ Fast
- ✓ Simple to perform
- ✓ Cost effective
- ✓ Can be safely deployed
- ✓ No environmental residues
- ✓ Reduces incidence of healthcare infections
- ✓ High quality supportive scientific evidence

# The Final Result