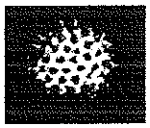
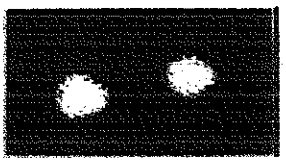
Norovirus

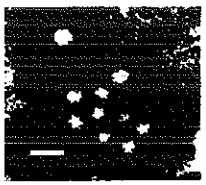
Virus Morphology



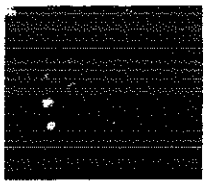
Rotavirus (60-80 nm)



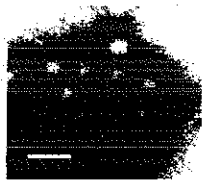
Adenovirus (70-90 nm)



Astrovirus (27-30 nm)



Sapovirus (27-35 nm)



Norovirus (27-35 nm)

www.virology.net/Big_Virology/BV/FamilyIndex.html

Noroviruses

- Norovirus (formerly Norwalk-like viruses-NLV) is a genus within the family *Caliciviridae*. SS-RNA with a capsid structure provides increased resistance to chemical disinfection.
- Causes acute gastroenteritis in humans; fecal-oral transmission primarily, although droplet and fomite transmission may facilitate spread.
- Infective dose as low as 10-100 particles.
- Outbreaks have been reported in hospitals, homes, camps, schools, restaurants, hotels, rehabilitation centers and cruise ships
- Outbreaks in hospitals have increased in recent years and this may lead to the closure of wards
- This group of viruses cannot be grown in cell culture so feline calicivirus used as a surrogate

Environmental Contamination

Norovirus

- Hospital-11/36 (31%) environmental swabs were positive for RT-PCR. Positive swabs were from lockers, curtains and commodes and confined to the immediate environment of symptomatic patients. J Hosp Infect 1998;39:39.
- Hotel-61/144 (42%) were positive for NLV RNA. Cheesbrough et al. Epid. Infect 2000;125:93.
- Rehabilitation Center-Norovirus detected from patients and three environmental specimens (physiotherapy instrument handle, toilet seat (2-room of symptomatic guest, public toilet) RT-PCR. Epid Infect 2002;129:133-138.
- LTCF-5/10 (50%) of the environmental samples were positive for norovirus by RT-PCR. Wu et al. ICHE 2005;26:802.

Some positive PCR results may represent non-infectious virus.

Environmental Survival

Norovirus

- Distilled water or saline: Survival 0-2 days West AP, et al. J Clin Path 1992;48:228
- Sterile river water: Survival 2 to 20-30 days Shahamat M, et al. Appl Environ Micro 1993;59:1231
- Tap water at 4°C: 4 days Fan EG, et al. J Gastroenterol Hepatol 1998;13:1096
- At 20°C a 9-$\log_{10}$ reduction of FCV between 21-28 days in a dried state Doultree et al. J Hosp Infect 1999;41:51
- At 20°C a 9-$\log_{10}$ reduction of FCV between 14-21 days in suspension Doultree et al. J Hosp Infect 1999;41:51
- At 20°C a 3-$\log_{10}$ reduction in infectivity (two animal caliciviruses) occurred in 1 week. Duizer et al. Appl Env Micro 2004;70:4538.

Role of the Environment

Norovirus

1. Prolonged outbreaks on ships suggest norovirus survives well
2. Outbreak of GE affected more than 300 people who attended a concert hall over a 5-day period. Norwalk-like virus (NLV) confirmed in fecal samples by RT-PCR. The index case was a concert attendee who vomited in the auditorium. GI illness occurred among members of 8/15 school parties who attended the following day. Disinfection procedure was poor. Evans et al. Epid Infect 2002;129:355
3. Extensive environmental contamination of a hospital ward.

   Suggest transmission most likely occurred through direct contact with contaminated fomites.

Inactivation of Feline Caliciviruses

Doultree et al. J Hosp Infect 1999;41:51

Disinfectant	Log Reduction	Contact Time
Glutaraldehyde, 0.5%	5	1
Hypochlorite, 1000 and 5000 ppm	5	1
QUAT	0	1
Iodine, 0.8%	5	1
Ethanol, 75%	1.25	1

Surface Disinfection

Norovirus

- School outbreak of NLV-cleaning with QUAT preparations made no impact on the course of the outbreak. The outbreak stopped after the school closed for 4 days and was cleaned using chlorine-based agents. Marks et al. Epid Inf 2003;131:727
- Detergent-based cleaning to produce a visibly clean surface consistently failed to eliminate norovirus contamination. A hypochlorite/detergent formulation of 5000 ppm chlorine was sufficient to decontaminate surfaces. Barker et al. J Hosp Infect 2004;58:42.

C. difficile and Norovirus

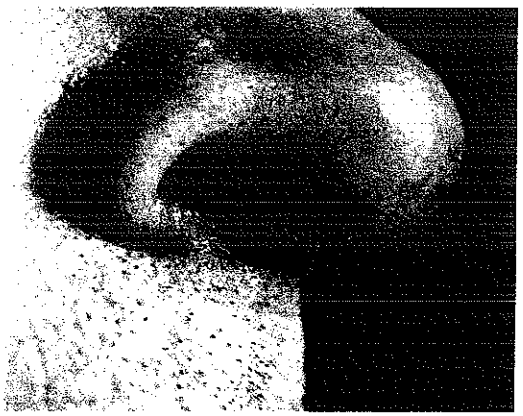
Due to the relative resistance of *C. difficile* spores and norovirus, during clusters, surfaces should be disinfected with a product shown to be effective (e.g., chlorine 5000ppm [1:10 bleach]

Prevention of *C. difficile*

- Role of the environment in transmission
- *C. difficile*
  - Microbiology and epidemiology
  - Environmental contamination
  - Environmental disinfection
  - Hand hygiene
- Norovirus
- MRSA
- Other issues: microfiber, computers, green products

MRSA

STAPHYLOCOCCAL ABSCESS



MRSA

- Frequency of environmental contamination in areas housing MRSA patients has ranged from 1 to 74% (23.1%, 53.6% from isolation rooms) of surfaces cultured.
- MRSA viable in the environment for days to weeks
- HCW can contaminate their hands or gloves by touching contaminated surfaces
- Cleaning or disinfecting the environment can reduce transmission but cleaning regimens, as currently practiced, may not eliminate MRSA from surfaces
- Since MRSA sensitive to all germicides, likely due to surfaces not cleaned/disinfected
- Need targeted methods to evaluate the thoroughness of room cleaning

Risk of Acquiring MRSA and VRE from Prior Room Occupants

- Admission to a room previously occupied by an MRSA-positive patient or VRE-positive patient significantly increased the odds of acquisition for MRSA and VRE (although this route a minor contributor to overall transmission). Arch Intern Med 2006;166:1945.
- Prior environmental contamination, whether measured via environmental cultures or prior room occupancy by VRE-colonized patients, increases the risk of acquisition of VRE. Clin Infect Dis 2008;46:678.

Practice or Product

Susceptibility of MSSA and MRSA to a Phenolic and Quaternary

Rutala et al. ICHE 1997;18:417

	Phenolic 1:256	Phenolic 1:128	QUAT 1:64	QUAT 1:32
MSSA	2/60	0/60	5/60	1/60
MRSA	0/60	0/60	4/60	1/60

TABLE 2
DISINFECTANT ACTIVITY AGAINST ANTIBIOTIC-SUSCEPTIBLE AND ANTIBIOTIC-RESISTANT BACTERIA

	Log_{10} Reductions							
	VSE		VRE		MSSA		MRSA	
Product	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vesphene IIse	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Clorox	>5.4	>5.4	>4.9	>4.9	>5.0	>5.0	>4.6	>4.6
Lysol Disinfectant	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Lysol Antibacterial	>5.5	>5.5	>5.5	>5.5	>5.1	>5.1	>4.6	>4.6
Vinegar	0.1	5.3	1.0	3.7	+1.1	+0.9	+0.6	2.3

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *S aureus*; VRE, vancomycin-resistant *Enterococcus*; VSE, vancomycin-susceptible *Enterococcus*. Data represent mean of two trials (n=2). Values preceded by "+" represent the limit of detection of the assay. Assays were conducted at a temperature of 20°C and a relative humidity of 45%. Results were calculated as the log of Nd/No, where Nd is the titer of bacteria surviving after exposure and No is the titer of the control.

Rutala WA, Barbee SL, Aguiar NC, Sobsey MD, Weber DJ. Antimicrobial Activity of Home Disinfectants and Natural Products Against Potential Human Pathogens. *Infection Control and Hospital Epidemiology* 2000;21:33-38.

Not Product: Is It Practice?

Surface Disinfection

Effectiveness of Different Methods

Rutala, Gergen, Weber, 2008, Unpublished

Technique (with cotton)	MRSA Log_{10} Reduction (QUAT)
Saturated cloth	4.41
Spray (10s) and wipe	4.41
Spray, wipe, spray (1m), wipe	4.41
Spray	4.41
Spray, wipe, spray (until dry)	4.41
Disposable wipe with QUAT	4.55
Control: detergent	2.88

Patient Area Cleaning/Disinfecting

PC Carling et al, SHEA 2007 and ICHE 2008;29:1

- Monitor cleaning performance using an invisible fluorescent targeting method. Rooms (14 high-touch objects) were marked and evaluated after terminal cleaning.
- Results: 1,119 rooms and 13,369 objects were evaluated in 23 hospitals. Mean proportion of objects cleaned was 49%. Following education and process improvement feedback, cleaning improved to 77%
- Conclusion: Substantial opportunity for improving terminal cleaning/disinfecting activities.

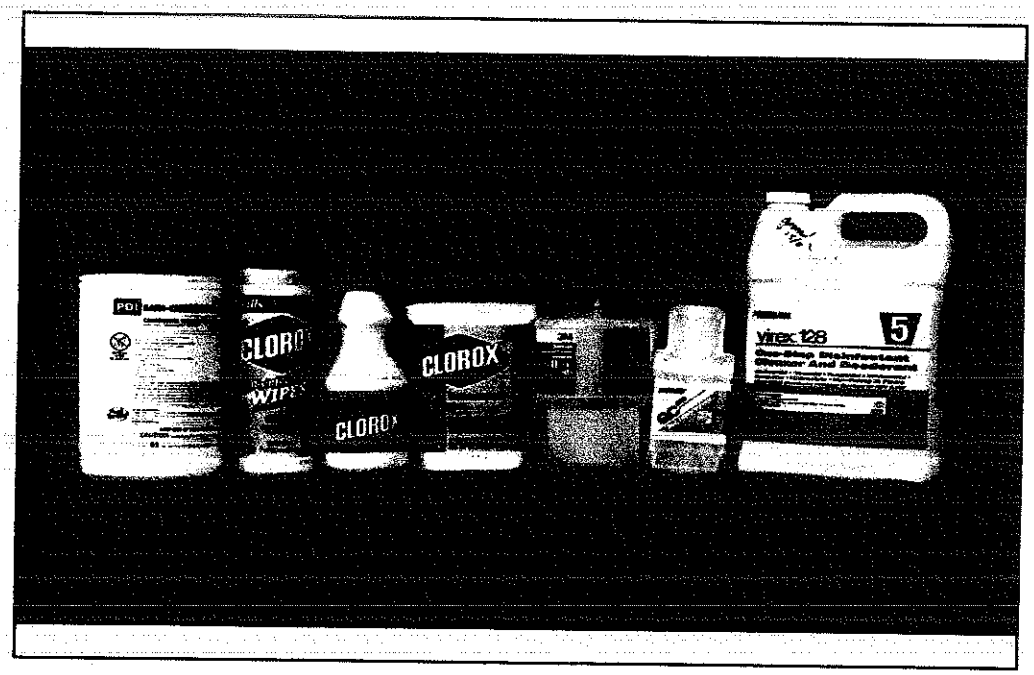
Practice* NOT Product

*surfaces not wiped

Removing *S. aureus* from Surfaces

Cardiff University, 2008, Williams et al

- Step 1-steel discs with 10^6-10^7 *S. aureus* and measured efficacy of wipes; disinfectants more effective
- Step 2-measured bacterial transfer from wipes
- Step 3-measured the bactericidal activity; disinfectant wipes killed high numbers (2.68-3.55 $\log_{10}$ reduction) but could not prevent cross contamination
- Press reported that wipes spread bacteria-unique methodology that did not represent clinical practice (e.g., 10 second exposure, *S. aureus* levels observed in healthcare)
- When wipes tested in conditions mimicking usage, we found them to be effective when used as recommended (gross filth should be removed before disinfecting, wipe surface and allow visible wetness for $\geq$ 1 minimum contact; use additional wipes to assure wet contact time; let air dry)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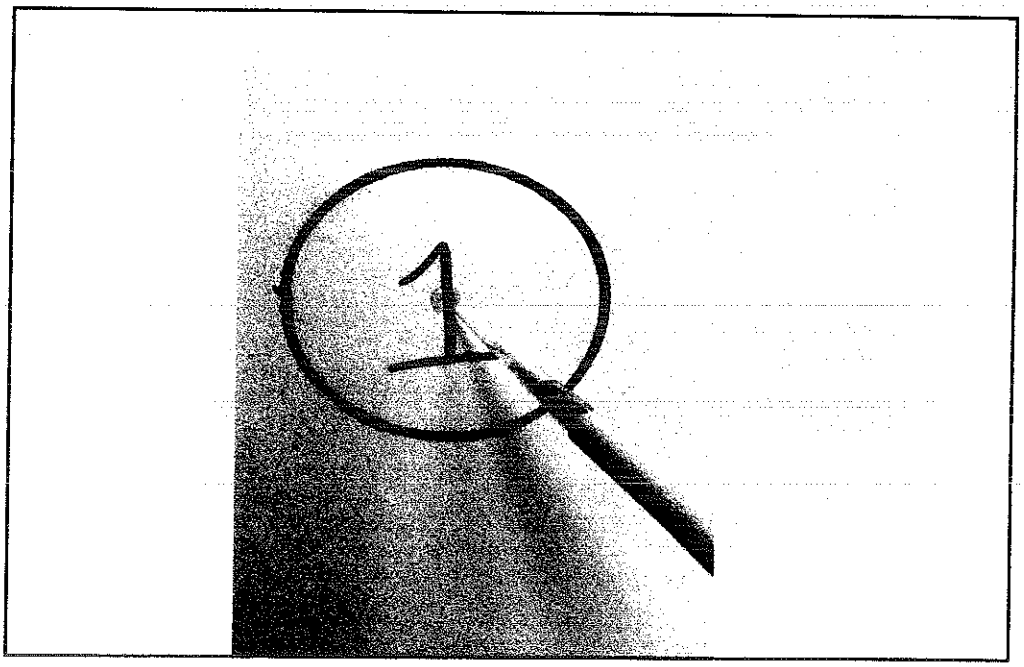
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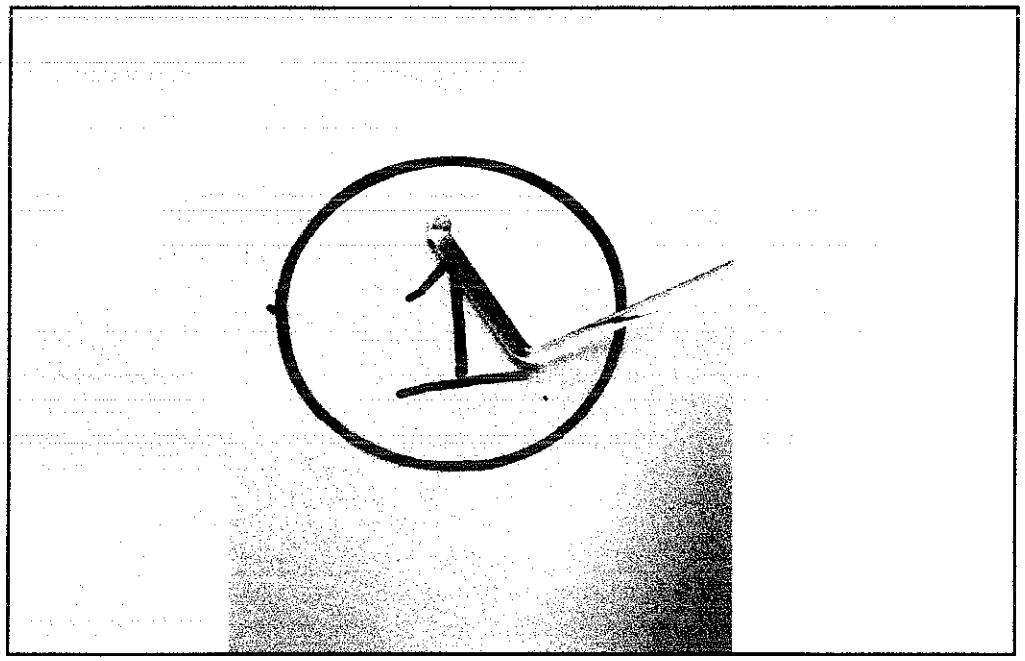

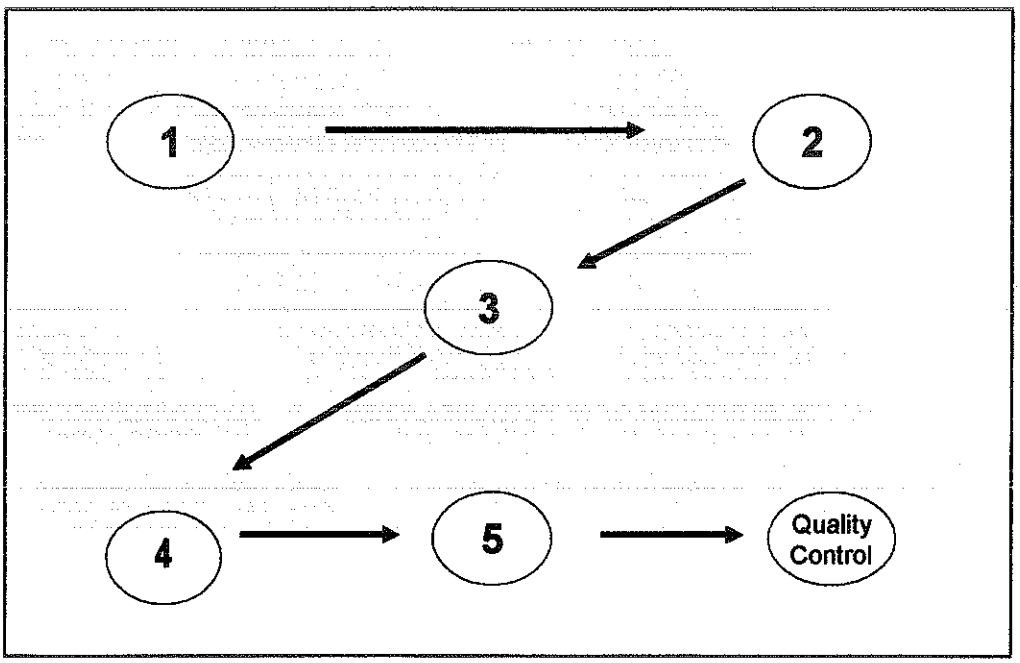
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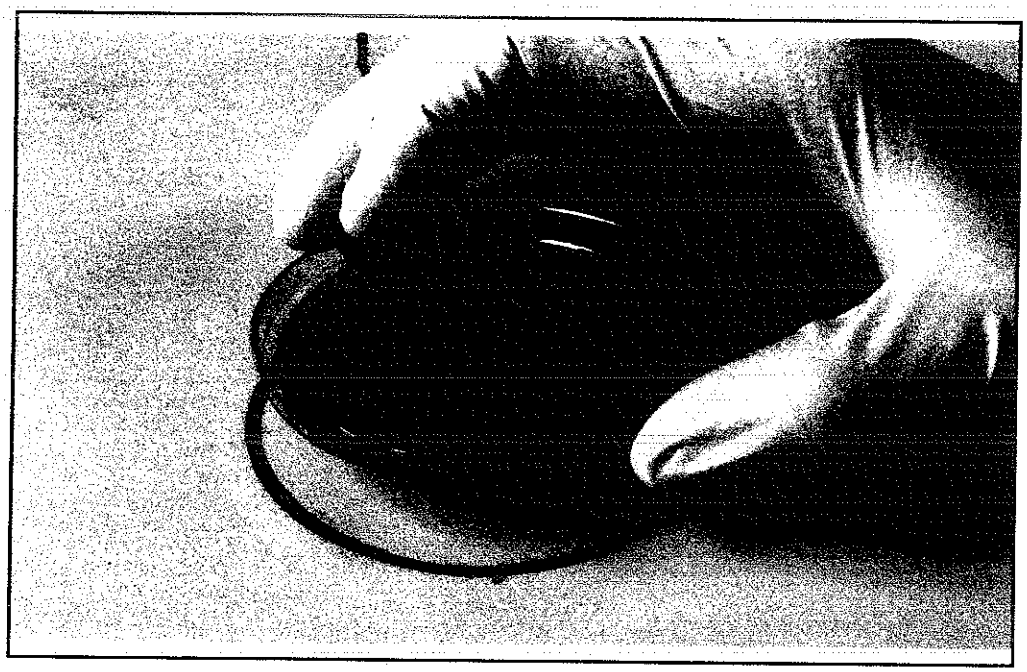
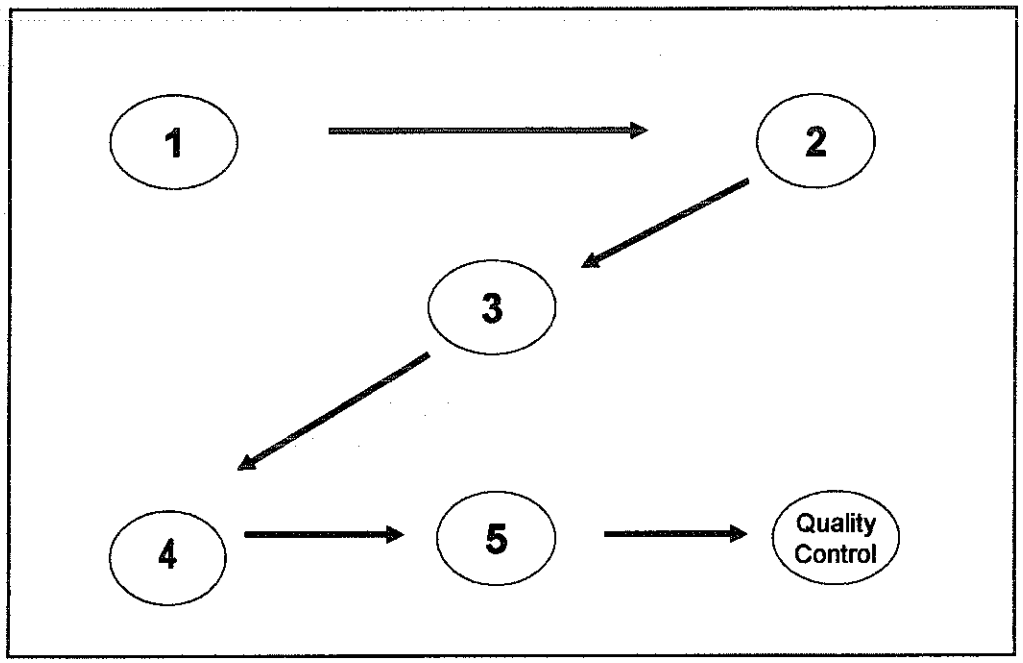
Quality Control





Surface Disinfection

Effectiveness of Different Methods

Rutala, Gergen, Weber, 2008, Unpublished

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Saturated cloth	4.41
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Spray	4.41
Spray, wipe, spray (until dry)	4.41
Disposable wipe with QUAT	4.55
Control: detergent	2.88

Germicide-containing disposable wipes are effective in removing/inactivating pathogens when used as directed

Disinfectant Use and Antibiotic Resistance

- Are disinfectants effective against drug-resistant pathogens (e.g., MRSA, VRE, multi-drug resistant GNR)? YES
- Is there a relationship between disinfectant use and antibiotic resistance? NO

Prevention of *C. difficile*

- Role of the environment in transmission
- *C. difficile*
  - Microbiology and epidemiology
  - Environmental contamination
  - Environmental disinfection
  - Hand hygiene
- Norovirus
- MRSA
- Other issues: microfiber, computers, green products

Disinfection of Computer Keyboards
Computer Keyboards, ICHE 2006;27:372

- Increased use of computers in patient areas has led to contamination of keyboards as reservoirs of pathogens
- Study performed to
  - Examine the efficacy of different disinfectants on the computer keyboard
  - Determine if there were cosmetic (key lettering removed) or functional changes after 300 wipes

Disinfection of Computer Keyboards

- All tested products were effective (>95%) in removing and/or inactivating the test pathogens (MRSA, *P. aeruginosa*). No functional/cosmetic damage after 300 wipes.
- Disinfectants included: 3 quaternary ammonium compounds, 70% isopropyl alcohol, phenolic, chlorine (80ppm)
- At present, recommend that keyboards be disinfected daily (for 5 sec) and when visibly soiled

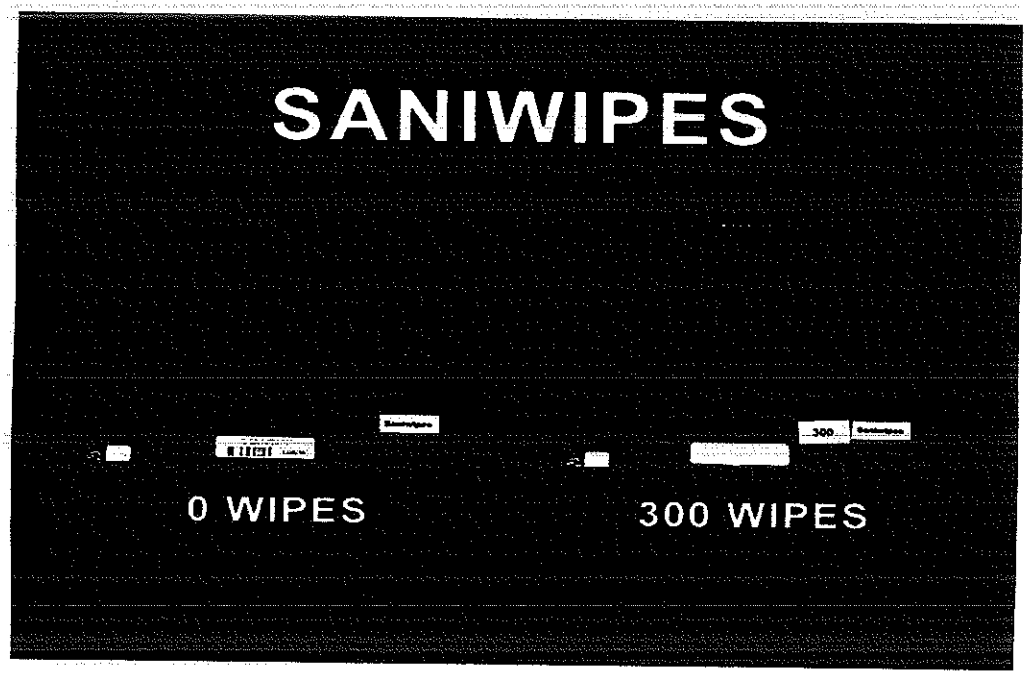


TABLE 3. Sustained Efficacy of Disinfectants Applied to Keyboard Against Vancomycin-Resistant *Enterococcus* Species

	Efficacy of Disinfectant, by Time of Microbial Challenge and Duration of Disinfectant Exposure, %					
	Challenge at 6 Hours		Challenge at 24 Hours		Challenge at 48 Hours	
Disinfectant	10-min Exposure	60-min Exposure	10-min Exposure	60-min Exposure	10-min Exposure	60-min Exposure
Alcohol	3.05	5.67	12.58	3.31	10.89	5.59
CaviWipes	100.00	100.00	100.00	100.00	100.00	100.00
Clorox Disinfecting Wipes	100.00	100.00	100.00	100.00	100.00	100.00
Sani-Cloth Plus	100.00	100.00	100.00	100.00	100.00	100.00
Sterile water	0.00	0.28	9.69	0.00	0.00	9.09

NOTE. Efficacy was calculated as the percentage difference in the number of colony-forming units on the treated keys, compared with the number of colony-forming units on the control keys. Challenge times are hours since disinfectant exposure.

Computer Keyboards

- All tested products were effective (>95%) in removing and/or inactivating the test pathogens (MRSA, *P. aeruginosa*). No functional/cosmetic damage after 300 wipes.
- QUATS demonstrated excellent sustained activity against VRE and antimicrobial activity was maintained over the 48 test period

Touchscreen Cleaning

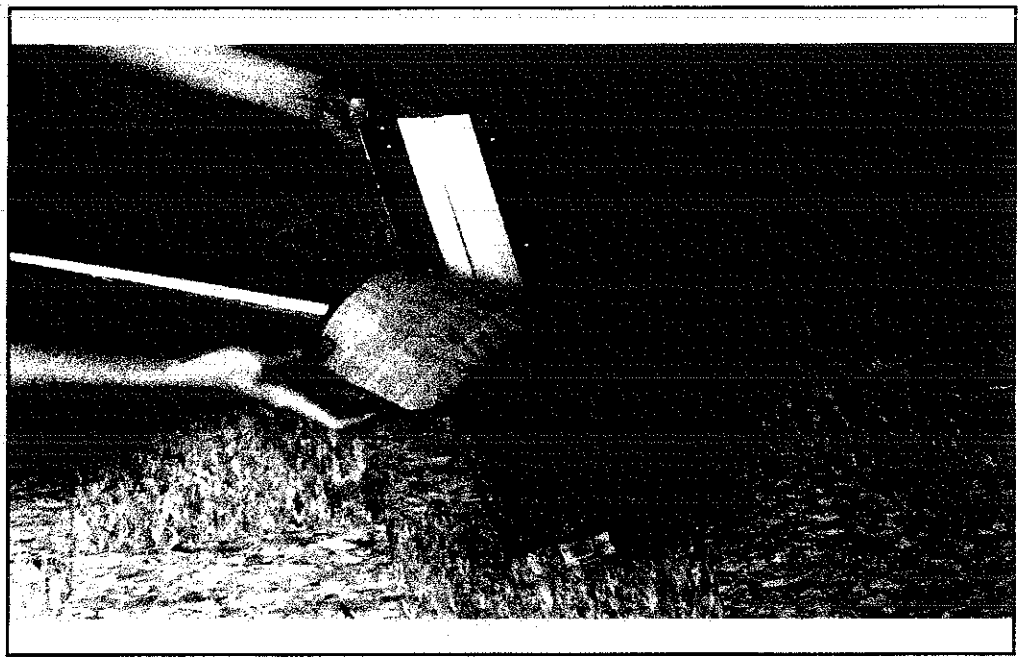
- Follow the manufacturer's recommendations
- Prepare the cleaning solution according to the manufacturer's instructions (e.g., alcohol, glutaraldehyde, mild soap, phenolic)
- Wet a clean, soft cloth with the selected cleaning solution
- Remove excess liquid from the cloth and squeeze damp
- Wipe exposed surfaces (do not allow liquid to enter interior)
- Remove any soap residue by gently wiping with clean cloth
- QUATS are not recommended by some manufacturers

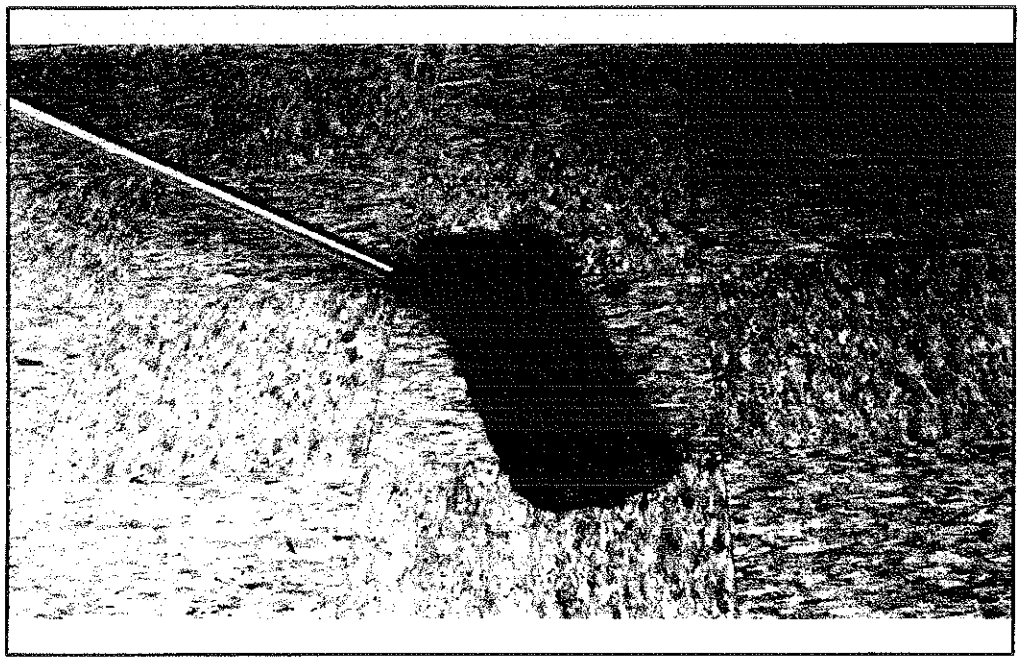
Prevention of *C. difficile*

- Role of the environment in transmission
- *C. difficile*
  - Microbiology and epidemiology
  - Environmental contamination
  - Environmental disinfection
  - Hand hygiene
- Norovirus
- MRSA
- Other issues: microfiber, computers, green products

Microfiber Cleaning

- Pad contains fibers (polyester and polyamide) that provide a cleaning surface 40 times greater than conventional string mops
- Proposed advantages: reduce chemical use and disposal (disinfectant solution not changed after every third room, clean microfiber per room [washing lifetime 500-1000x]); light (~5 lb less than string mop) and ergonomic; reduce cleaning times.
- Does the microfiber provide the same or better removal of microorganisms on surfaces?





Effectiveness of Microfiber Mop

- Test conditions with a EPA-registered disinfectant: compared routine mop and bucket; microfiber mop and bucket; microfiber mop and system bucket. Twenty-four replicates per condition.
- Conducted RODAC sampling before and after floor disinfection (5 samples per room)
- New disinfectant solution for each test condition
- Dry time varied from 2 (routine mop and bucket)-8 (microfiber mop and bucket) minutes

Effectiveness of Microfiber Mop

(Rutala, Gergen and Weber, Am J Infect Control, 2007;35:569)

Disinfectant-regular mop	95%
Disinfectant-microfiber system	95%
Disinfectant-microfiber mop and regular mop bucket	88%
Detergent-regular mop	68%
Detergent-microfiber system	95%
Detergent-microfiber mop and regular mop bucket	78%

Microfiber
Summary

- The microfiber system demonstrated superior microbial removal compared to cotton string mops when used with a detergent cleaner
- The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system
- Use of a disinfectant did significantly improve microbial removal when a cotton string mop was used

Prevention of *C. difficile*

- Role of the environment in transmission
- *C. difficile*
  - Microbiology and epidemiology
  - Environmental contamination
  - Environmental disinfection
  - Hand hygiene
- Norovirus
- MRSA
- Other issues: microfiber, computers, green products

The Green Hospital

Keslar. Proto (Mass Gen Hosp). Fall 2007

- Hospitals are feeling the pressure to go green, both from eco-conscious donors and governmental agencies
- Some features of The Green Hospital
  - Roof garden-wildlife habitat, adds insulation, absorbs rain
  - Fewer contaminants-upholstery and mattresses without flame retardants, formaldehyde-free insulation, green cleaning products (no hazardous fumes), triple-filtered air
  - Exposure to natural light
  - Reduced water usage-water efficient toilets and faucets
  - Greater energy efficiency-low energy fluorescent bulbs
  - More quiet-number 1 complaint is noise, better insulation between rooms

TABLE 1
EFFECTIVENESS OF DISINFECTANT AGAINST POTENTIAL PATHOGENS

	Log_{10} Reductions							
	Staphylococcus aureus		*Salmonella choleraesuis*		*Escherichia coli* 0157:H7		*Pseudomonas aeruginosa*	
Product	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vesphene IIse	>8.2	>8.2	>6.7	>6.7	>6.6	>6.6	>6.7	>6.7
TBQ	>6.4	>6.4	>6.6	>6.6	>6.4	>6.4	>6.9	>6.2
Clorox	>5.8	>5.8	>5.9	>5.9	>5.6	>5.6	>5.3	>5.3
Ethanol	6.2	>6.7	>6.0	>6.0	>6.8	>6.8	>6.4	>6.4
Lysol Disinfectant	4.2	4.3	4.0	3.9	4.0	4.1	4.2	4.0
Lysol Antibacterial	>5.6	>5.6	>5.8	>5.8	>5.7	>5.7	>5.5	>5.5
Mr. Clean	4.1	>6.0	>5.7	>5.7	>6.1	4.7	>5.7	>5.7
Vinegar	0.03	0.3	>6.0	>6.0	0.4	2.4	>5.8	>5.8
Baking soda	0.2	0.5	2.3	2.3	0.4	0.7	1.1	1.1

Data represent mean of two replicates. Values preceded by ">" represent the limit of detection of the assay. Assays were conducted at a temperature of 20°C and a relative humidity of 45%. Results were calculated as the log of Nd/No, where Nd is the titer of bacteria surviving after exposure and No is the titer of the control.

Rutala WA, Barbee SL, Aguiar NC, Sobsey MD, Weber DJ. Antimicrobial Activity of Home Disinfectants and Natural Products Against Potential Human Pathogens. *Infection Control and Hospital Epidemiology* 2000;21:33-38.

TABLE 2
DISINFECTANT ACTIVITY AGAINST ANTIBIOTIC-SUSCEPTIBLE AND ANTIBIOTIC-RESISTANT BACTERIA

	Log_{10} Reductions							
	VSE		VRE		MSSA		MRSA	
Product	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vesphene IIse	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Clorox	>5.4	>5.4	>4.9	>4.9	>5.0	>5.0	>4.6	>4.6
Lysol Disinfectant	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Lysol Antibacterial	>5.5	>5.5	>5.5	>5.5	>5.1	>5.1	>4.6	>4.6
Vinegar	0.1	5.3	1.0	3.7	+1.1	+0.9	+0.6	2.3

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *S aureus*; VRE, vancomycin-resistant *Enterococcus*; VSE, vancomycin-susceptible *Enterococcus*. Data represent mean of two trials (n=2). Values preceded by ">" represent the limit of detection of the assay. Assays were conducted at a temperature of 20°C and a relative humidity of 45%. Results were calculated as the log of Nd/No, where Nd is the titer of bacteria surviving after exposure and No is the titer of the control.

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Currently, "green" cleaners will remove microbial contaminants but will not dependably kill pathogens causing HAIs

Summary

- Environment has a role in disease transmission for some pathogens such as *C. difficile*, MRSA, VRE and norovirus.
- C. difficile has been found commonly in the environment of individuals with disease
- During clusters, surfaces potentially contaminated with *C. difficile* spores or norovirus should be disinfected with with an agent shown to have efficacy (e.g., hypochlorite, 5000 ppm)
- There is substantial opportunity for improving terminal cleaning/disinfecting activities; ensure complete cleaning of all potentially contaminated surfaces.
- Microfiber is effective in removing microorganisms form surfaces
- Germicide-containing disposable wipes are effective in removing/inactivating pathogens when used as directed
- Disinfectants (but not "green" products) demonstrate excellent activity against MRSA but practices are deficient. QUATS have sustained antimicrobial activity.

Prevention of *C. difficile*

- Role of the environment in transmission
- *C. difficile*
  - Microbiology and epidemiology
  - Environmental contamination
  - Environmental disinfection
  - Hand hygiene
- Norovirus
- MRSA
- Other issues: microfiber, computers, green products

disinfectionandsterilization.org

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