SURFACE DECONTAMINATION

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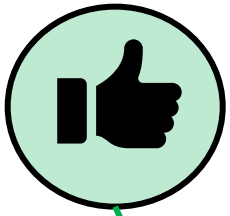
Covered / Not covered



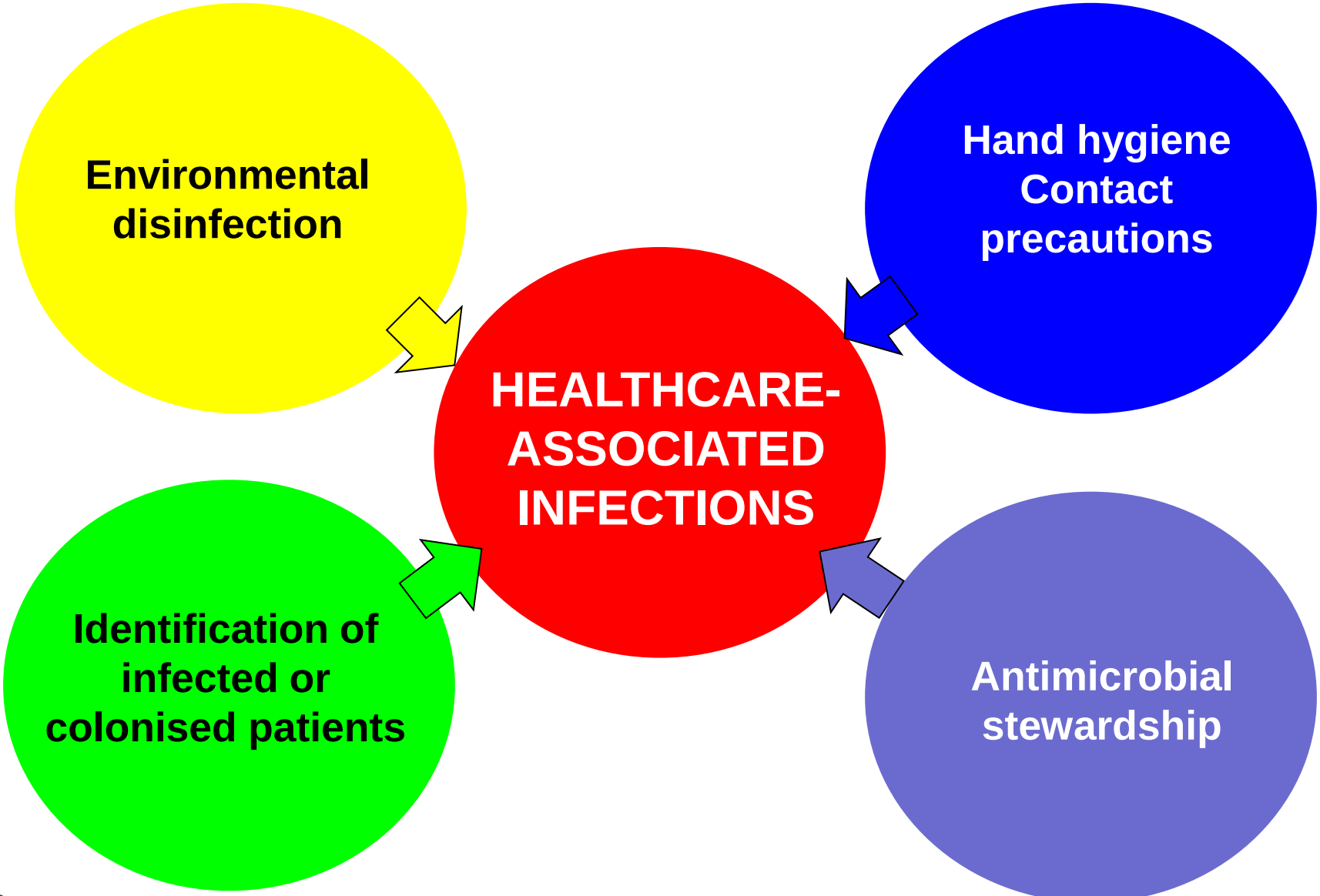
COVERED

- Chemical disinfection
- Factors affecting activity
- Biocide delivery

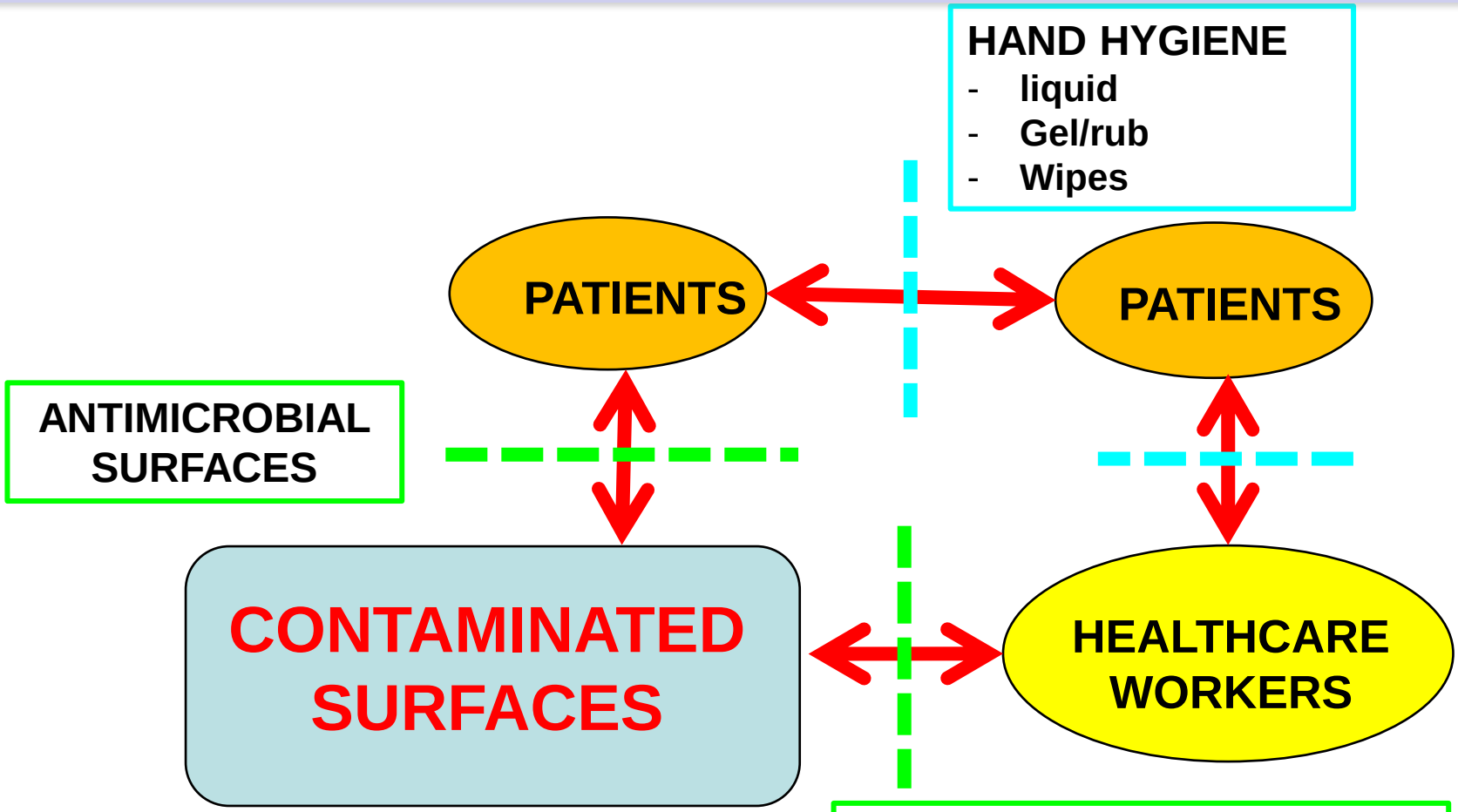
NOT COVERED

- Physical disinfection (UV-irradiation)
- Specific product efficacy
- Detailed standard efficacy test
- Product regulation

Breaking the chain of transmission

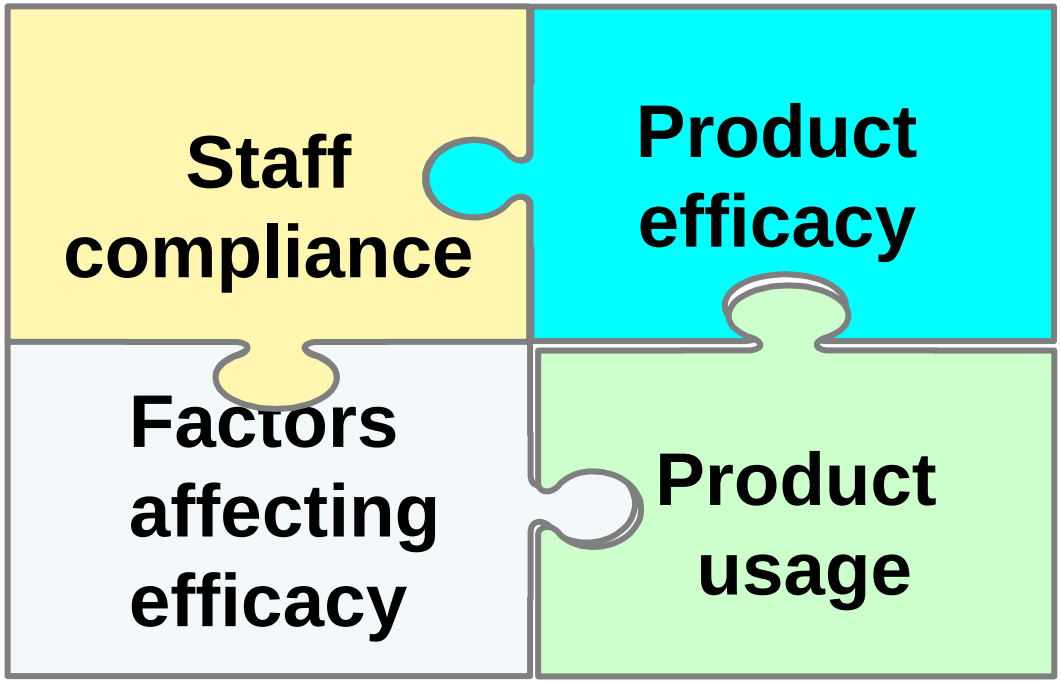


Breaking the chain of transmission

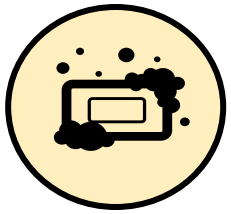


- Hand hygiene compliance: 30-85%
- Surface disinfection: 32%

Breaking the chain of transmission

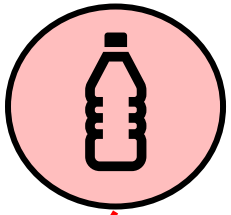


Definitions



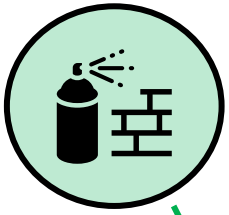
CLEANING

- Removal of dirt
- Might remove pathogens
- Not designed to kill pathogens



DISINFECTION

- Killing of pathogens
- Different levels of disinfection



DECONTAMINATION

- Decrease of microbial bioburden
- Render a surface safe?

Surface decontamination

- Make a surface safe?
- Decrease number of pathogens to a safe level?
- What is visibly clean?

Surface decontamination

Revised Spaulding Classification

Spaulding classification

CRITICAL DEVICES
In contact with sterile tissue or vascular system

Sterilisation required
- Physical sterilisation (heat)
- Radiation sterilisation
- Chemical disinfectant (ethylene oxide, hydrogen peroxide

High-level disinfection
(may be acceptable)
- PAA, H_2O_2, ClO_2, GTA, OPA,

SEMI-CRITICAL DEVICES
In contact with intact mucous membrane

High-level disinfection required
- Heat
- Glutaraldehyde
- Peracetic acid
- Chlorine dioxide
- Hydrogen peroxide
- Chlorine releasing agents

NON-CRITICAL
Not in contact with patient/ contact with intact sklin

Low-level disinfection required
- Alcohols
- QACs
- Biguanides

Cleaning or disinfection
- Cleaning and drying
- Disinfection in case of contaminated spillage

Surface decontamination

HARD SURFACE DISINFECTION

- Chlorine releasing agents
- Peroxygen-based products

- Quaternary ammonium compounds
- Biguanides
- Phenolics
- Organic acids
- Antimicrobial dyes
- Iodine
- Natural antimicrobials

FORMULATION

- Complex - multiple QACs
- Excipients - surfactants, wetting agents

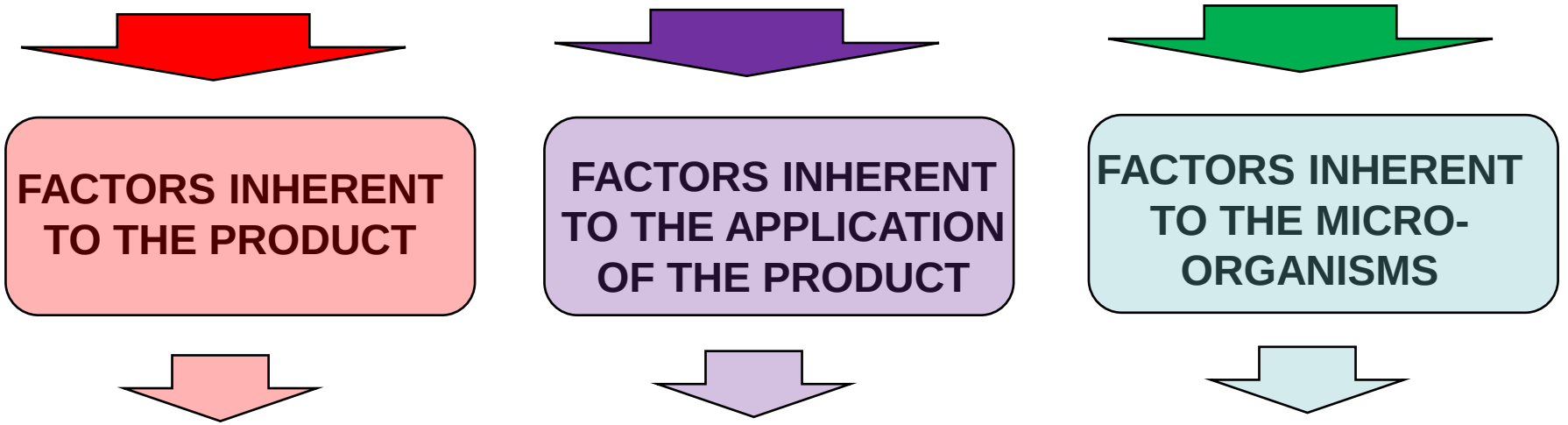
DELIVERY

- Spray
- foam
- Mist
- Pre-wetted wipes

CLEANING

- Detergents: ionic, non-ionic, amphoteric surfactants, alcohols
- Cationic surfactants (QAC) – biocides

Factors affecting efficacy



- Concentration
- Formulation
- pH
- Delivery

- Surface
- Organic load (soiling)
- Temperature
- Contact time
- Humidity
- Material (fabric)
- *Delivery*

- Type
- Number
- Phenotype
- Association (biofilms)

Factors affecting efficacy

FACTORS INHERENT TO THE PRODUCT

	IMPORTANCE	PREDICTABILITY
○ Concentration	+++	➢ Concentration exponent (η) ➢ Bioavailability ➢ Residual concentration
○ Formulation	++	?
○ pH	+*	Organic acids
○ Delivery (material)	++	➢ Release or not of antimicrobial ➢ Bioavailability?

Factors affecting efficacy

FACTORS INHERENT TO THE APPLICATION OF THE PRODUCT

	IMPORTANCE	PREDICTABILITY
○ Surface	++	?
○ Organic load (soiling)	++	➢ Depend on the active
○ Temperature	+*	➢ Temperature coefficient (Q_{10})
○ Contact time	++	➢ Continuous release (reservoir)?
		➢ Short contact time
○ Humidity	++	➢ Aerial disinfection
○ Material (fabric)		➢ Retention / compatibility

Factors affecting efficacy

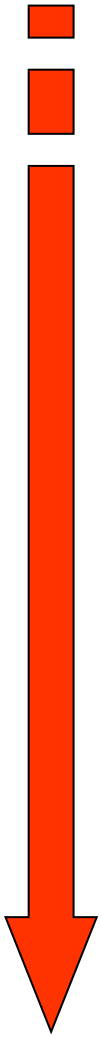
Biocide		Concentration Exponent	Soiling
Phenolics	Triclosan	4-9.9	+++
Alcohols	Benzyl alcohol Aliphatic alcohols	2.6-4.6 6.0-12.7	+
Cationics	Chlorhexidine Polymeric biguanides QACs Dyes (Crystal violet)	2 1.5-1.6 0.8-2.5 0.9	++
Aldehydes	Formaldehyde Glutaraldehyde	1 1	+
Peroxygens	Hydrogen peroxide Peracetic acid	0.5 0.5	+++
Metallic salts	Silver nitrate Mercurials	0.9-1.0 0.03-3.0	+++
Organic acid	Parabens Sorbic acid	2.5 2.6-3.2	++

- **Concentration exponent:** the higher it is the more loss of efficacy upon dilution

Factors affecting efficacy

LOW

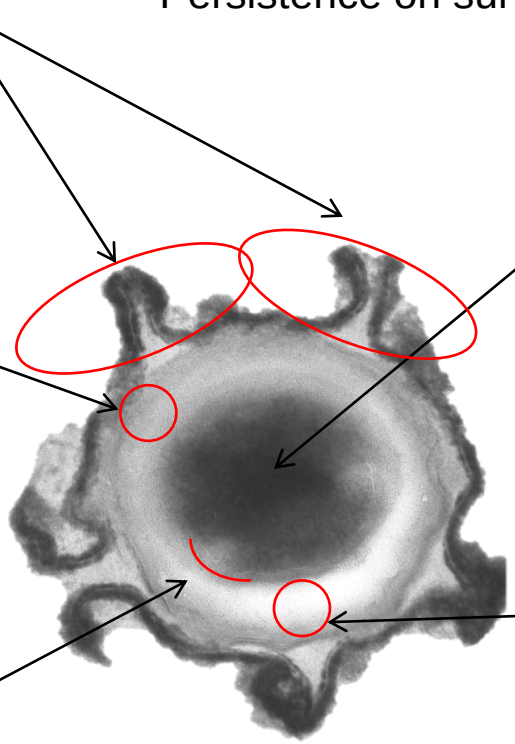
SUSCEPTIBILITY LEVEL TO DISINFECTION



HIGH

Group		Examples
Prions		PrP^{res}, a protein-only agent implicated in transmissible diseases such as scrapie (in sheep) and Creutzfeld-Jakob disease (in humans)
Bacteria Endospores		*Bacillus, Clostridioides* spores
Protozoal Oocysts	?	*Cryptosporidium* oocysts
Helminth Eggs or Cysts	?	*Ascaris, Enterobius*
Protozoal Cysts		*Giardia, Acanthamoeba*
Mycobacteria		*Mycobacterium tuberculosis*
Small, Non-Enveloped Viruses		Poliovirus, Parvoviruses
Fungal Spores		*Aspergillus, Candida*
Gram-negative bacteria		*Pseudomonas, Escherichia*
Vegetative Fungi		*Trichophyton, Candida*
Adult Helminths and Protozoa	?	*Ascaris, Cryptosporidium*
Large, non-enveloped viruses		Adenoviruses, Rotaviruses
Gram positive bacteria		*Staphylococcus, Streptococcus*
Enveloped viruses		HIV, Vaccinia

Challenge - endospores



EXOSPORIUM

Degradation ?
Persistence on surfaces

SPORE CORE

Small Acid Soluble Proteins (SASPs)
Protection of nucleic acid

Low water content
Protection of proteins

SPORE COATS

Barrier to biocides

INNER MEMBRANE

Highly compressed
Barrier to biocide
Barrier to rehydration

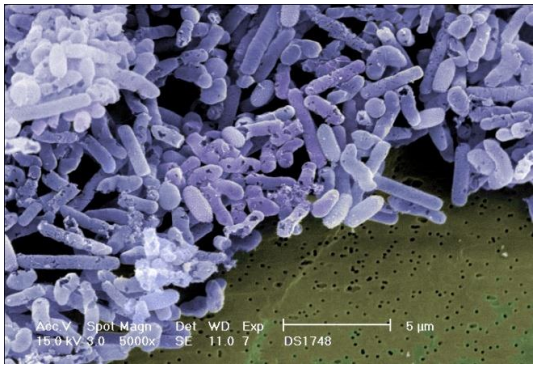
CORTEX

Barrier to biocides
Physical pressure to inner membrane

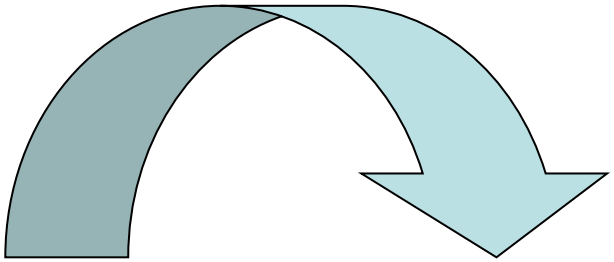
Leggett *et al. J Appl Microbiol* 2012; 113: 485-98.

Product claim – sporicidal activity

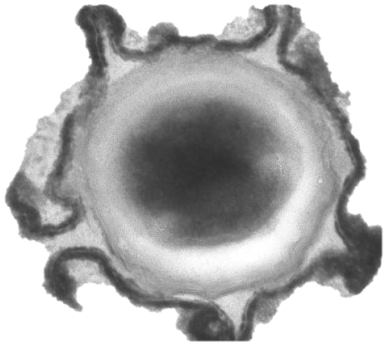
BACTERICIDAL ACTIVITY



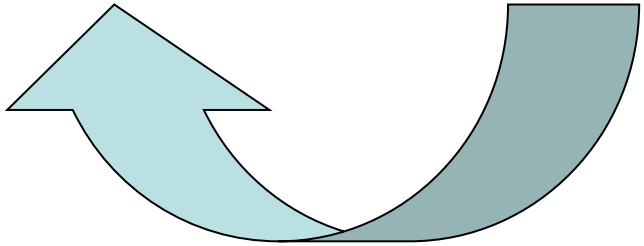
SPORULATION



SPORICIDAL ACTIVITY



OUTGROWTH



SPORISTATIC ACTIVITY

GERMINATION

Product claim – sporicidal activity

SPORICIDAL ACTIVITY

- Hydrogen peroxide
- Peracetic acid
- Chlorine dioxide
- Ozone

- Ethylene oxide
- Glutaraldehyde
- Formaldehyde
- *ortho*-phthalaldehyde

- Sodium hypochlorite
- Sodium dichlororisocyanurate (?)
- Chloramine-T
- Calcium hypochlorite
- Iodine and iodophors

"SPORISTATIC" ACTIVITY

- Phenols and cresols
- Quaternary ammonium compounds
- Biguanides
- Organic acids and esters
- Alcohols

Russell AD. Clin Microbiol Rev 1990;3:99-119.

Reality check – Product claim

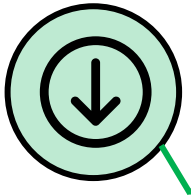
“**Sporicidal 70% Alcohol Gel & Moisturiser (250ml)**
Kills 99.999% of bacteria
Sporicidal 70% Alcohol Hand Gel with moisturiser, 250ml with flip top cap - the only alcohol hand gel effective against C. Difficile spores.”

“**Product C** to date has killed every virus, spore and bacteria it has been tested on including MRSA, C-Diff, Norovirus and many more pathogens in 1/5 of the EN1276 required time making it 1000 time more effective than EN1276 requirements - EN1276 is the chemical disinfectants and antiseptics.”

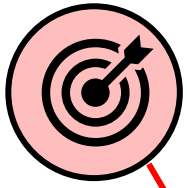
Bioavailability

PRINCIPLE FOR MICROBICIDAL EFFICACY

➢Need contact between the target micro-organism and the antimicrobial



➢Need to penetrate to reach target site(s)



➢Number of targets affected and overall damage to the target(s) produce a lethal or an inhibitory effect

Failure to understand factors affecting efficacy

Chlorhexidine-based products

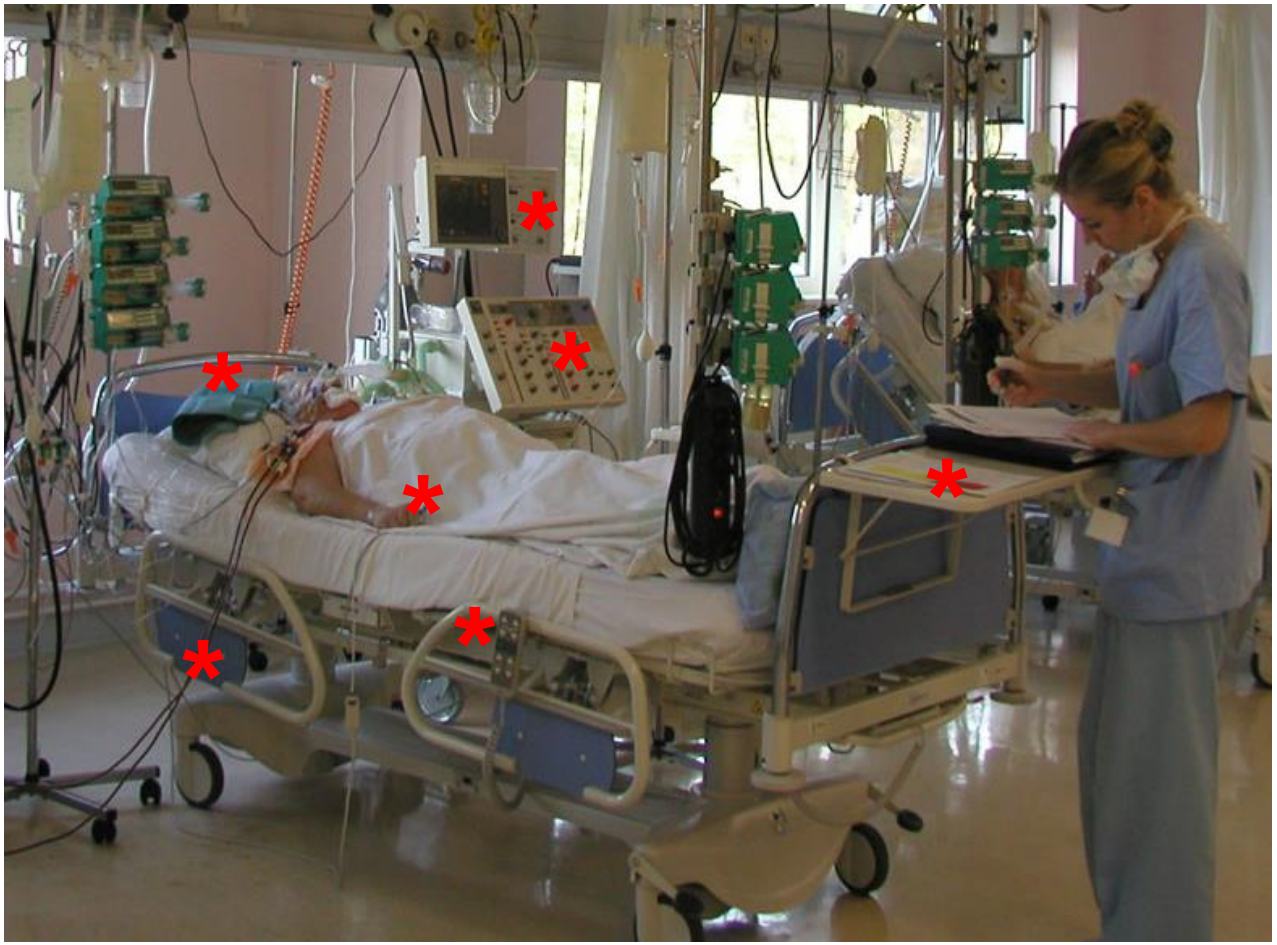
Contaminant(s)	Site(s) of microbes	Mechanism of contamination/source
***Pseudomonas* spp.**	Not stated	**Refilling contaminated bottles**; washing used bottles using cold tap water; contaminated washing apparatus; low concentration (0.05%)
Pseudomonas sp., Serratia marcescens, Flavobacterium sp.	Not stated	Not determined, but authors speculate due to **overdilution** or refilling of contaminated bottles
Pseudomonas aeruginosa	Wounds	Tap water used to **dilute stock solutions**; low concentration (0.05%)
Bulkholderia cepacia	Blood, wounds, urine, mouth, vagina	Metal pipe and rubber tubing in pharmacy through which deionized water passed during dilution of chlorhexidine; low concentration
Ralstonia pickettii	Blood	Contaminated bidistilled water **used to dilute chlorhexidine**; low concentration (0.05%)
Ralstonia pickettii	Blood (pseudo-bacteremia)	Distilled water used to dilute chlorhexidine; low concentration (0.05%)
Serratia marcescens	Bood, urine, wounds, sputum, others	Not determined, but use of **nonsterile water for dilution** to 2% and distribution in reusable nonsterile containers
Bulkholderia cepacia	Blood	Intrinsic contamination, Contaminated 0.5% chlorhexidine
Serratia marcescens	Blood	Intrinsic contamination, 2% aqueous chlorhexidine antiseptic

Failure to understand factors affecting efficacy

Benzalkonium chloride- based products

Contaminant(s)	Site(s) of microbes	Mechanism of contamination/source
Enterobacter aerogenes	Blood, sinus tract	Storage of benzalkonium chloride (0.13%) with cotton/gauze
Pseudomonas-Achromobacteriaceae group	Blood, urine	Storage of benzalkonium chloride (0.1%) with cotton/gauze; **dilution with nonsterile water**
Enterobacter aerogenes	Blood, sinus tract	Storage of benzalkonium chloride (0.1%) with cotton/gauze; **dilution with nonsterile water**
Bulkholderia cepacia, Enterobacter spp.	Blood (pseudobacteremia)	Storage of benzalkonium chloride with cotton/gauze; **improper dilution**; storage bottles infrequently sterilized
Serratia marcescens	Intravenous catheters (dogs and cats), other sites	Storage of benzalkonium chloride (0.025%) with cotton/gauze
Mycobacterium chelonae	Skin abscesses	Storage of benzalkonium chloride with cotton/gauze; **improper dilution**
Pseudomonas aeruginosa	Corticosteroid injection multidose vial	Inoculation with pseudomonads via needle puncture after vial septa were **wiped with contaminated disinfectant**
Mycobacterium abscessus	Joint	Storage of benzalkonium chloride with cotton/gauze; dilution with probable **contaminated tap water**
Bulkholderia cepacia	Blood, catheter	**1:1000 aqueous** BAC solution

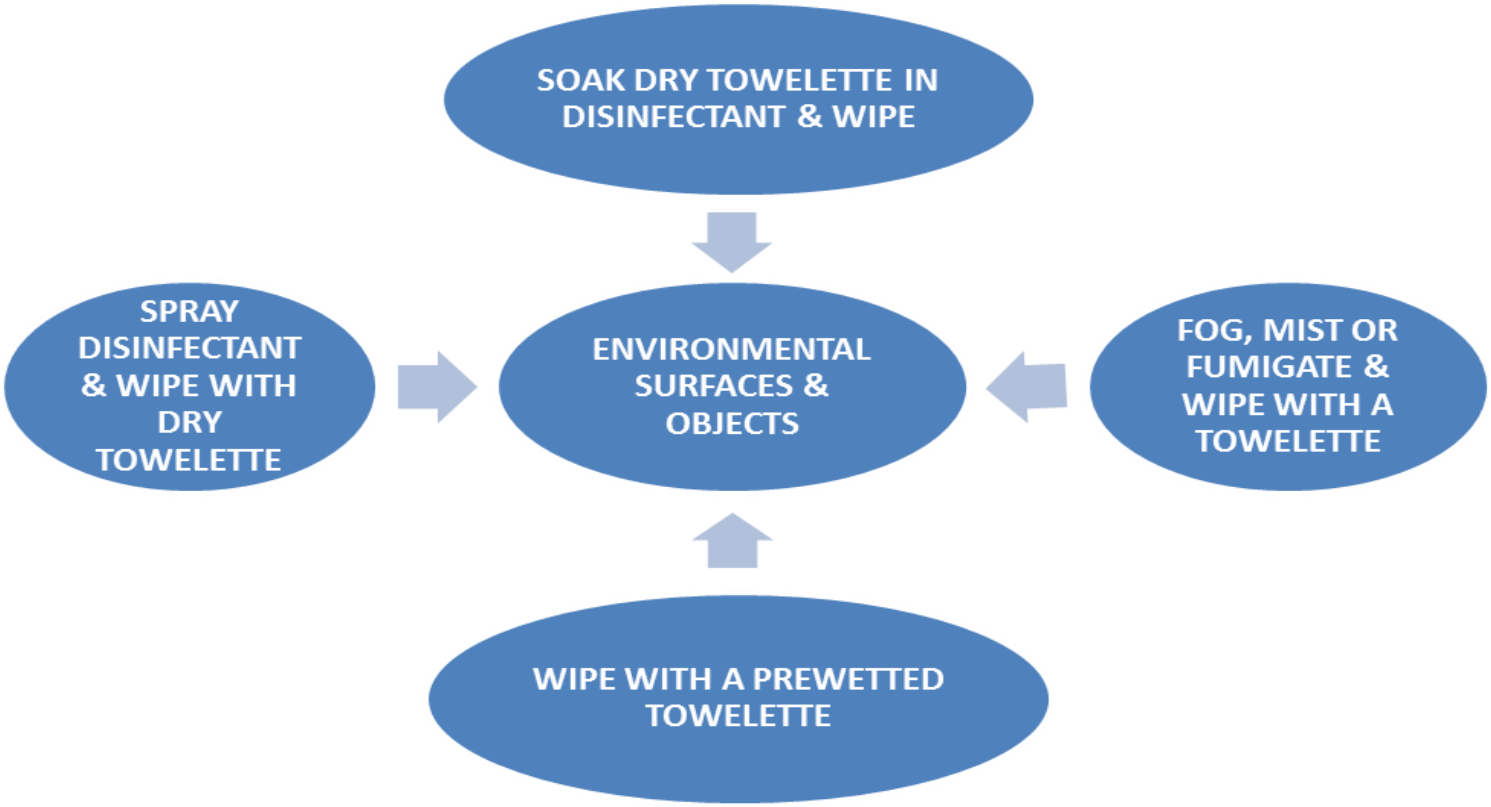
Surface decontamination



Surface decontamination

Possible scenarios for decontaminating environmental surfaces by wiping

Sattar and Maillard *AJIC* 2013;41:S97-S104.



Factors affecting efficacy of wipes

Observation of usage in practice –cleaning staff in ITUs

- use of wipes – surface area
- contact
- rotation

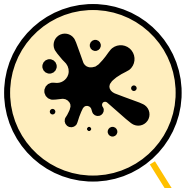
Wipe Number	Surface initially wiped	Time applied (seconds)	Number of consecutive surfaces wiped (other surfaces)
1	Bed Rail	4	5 (bedside table, monitor X2, monitor stand)
2	Steel Trolley	6	2 (both shelves on the trolley wiped)
1	Monitor	4	5 (monitors, two keypads, monitor stand)
2	Bed rail	7	4 (table, monitor, keypad)
3	Bedside table	10	4 (folder, two bed rails)

One wipe – one direction – one surface…bin it

Factors affecting efficacy of wipes

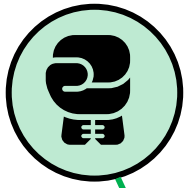
Sattar and Maillard *Am J Infect Control* 2013 41;S97-S104

Which wipes?



Detergent wipes: to clean surfaces (removal dirt or organic matter)

- Essential to the cleaning process, acting to release dirt from a surface
- Not designed to remove microorganisms from surface, but they might



Disinfectant wipes

- Contain a biocide and may or may not contain an additional detergent
- Wipes that do not contain a detergent will have only limited cleaning properties
- Disinfectant wipes might have a claim to kill bacteria (bactericidal), fungi (fungicidal) viruses (virucidal) or bacterial endospores (sporicidal).

It is not possible to 'sterilise' surfaces of equipment/ patient environment using wipes alone; only to temporarily reduce the number of microbes present.

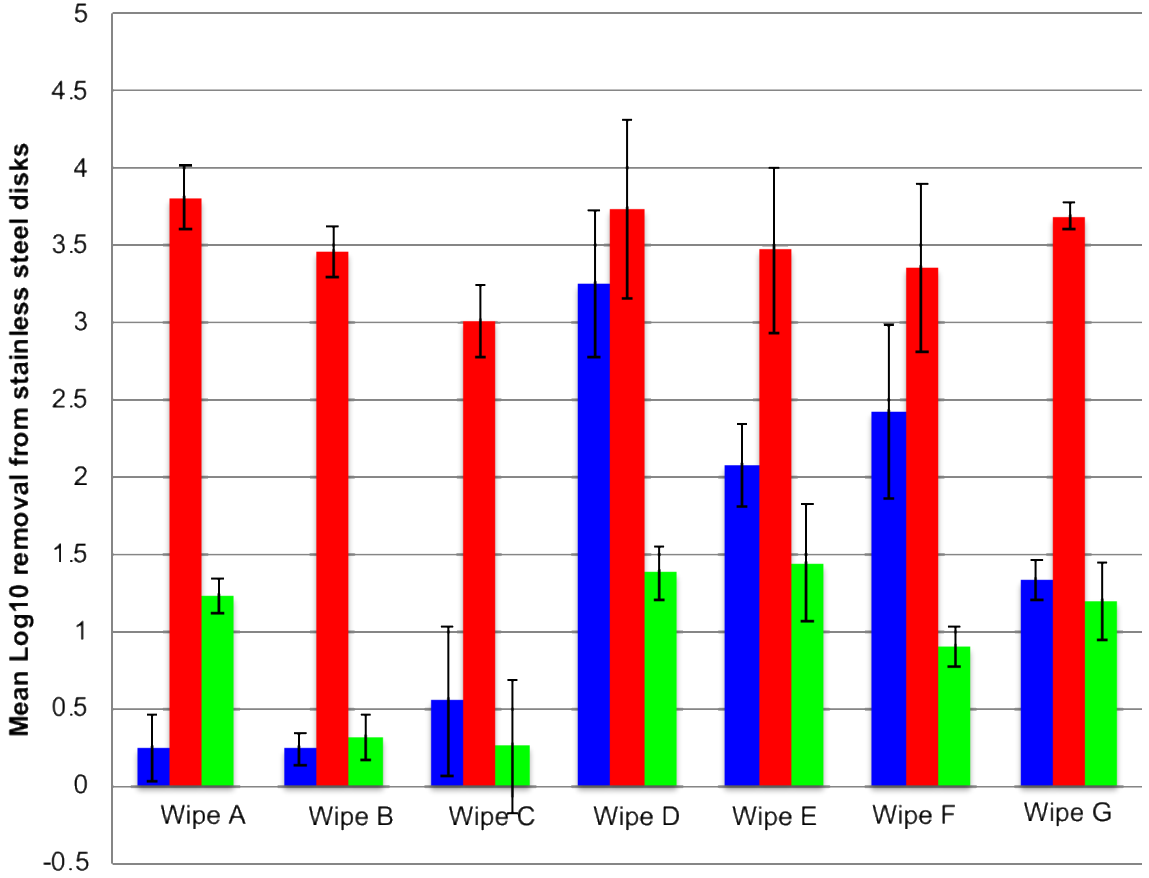
Which wipes?

EFFICACY OF DETERGENT WIPES

Ramm *et al*. *AJIC* 2015;43:724-8.

Bacterial/spore removal from surface

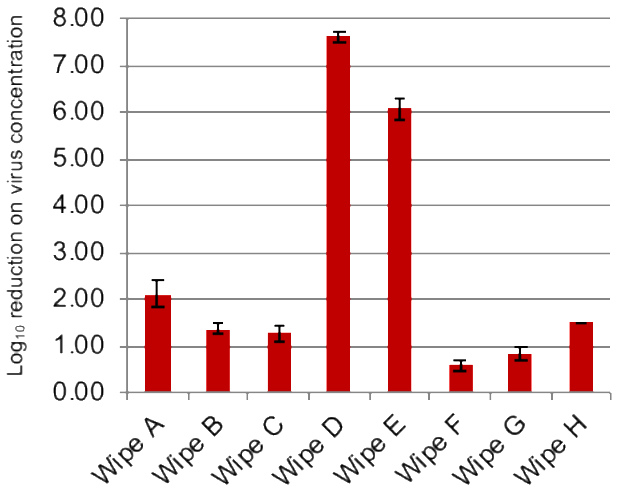
- *S. aureus*
- *A. baumannii*
- *C. difficile*



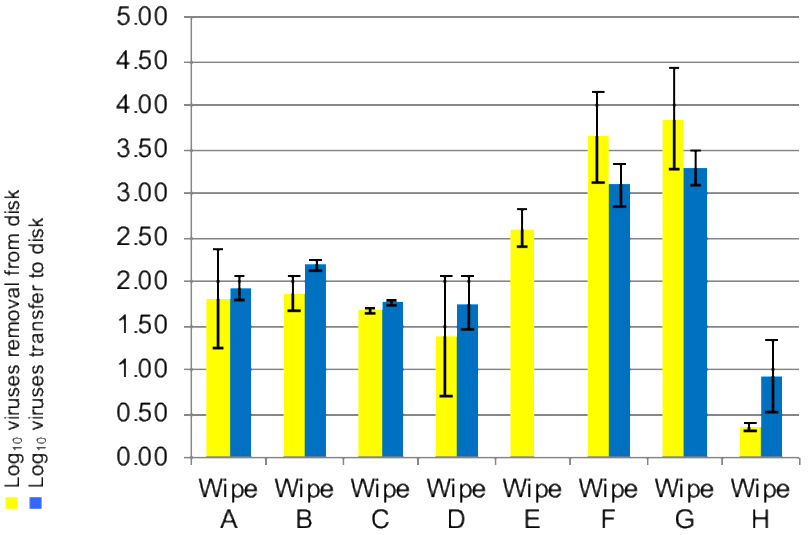
Which wipes?

EFFICACY OF ANTIMICROBIAL WIPES AGAINST VIRUSES

Virucidal activity of expressed wipe solutions (n=3)



Virus removal from disks and virus transfer from wipes to disks. (n=3)



	Mean removal	Range
'Universal' wipes	1.68 $\log_{10}$	1.37-1.87 $\log_{10}$
Sporicidal wipes	3.13 $\log_{10}$	2.61- 3.65 $\log_{10}$
Detergent wipes	2.11 $\log_{10}$	0.36- 3.85 $\log_{10}$

Which wipes?

"SPORICIDAL" WIPES – efficacy testing against *C. difficile* NCTC12727

Siani *et al. AJIC* 2011; 39(3), 212-218

Wipes*	Bacterial Removal (log_{10} cfu/disk ± SD) 500 g surface pressure	Bacterial transfer following 10 s wiping time at 500 g surface pressure
Negative control	**1.13 (± 0.36)**	5 consecutive transfers. TNTC
NaOCl soaked wipe	**2.02 (± 0.21)**	5 consecutive transfers. TNTC
Wipe A	**4.09 (± 0.79)**	No spore transferred
Wipe B	**0.22 (± 0.07)**	**5 consecutive transfers. From 0 to TNTC**
Wipe C	**1.30 (± 0.33)**	**5 consecutive transfers. From 0 to TNTC**
Wipe D	**0.57 (± 0.07)**	**5 consecutive transfers. From 1 to TNTC**
Wipe E	**+0.08 (± 0.08)**	5 consecutive transfers. TNTC
Wipe F	**1.14 (± 0.65)**	5 consecutive transfers. From 83 to TNTC
Wipe G	**0.67 (± 0.11)**	5 consecutive transfers of ≤43 spores
Wipe H	**0.88 (± 0.13)**	5 consecutive transfers. From 2 to TNTC
Wipe I	**0.84 (± 0.66)**	5 consecutive transfers. From 40 to TNTC

* At the time of testing i.e. 2010-2011

Which wipes?

Study between 2006-2010; in 2008 chlorine based cleaning regimens and products changed to non-chlorine based sporicidal wipe

Average *C. difficile* rate per 1000 patients			
Financial year	Number of weeks	Mean C. difficile rate	Median C. difficile rate
2006-07	51	6.27	5.54
2007-08	52	6.99	5.95
Introduction of changes			
2008-09	51	2.05	1.74
2009-10	23	1.66	1.59

Carter Y and Barry D Nursing Time 2011, 107

- Changes included staff training on wipe usage
- Daily environmental cleaning (including surfaces at risks)
- Weekly ward visit to ensure good practice (e.g. supply of wipes)
- Weekly multidisciplinary ward round to monitor infection prevention and control measures
- Increase awareness campaign

Delivery – prewetted wipe *vs.* spray & cloth

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

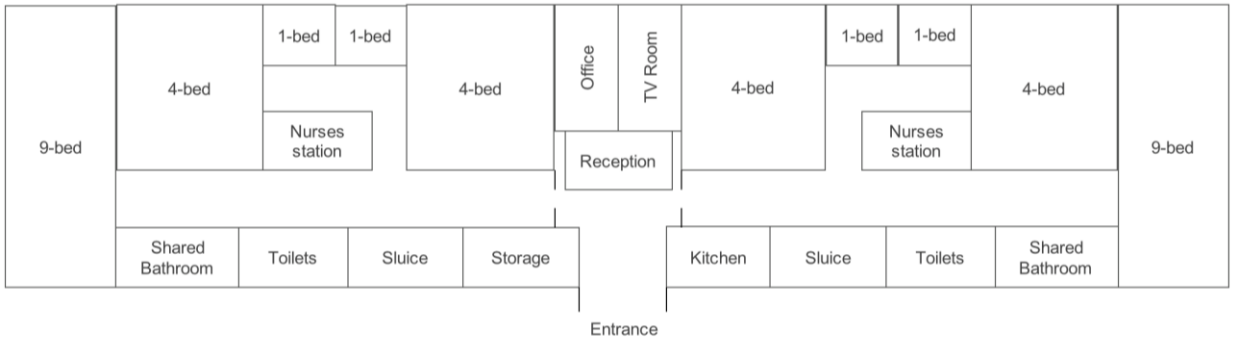
Major Article

Impact of antimicrobial wipes compared with hypochlorite solution on environmental surface contamination in a health care setting: A double-crossover study

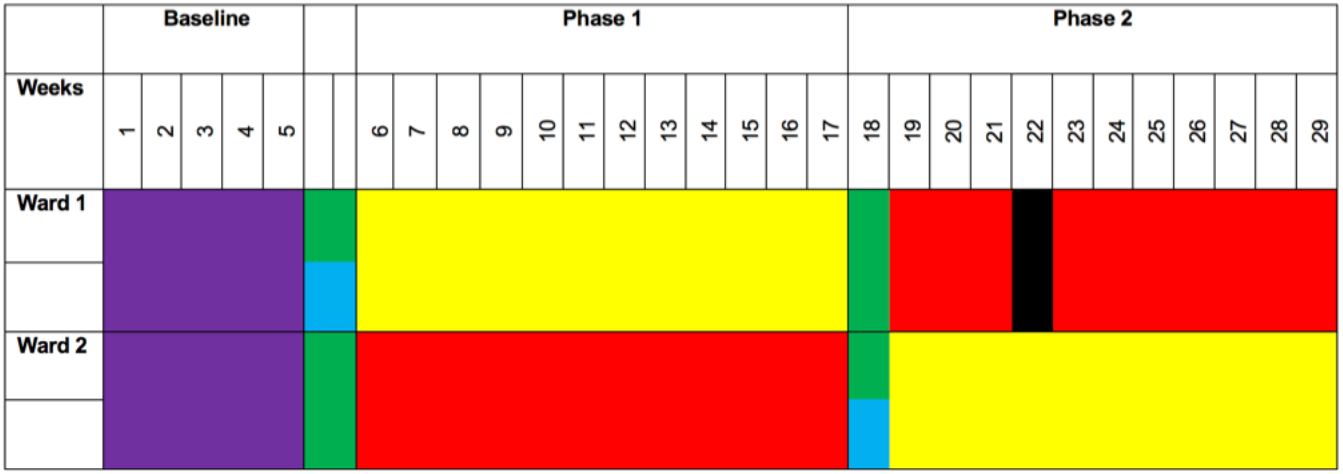
Harsha Siani BSc, Rebecca Wesgate BSc, Jean-Yves Maillard PhD *

School of Pharmacy and Pharmaceutical Sciences, Cardiff University, Cardiff, UK

- A double-crossover study was performed on 2 different surgical and cardiovascular wards in a 1,000-bed teaching hospital over 29 weeks.
- The intervention period that consisted of surface decontamination with pre-impregnated wipe or cloth soaked in chlorine



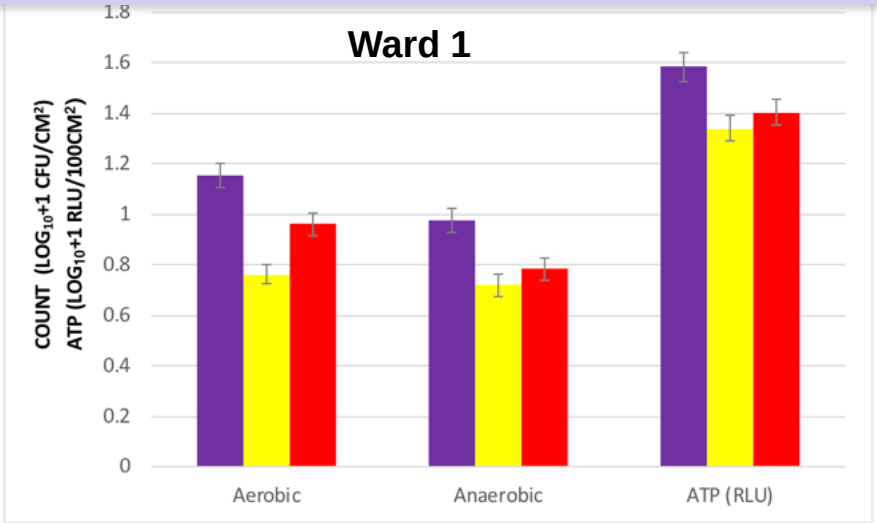
Delivery – preformulated wipe *vs.* spray & cloth



- Use of standard cleaning regimen.
- Use of detergent and chlorine 1,000 ppm.
- Use of pre-impregnated sporicidal wipes.
- Green shading indicates general training on disinfectant use, wiping, and infection prevention.
- Specific training on the use of preformulated wipes.
- Black shading indicates wards closure.

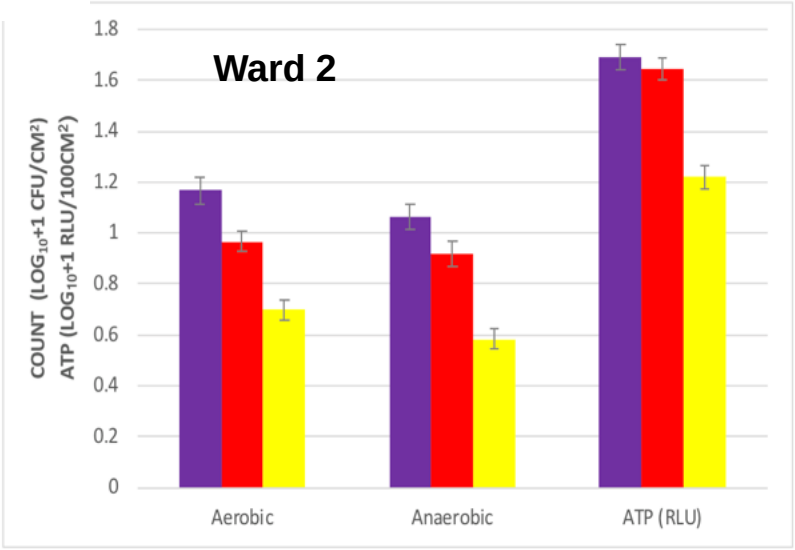
- Environmental samples from 11 surfaces were analysed weekly for their microbial content.
- In total, 1,566 environment samples and 1,591 ATP swabs were taken from the 2 wards

Delivery – preformulated wipe *vs.* spray & cloth



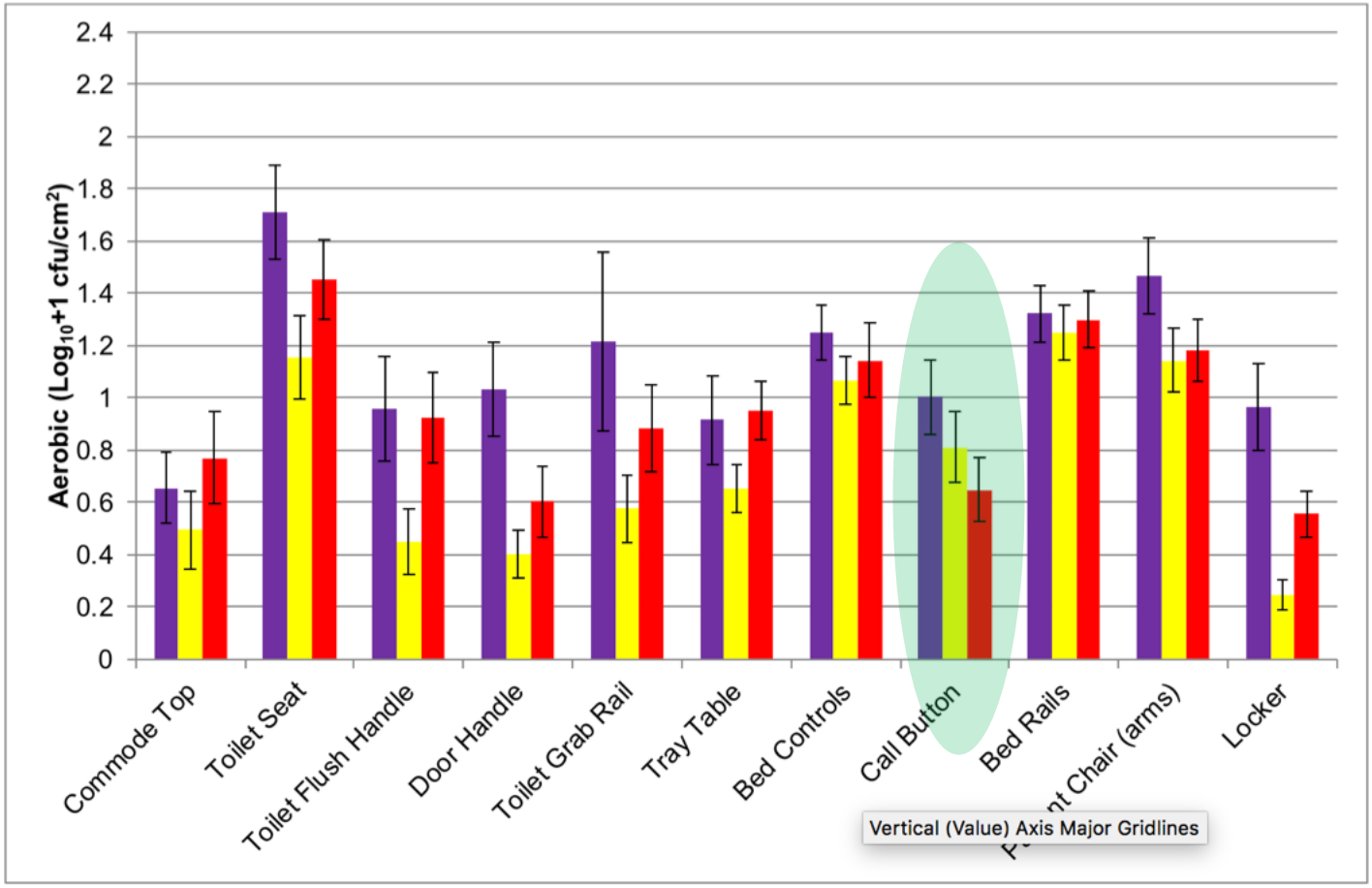
- Pre-formulated wipe first followed by cleaning + hypochlorite

- Baseline.
- Cleaning and use of chlorine 1,000 ppm
- Sporicidal wipe



- Cleaning + hypochlorite first followed by pre-formulated wipe

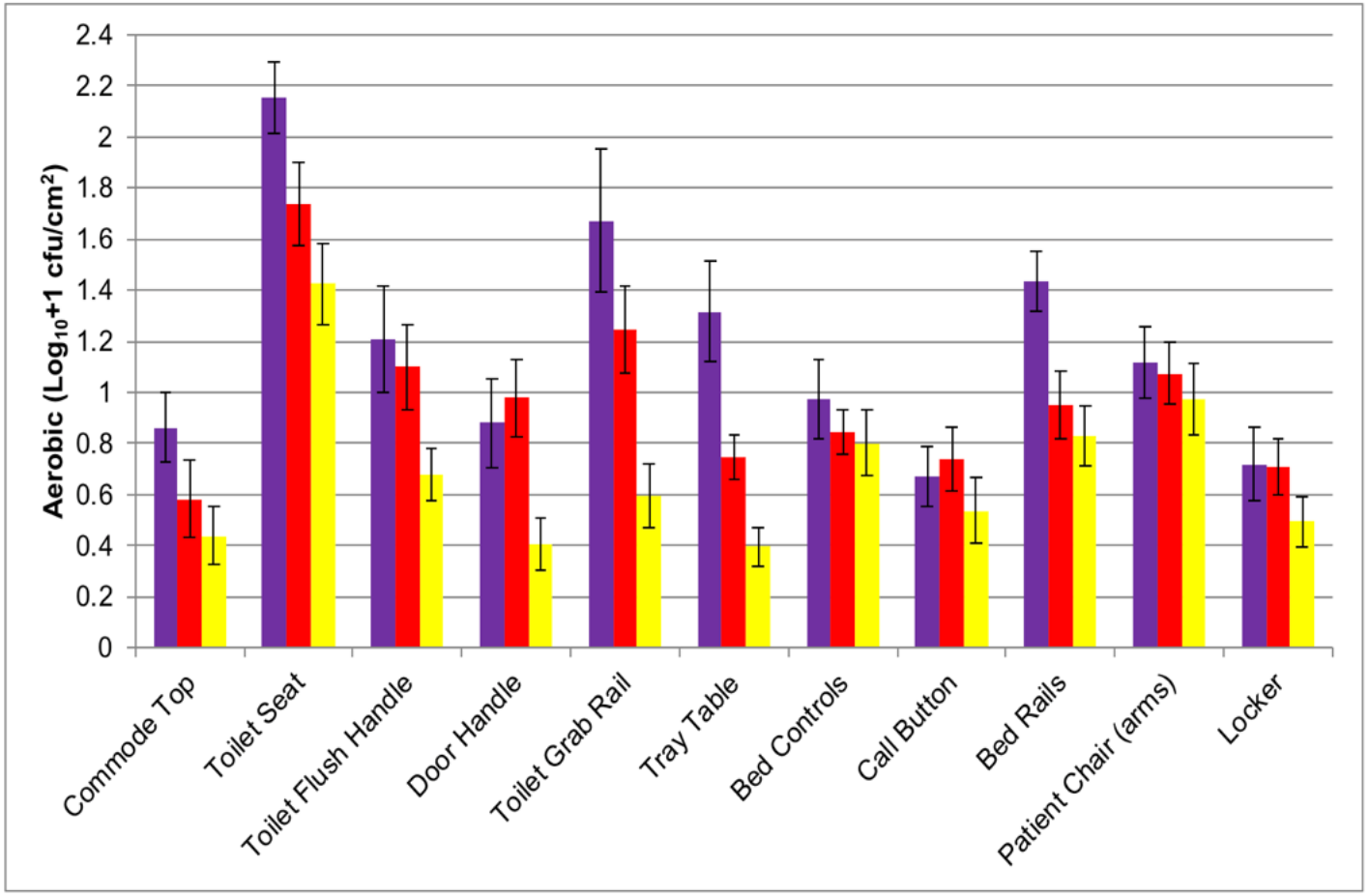
Delivery – preformulated wipe *vs.* spray & cloth



- Baseline.
- Cleaning and use of chlorine 1,000 ppm
- Sporicidal wipe

➢ Pre-formulated wipe first followed by cleaning + hypochlorite

Delivery – preformulated wipe *vs.* spray & cloth



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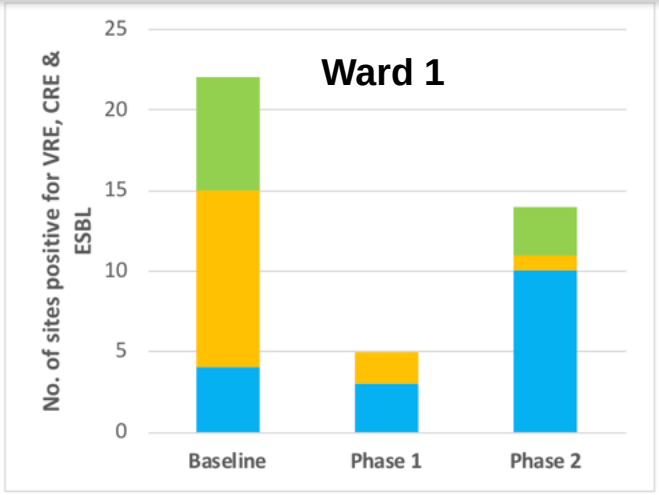

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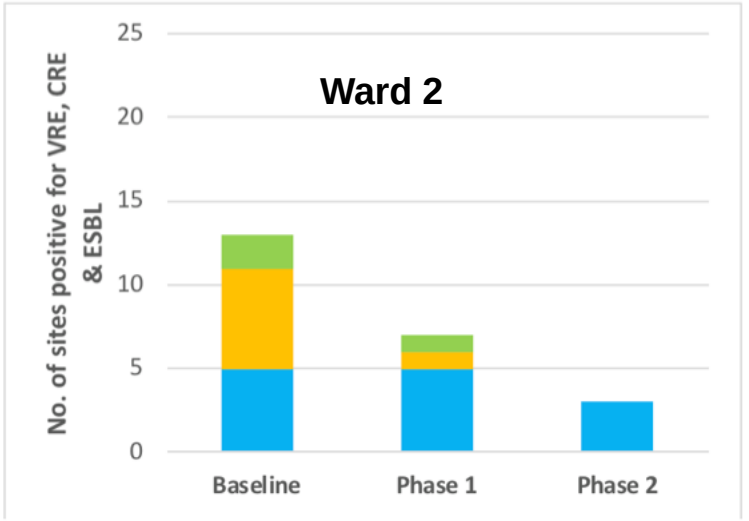


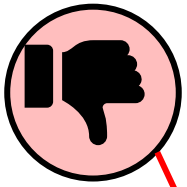
- Extended-spectrum beta lactamases (ESBL)
- Carbapenem-resistant Enterobacteriaceae (CRE)
- Vancomycin-resistant enterococci (VRE).

- Cleaning + hypochlorite first followed by pre-formulated wipe

Delivery – preformulated wipe *vs.* spray & cloth

- Appropriate training & auditing was effective in reducing bacterial bioburden

- The use of pre-formulated wipes significantly decreased microbial bioburden from high-touch surfaces compared to the use of cleaning and hypochlorite 1000ppm from a bucket

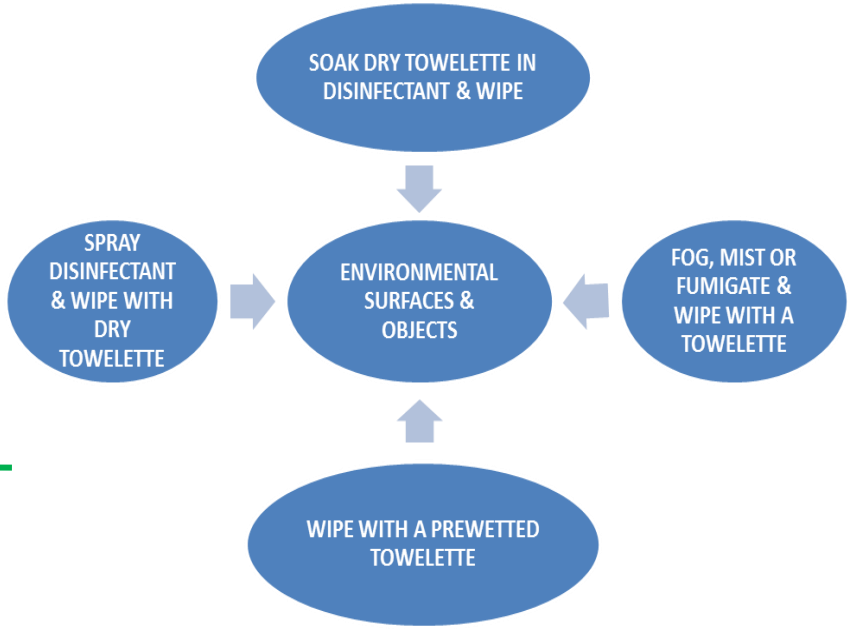


- Aerobic count / site & number of sites with MDRO increased again following the re-introduction of cleaning and hypochlorite 1000ppm from a bucket

Product claim – type of tests

- **Formulation tests**
- **Product test**
  - EN14776-15: “4-field test”
- **New technology**
- **Residual activity**
  - PAS2424

Sattar & Maillard (2013) *Amer J Infect Control* 2013;41:S97-S104.



Residual activity

Wesgate *et al. Antimicrob Agents Chemother* 2020;63:e01131-20

- What concentration left on surface?
- Risk associated with selection for/emerging bacterial resistance

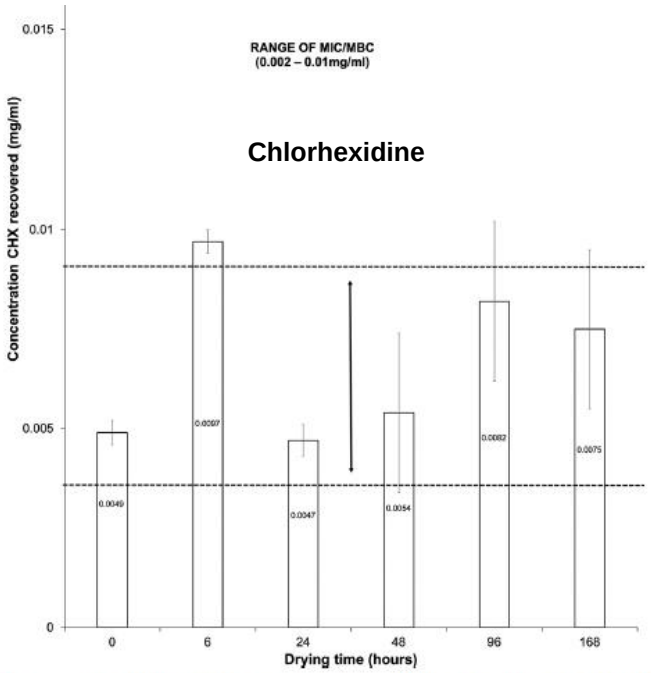


FIG 1 Concentration of CHX (initially set at 20 mg/m) recovered after drying this solution directly on a glass surface. Error bars are standard deviations from the means. Dashed lines depict the range of MIC and MBC values for all *E. coli* isolates tested (see Table S1 in the supplemental material). Note the abscissa distance for the histogram is not proportional to increasing drying time (data based on 3 biological repeats).

TABLE 3 Clinically relevant changes from antibiotic sensitive to resistant according to EUCAST (2020) breakpoint values for *E. coli* before and after a 5-min initial exposure to, and passage in, CHX or broth only

	Initially exposed to CHX at:[a]			
	0.0047 mg/ml, passaged in:		0.0075 mg/ml, passaged in:	
Strain	CHX	Broth	CHX	Broth
E. coli 13P5				
Initial exposure	AMC		AMC, FOX	
Passage 1	AMC	–[b]	AMC	–
Passage 5	AMC	AMC	AMC, IPM[c]	AMC
Passage 10	AMC	AMC	AMC	AMC
E. coli 1B2				
Initial exposure	–		AMC	
Passage 1	–	AMC[c]	AMP[c]	AMC
Passage 5	–	AMP, AMC[c], CIP, CPD, CF	AMP, AMC, CPD, CF	AMP, AMC, CIP, CPD, CF
Passage 10	CF	AMP, AMC, CPD, CF	AMP, AMC, CPD, CF	AMP, AMC, CPD, CF

[a]AMP, ampicillin; AMC, amoxicillin/clavulanic acid; CPD, cefpodoxime; CF, cephalothin; CIP, ciprofloxacin; IMP, imipenem; FOX, cefoxitin.
[b]–, no change in antibiotic susceptibility observed.
[c]Only observed in one-half of the repeats.

Key messages

PRODUCT EFFICACY

- MDRO not an issue compared to non-MDRO
- SARS-CoV-2 (generally enveloped viruses) not an issue
- Environmental isolates more resilient

FACTORS AFFECTING EFFICACY

- Predictable for some
- Concentration is paramount
- Formulation & Formulation delivery key
- Cleaning (detergent) will remove but may contribute to pathogen spread

CHALLENGES

- Endospores
- Biofilms - Environmental dry surface biofilms
- Residual activity

THANK YOU

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