Novel decontamination techniques, what is their role in healthcare?

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DECONTAMINATION

Decontamination is a process which removes or destroys contamination and thereby prevents micro-organisms, or other contaminants, reaching a susceptible site in sufficient numbers to initiate infection or some other harmful response.

Decontamination is the whole process. It includes cleaning, disinfection and sterilization.

Minimum Decontamination Standards Based on Risk of Infection (Spaulding Classification)

Non-Critical – contact with intact skin only

"LOW RISK": CLEAN with detergent and water

Semi-Critical: Intact mucous membranes or broken skin

"INTERMEDIATE RISK" e.g. transvaginal ultrasound probes

DISINFECTION or STERILIZATION

Critical Device: Contact with sterile body cavity or sterile tissue e.g. surgical instruments

"HIGH RISK": STERILIZATION

Minimum Decontamination Standards Based on Risk of Infection (Spaulding Classification)

Non-Critical – contact with intact skin only
"LOW RISK": CLEAN with detergent and water

Intact mucous membranes or broken skin
"INTERMEDIATE RISK": DISINFECTION (or STERILIZATION*)
- Automated to improve standardization & protect staff

Critical Device: Contact with sterile body cavity or sterile tissue
"HIGH RISK": STERILIZATION*

*Consider Sterile SINGLE-USE alternatives where clinically acceptable products are available and cost effective

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1)Whole Room Disinfection Options

Cabinets such as UV light boxes and hydrogen peroxide chambers follow the same principles

Environmental Decontamination Options

Liquid Detergents & Surface Disinfectants (inc. wipes)

Ultraviolet Radiation Whole Room Disinfection – fixed or mobile

Disinfectant Gasses & Vapours, inc.: Hydrogen peroxide, Peracetic Acid & Ozone – Whole Room

Novel Automated Decontamination Techniques

Pros	Cons
Automated disinfection	Still requires a manual clean & set up
	Additional staff training
	Large capital outlay

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2) Cleaning and Disinfection - recap

CLEANING

Cleaning manually removes visible soil.

Cleaning removes up-to 80% of contamination – this may be enough.

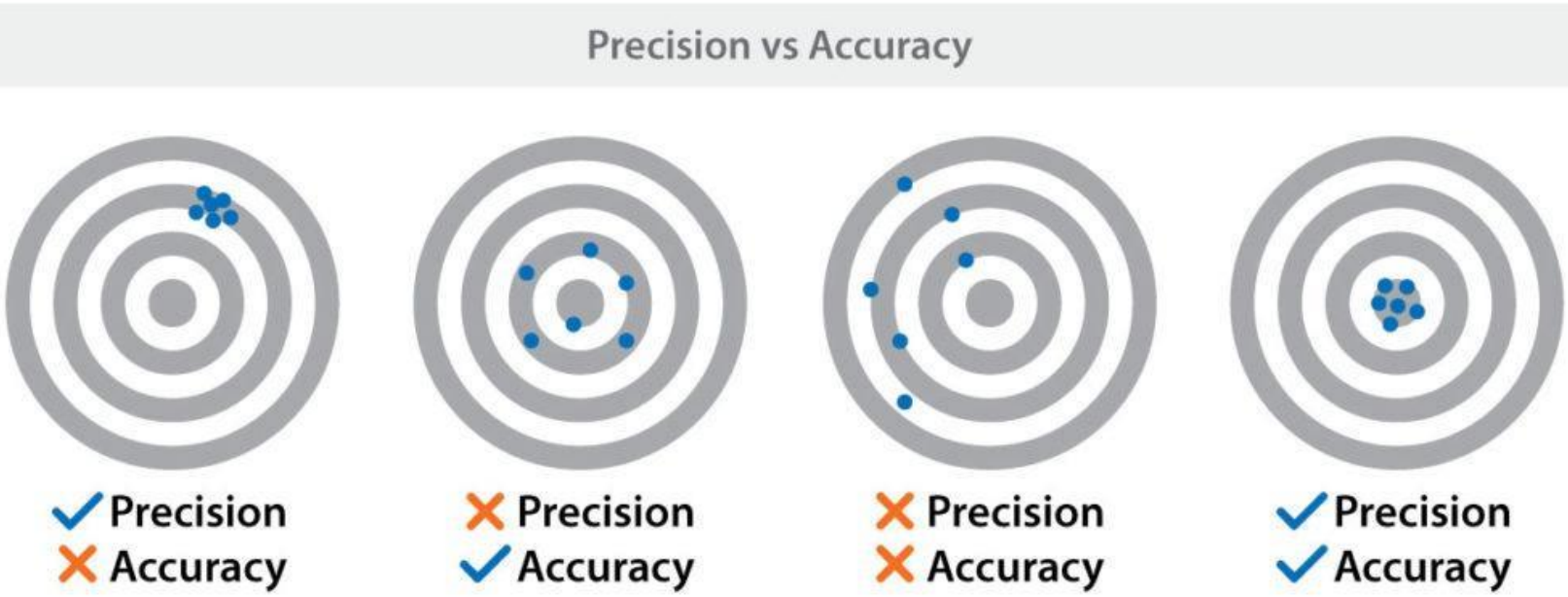
Where disinfection is required then we must still complete a thorough manual clean first

Whole room disinfection may be automated but a thorough manual pre-clean is required to ensure whole room disinfection is effective

DISINFECTION

The destruction of micro-organisms but not usually bacterial spores. The process does not necessarily kill all micro-organisms but reduces them to a level which is not harmful to health

- Automation combined with validation will reduce risk through improved standardisation
- Automation will reduce staff exposure to environmental contamination
- Disinfectants work more effectively on clean surfaces –where organic soil does not interfere with the chemical or physical processes required to achieve a 4 to 5 log reduction microorganisms contamination



People can be precise or accurate or both

They may also be neither – and this can change by the second

Automated processes are inherently more reproducible

This gives us precision by not always accuracy (1st or 4th)

Quality control checks are more effective for automated systems

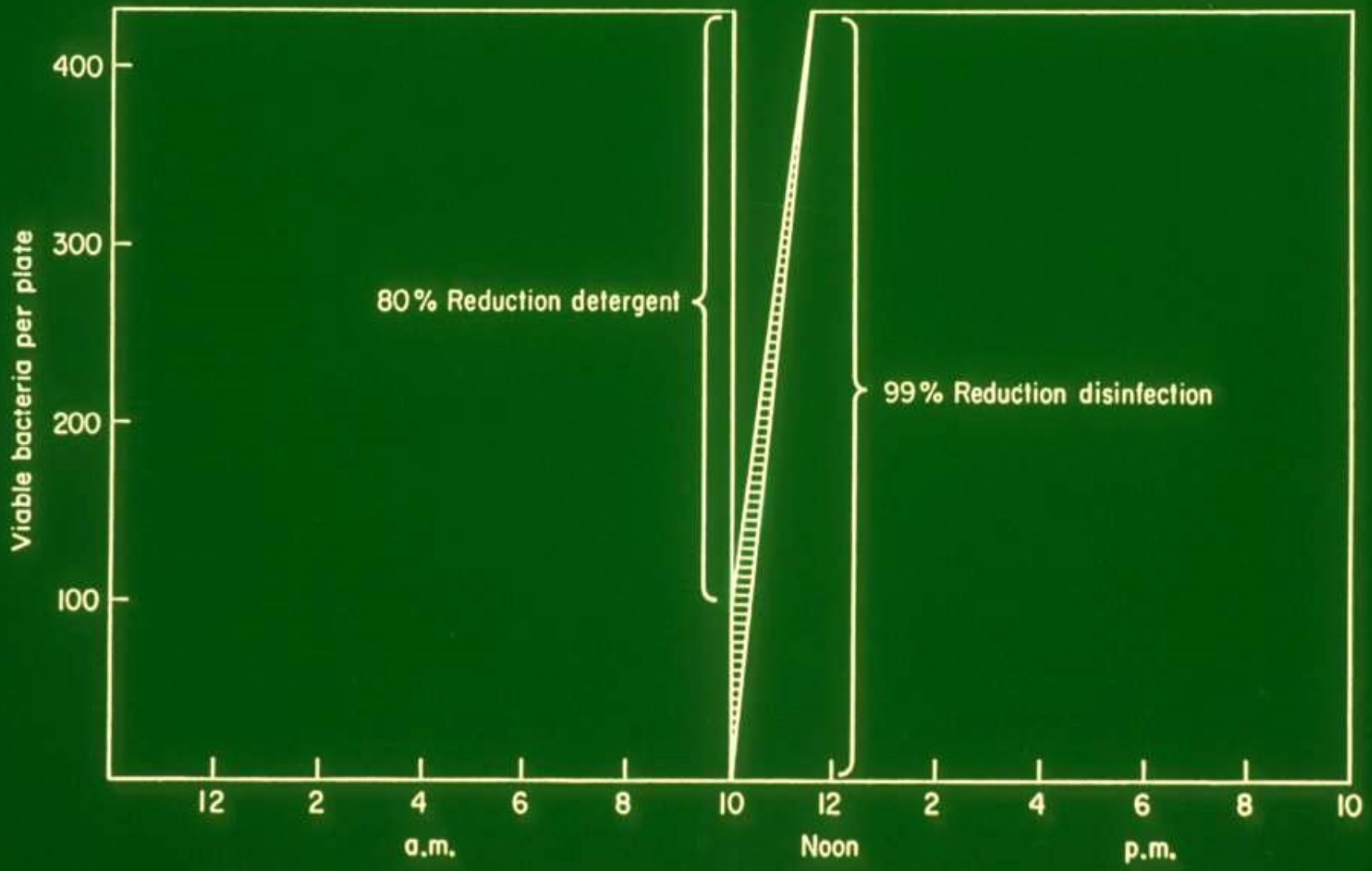


Diagram representing the bacteriological effect of floor cleaning at 10 am.

Novel Automated Decontamination Techniques

Pros	Cons
Automated disinfection	Still requires a manual clean & set up
Reproducible & Auditable	Optimising set up can be challenging And time consuming
Staff training needs are clear	Additional staff training
More effective than cleaning alone	Effects may be short-lived, if recontamination occurs frequently
	Large capital outlay

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3) Are they effective in laboratory tests

ECHA – tells us which test are required for manufacturer's to claim efficacy in an application areas e.g. PT2 hard surfaces in healthcare

PT 2						
Product type / micro-organism	**Requirements[1]**	**Test required[2]**	**Contact time[3]**	**Temp (°C)**	**Soiling conditions[4]**	**Required lg reduction**
PT 2 hard surfaces and other uses where EN tests are applicable, use in healthcare						
bacteria	Basic requirement - 2,1 test	EN 13727 / EN 1276[5]	5 min[13] / 60 min	20	clean / dirty	5
bacteria	Basic requirement - 2,2 test	EN 13697 / EN 16615[14]	5 min[13] / 60 min	20	clean / dirty	4 / 5
yeast	Basic requirement - 2,1 test	EN 13624 / EN 1650[5]	5 min[13] / 60 min	20	clean / dirty	4
yeast	Basic requirement - 2,2 test	EN 13697 / EN 16615[14]	5 min[13] / 60 min	20	clean / dirty	3 / 4
mycobacteria / tuberculosis	Optional - 2,1 test	EN 14348	5 min[13] / 60 min	20	clean / dirty	4
viruses	Optional - 2,1 test	EN 14476	5 min[13] / 60 min	20	clean / dirty	4
viruses	Optional – 2,2 test	See[15]	5 min[13] / 60 min	20	clean / dirty	4
fungal spores	Optional - 2,1 test	EN 13624 / EN 1650[5]	5 min[13] / 60 min	20	clean / dirty	4
fungal spores	Optional - 2,2 test	EN 13697	5 min[13] / 60 min	20	clean / dirty	3


TOTACIDE 28
COLD
STERILISER
ASEP

New UV Disinfection Efficacy Test

Publication Start Date: 31/03/2022

BS 8626:2022

Method for quantitative testing of automated ultraviolet disinfection activities by direct illumination, determination of bacteriocidal, mycoacteriacidal, sporicidal, yeasticidal, fungicidal, viricidal and phagocidal activities.

Contaminated discs exposed for fixed time at fixed angle and distance.

EUROPEAN NORMS – sequence of tests moving closer to real application area

Phase 1 Suspension tests for the basic activity of the product

Phase 2/step 1 Suspension tests under conditions representative of practical use

Phase 2/step 2 Other laboratory tests simulating practical conditions e.g. hand wash, hand-rub & surface tests

(Phase 3 Field tests under practical conditions)*

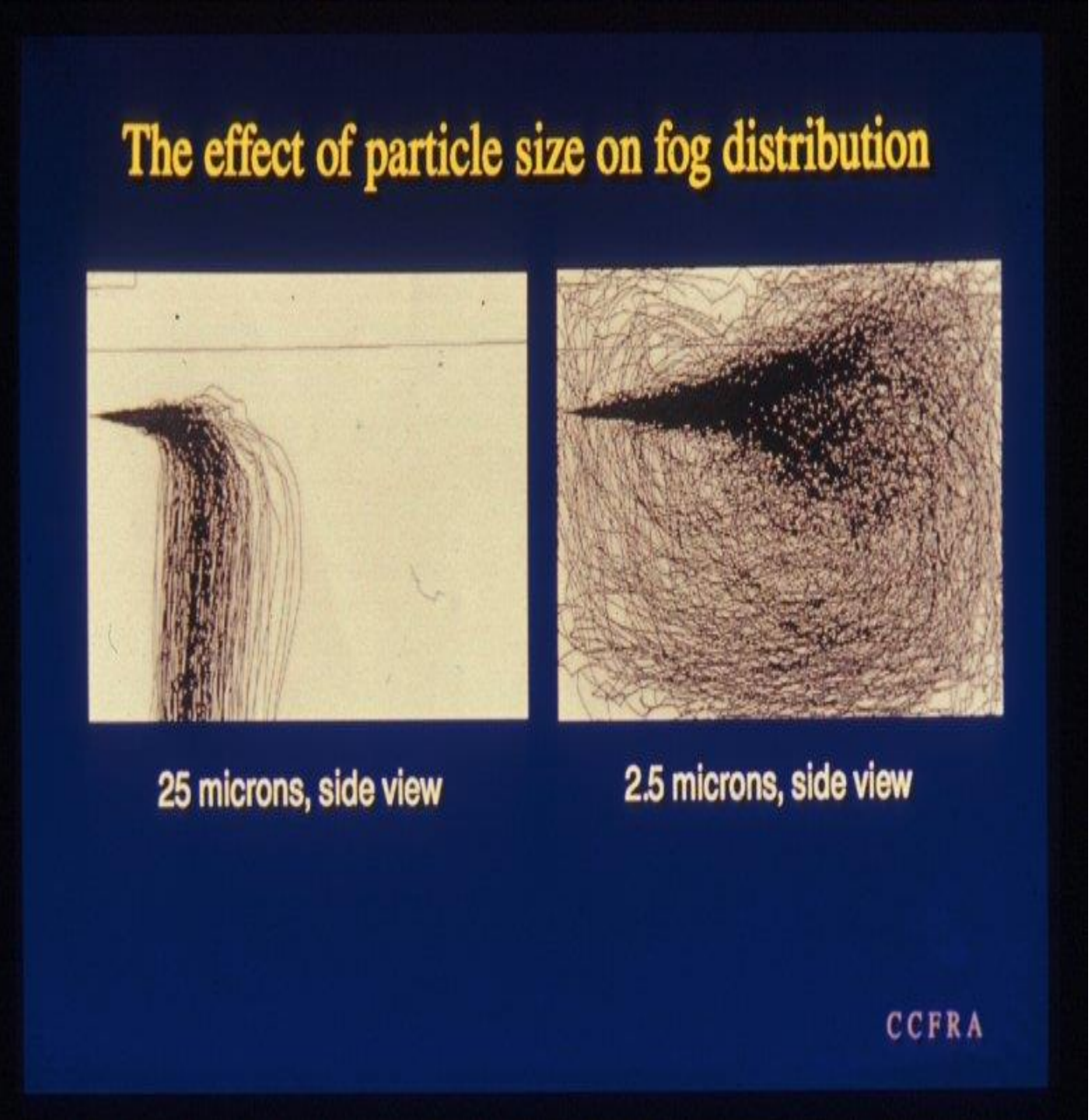
*user is responsible for this – only really enforced in food only production

Use and try to understand what disinfect efficacy testing really tells us – be sceptical, challenge manufacturer's to explain & justify

Phase 2, step 2 tests more closely represent the specific application area for disinfectant

bsi.

British Standards Document
BS EN 16615
Chemical disinfectants and antiseptics. Quantitative test method for the evaluation of bactericidal and yeasticidal activity on non-porous surfaces with mechanical action employing wipes in the medical area (4- field test). Test method and requirements (phase 2, step 2)



Efficacy in a tube gives no assurance that disinfectant fogs, gases or vapours will reach all surfaces in a room

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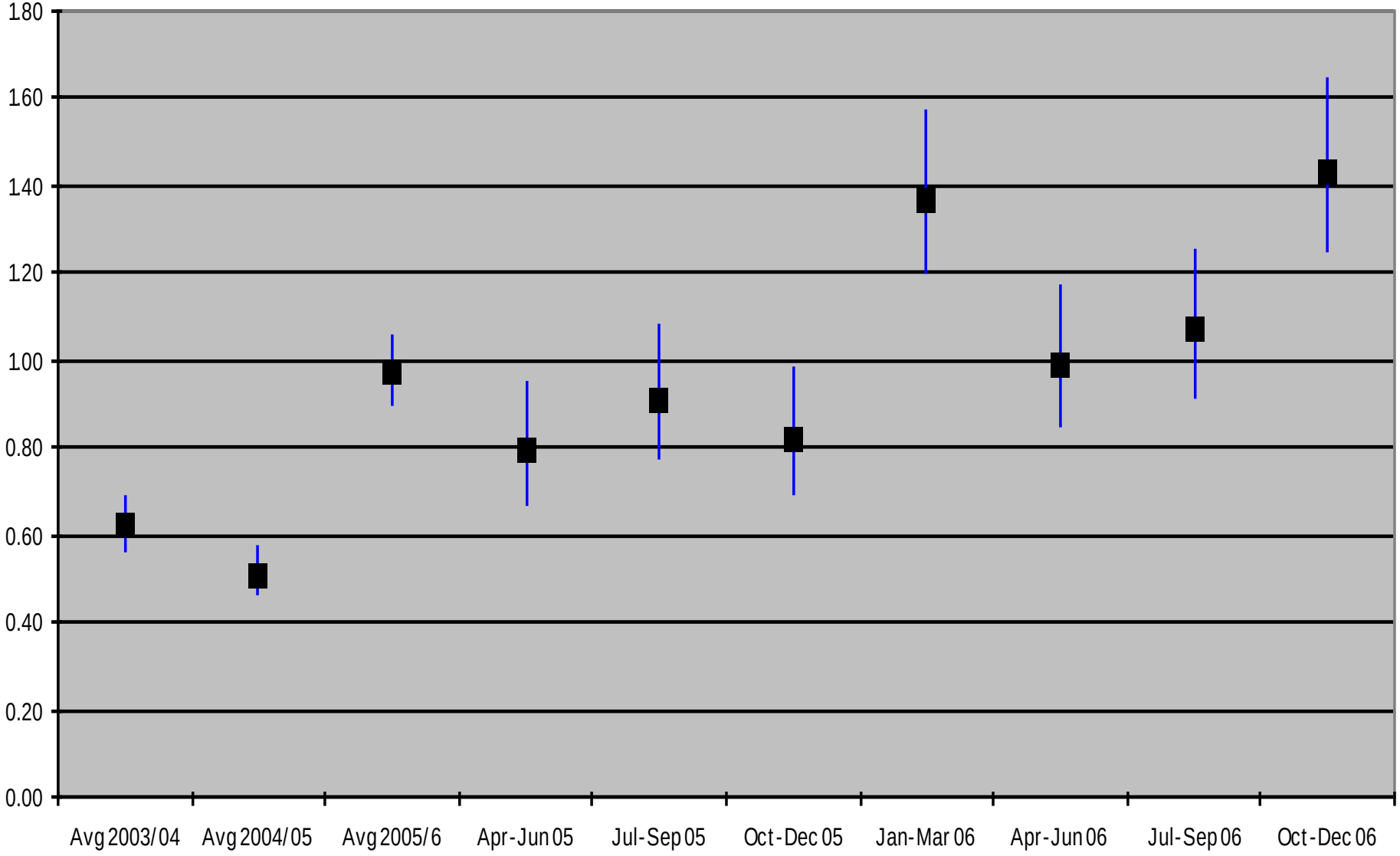
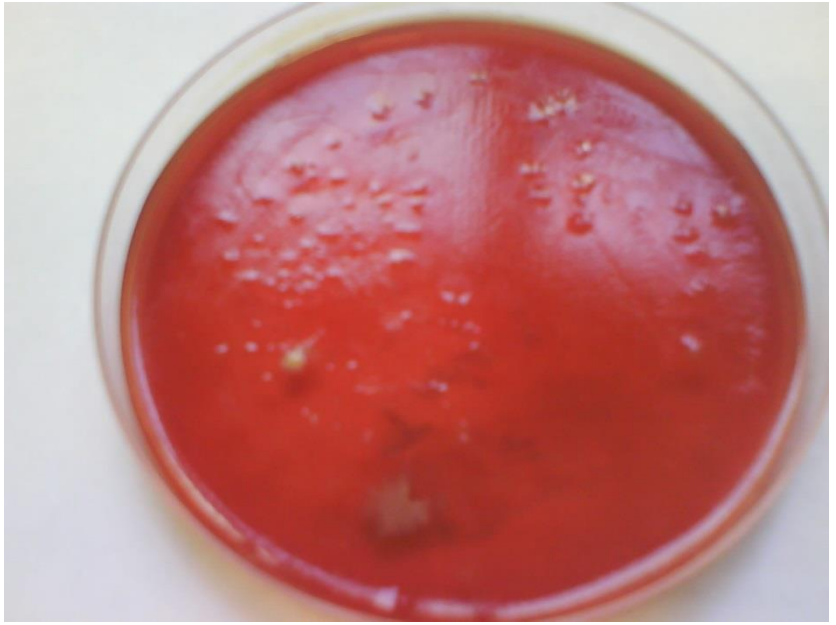
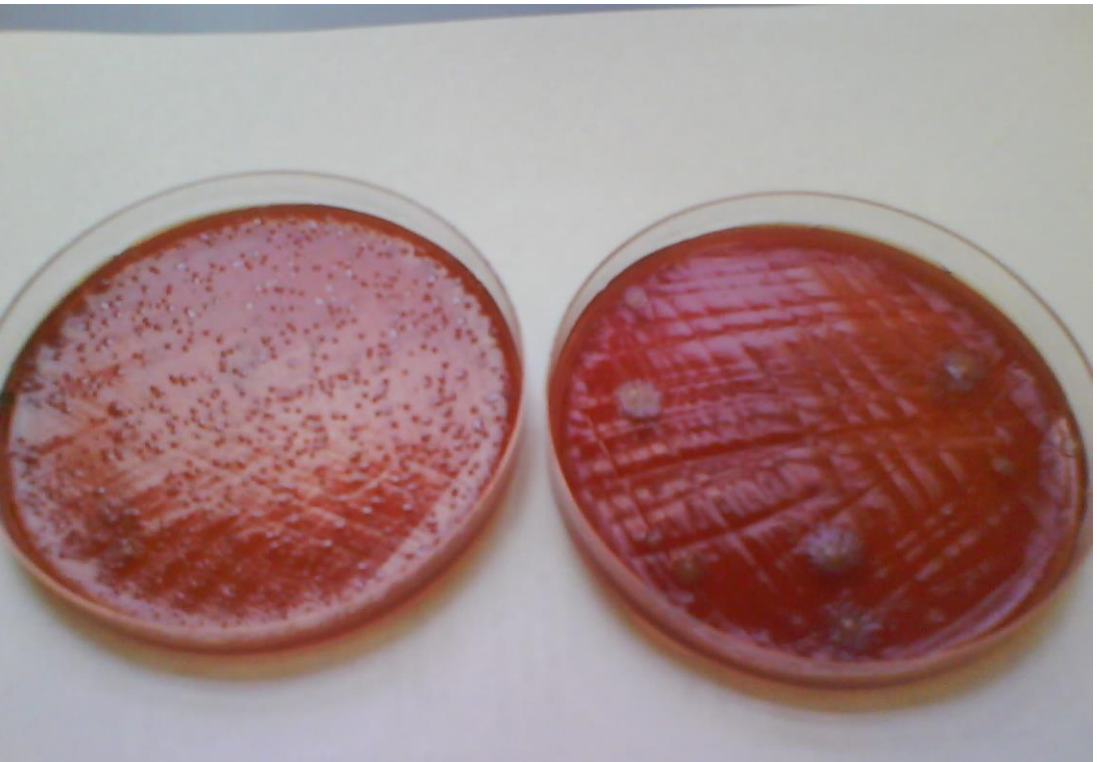
4) Do they work in clinical areas

NUH Acquired *C. difficile* Rates per 1000 bed days



1 in 5 surfaces tested positive after cleaning and disinfection with 10000ppm chlorine





C. Difficile found on floors, touch points, macerators and commodes

Journal of Hospital Infection (2008) 70, 136–141

Available online at www.sciencedirect.com

ScienceDirect

www.elsevierhealth.com/journals/jhin

Activity of a dry mist hydrogen peroxide system against environmental *Clostridium difficile* contamination in elderly care wards☆

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KEYWORDS
Clostridium difficile;
Environmental contamination;
Hydrogen peroxide;
Decontamination;
Ribotype

Summary *Clostridium difficile* causes serious healthcare-associated infections. Infection control is difficult, due in part to environmental contamination with *C. difficile* spores. These spores are relatively resistant to cleaning and disinfection. The activity of a dry mist hydrogen peroxide decontamination system (Sterinis®) against environmental *C. difficile* contamination was assessed in three elderly care wards. Initial sampling for *C. difficile* was performed in 16 rooms across a variety of wards and specialties, using Brazier's CCEY (cycloserine–cefoxitin–egg yolk) agar. Ten rooms for elderly patients (eight isolation and two sluice rooms) were then resampled following dry mist hydrogen peroxide decontamination. Representative isolates of *C. difficile* were typed by polymerase chain reaction ribotyping. *C. difficile* was recovered from 3%, 11% and 26% of samples from low, medium and high risk rooms, respectively. In 10 high risk elderly care rooms, 24% (48/203) of samples were positive for *C. difficile*, with a mean of 6.8 colony-forming units (cfu) per 10 samples prior to hydrogen peroxide decontamination. Ribotyping identified the presence of the three main UK epidemic strains (ribotypes 001, 027 and 106) and four rooms contained mixed strains. After a single cycle of hydrogen peroxide decontamination, only 3% (7/203) of samples were positive ($P < 0.001$), with a mean of 0.4 cfu per 10 samples (~94% reduction). The Sterinis® hydrogen peroxide system significantly reduced the extent of environmental contamination with *C. difficile* in these elderly care rooms.

☆ This work was presented in part at the Federation of Infection Societies meeting, Cardiff, UK, November 2007.

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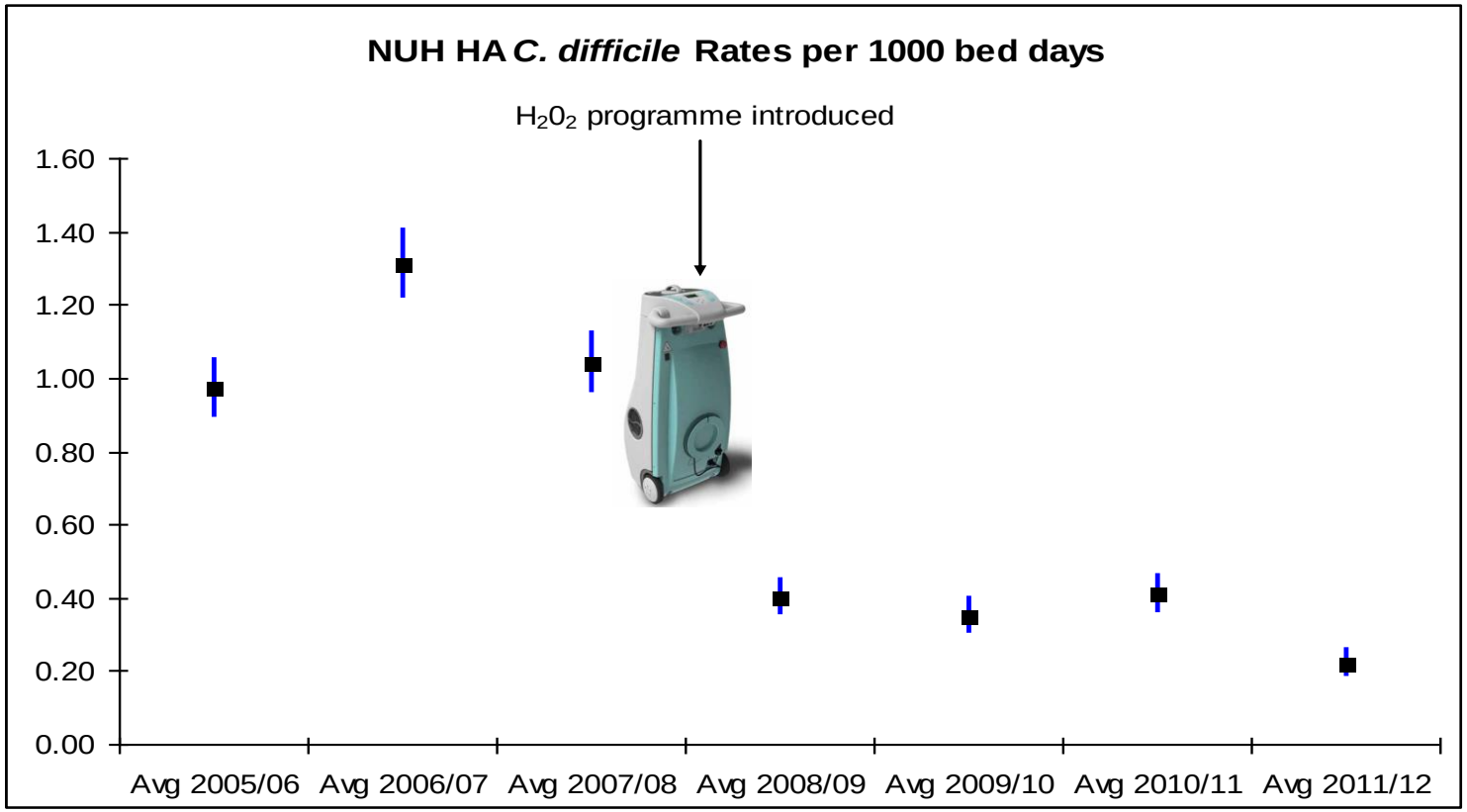
doi:10.1016/j.jhin.2008.06.008

This portable hydrogen peroxide fumigation unit can significantly reduce toxigenic *Clostridium difficile* environmental contamination within patient isolation and sluice rooms (~94% reduction) ($p<0.001$)

This may prove to be a useful addition to conventional "terminal" cleaning and disinfection

Impact on *Clostridium difficile* Infection Rates



Boswell T. Nottingham University Hospitals Surveillance Data 2005-2012 (unpublished)

Decontamination Failures

- Windowsill behind a curtain
- Fabric notice board
- Extract grill (visible dirt on inspection)
- Top of a cupboard (visibly dirt on inspection)

<u>Conclusions:</u>

- The manual pre-clean is important
- Porous items should be removed and replaced

2008

C. difficile Testing in Side-rooms "Ready for Occupation" (Dedicated _C. difficile_ Ward, 2008)

Number of Rooms Examined	Number Surfaces Tested	_C.difficile_ Count (per 100 cm^2)
3	60	1 colony forming unit (bed rail)

C. difficile (spores plus vegetative cells): a side-room occupied by a relapsing *C. difficile* patient	
Armchair	30
Floor corner	2
Floor – other	1
Nurse call	70
Soap dispenser	1
Curtain	1
Radiator – lower grill	2
Stethoscope	1

BETR: Benefit of Enhanced Terminal Room Disinfection Study

Anderson DJ, Knelson LP, Moehring RW, Lewis SS, Weber DJ, Chen LF, Triplett PF, Blocker M, Cooney RM, Schwab JC, Lokhnygina Y. Implementation lessons learned from the benefits of enhanced terminal room (BETR) disinfection study: process and perceptions of enhanced disinfection with ultraviolet disinfection devices. infection control & hospital epidemiology. 2018 Feb;39(2):157-63.

Conclusion: A contaminated healthcare environment is an important source for acquisition of pathogens; enhanced terminal room disinfection decreases this risk

Pragmatic, cluster-randomised, crossover trial at nine hospitals… Rooms from which a patient with infection or colonisation with a target organism was discharged were terminally disinfected with one of four strategies (n=21395 rooms: A=4916, B=5178,C=5438, D=5863)

Target Organisms	Terminal Disinfection Strategies	Strategy Classification
• MRSA • VRE • *C. difficile* • MDRO - Acinetobacter	A: Reference = Quaternary ammonium (QAC)* B: UV Group = QAC + UV C: Bleach Group = Bleach disinfectant D: Bleach and UV Group = Bleach	A: Standard B: Enhanced C: Enhanced D: Enhanced

Conclusion: adding UV reduced all HCAIs, except for C.difficile

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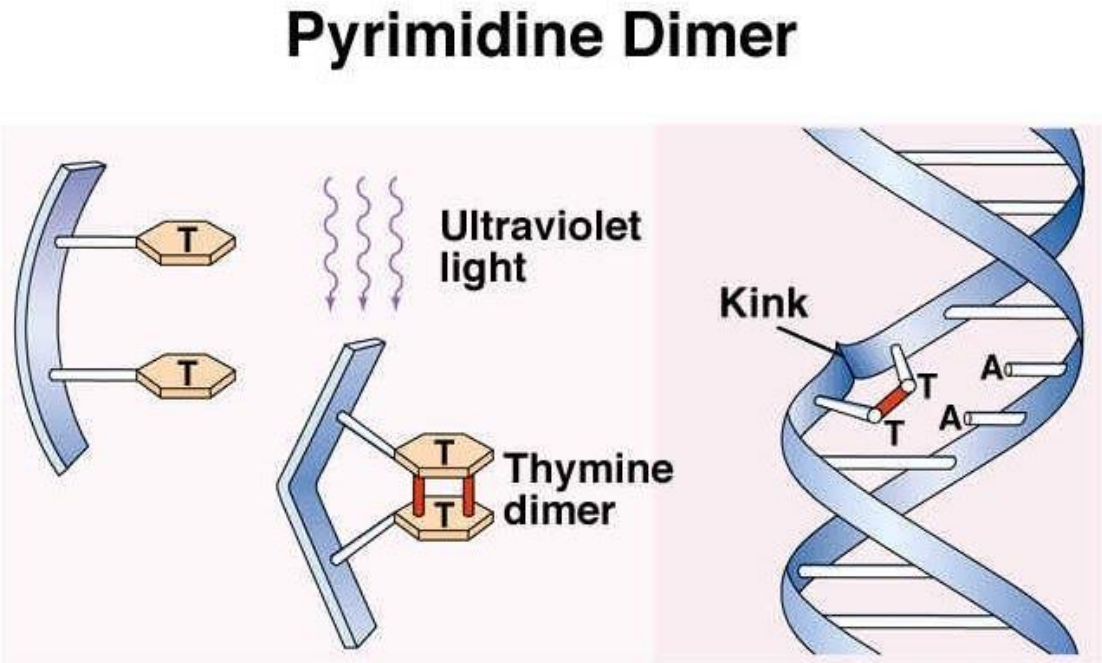

-This illustrates the impact of UV light on DNA
- The impact is greater for RNA which is more likely to break
Efficacy varies with power output & wavelength

Limitations (UV Radiation)

Line of site can be difficult to achieve

Efficacy is reduced by shadowing

UV only works over shorter distances (inverse square rule: double the distance and you loose ¾ of the power)

UV is very useful in narrow kitchen. Rapid, effective on counters and no rinsing/no taste or smell (taint)

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C. difficile can protect itself from UV radiation inside the endospore

INCREASING RESISTANCE TO CHEMICAL DISINFECTANTS

Bacterial spores	**(C.diff, gangrene, tetanus)**
Mycobacteria	(*M. tuberculosis*)
Non enveloped viruses	(Adenovirus and HPV)
Fungi	(*Candida albicans*)
Gram negative bacteria	(*Pseudomonas aeruginosa,* CPE)
Gram positive bacteria	(*Staphylococcus aureus*/MRSA)
Enveloped viruses	(HIV, HEP B, HEP C, influenza and **SARS-CoV-2**)

Benefits: HP & UV Disinfection

- **Hydrogen Peroxide**
- Highly effective oxidising disinfectant
- Validated for effective distribution for a side-room and multiple units can be linked for larger spaces
- Highly validated, effective = method of choice for VHFs
- Minimal damage to surface (take care with expose Aluminium)
- Chemical and Biological indicators are available and easy to use

- **UV Radiation**
- Rapid action
- Highly effective at close range with direct line of sight (carefully staging required)
- Safe for many surfaces although prolonged expose may reduce the life of plastics
- Minimal recuring costs (bulbs need replacing regularly to maintain power output)
- Chemical indicators are available

Effective Automated Decontamination Systems (Validated and Deployed in accordance with MIU) can be:

- Effective
- Reproducible
- Easy to use
- Safe – Staff and Patients (PPE / COSHH)
- Minimise damage to surfaces
- Cost effective
- Auditable
- Sustainable

Environmental Decontamination Options

Liquid Detergents & Surface Disinfectants (inc. wipes)

Ultraviolet Radiation Whole Room Disinfection – fixed or mobile

Disinfectant Gasses & Vapours, inc.: Hydrogen peroxide, Peracetic Acid & Ozone – Whole Room

So, HP whole room disinfection might be more effective (especially for C. difficile)

Except Mark Garvey confirmed that you don't need an effective disinfectant because well trained /motivated staff (QE ED), armed with a sanitising wipe achieved a reduction in MRSA AND C.difficile infection rates ????

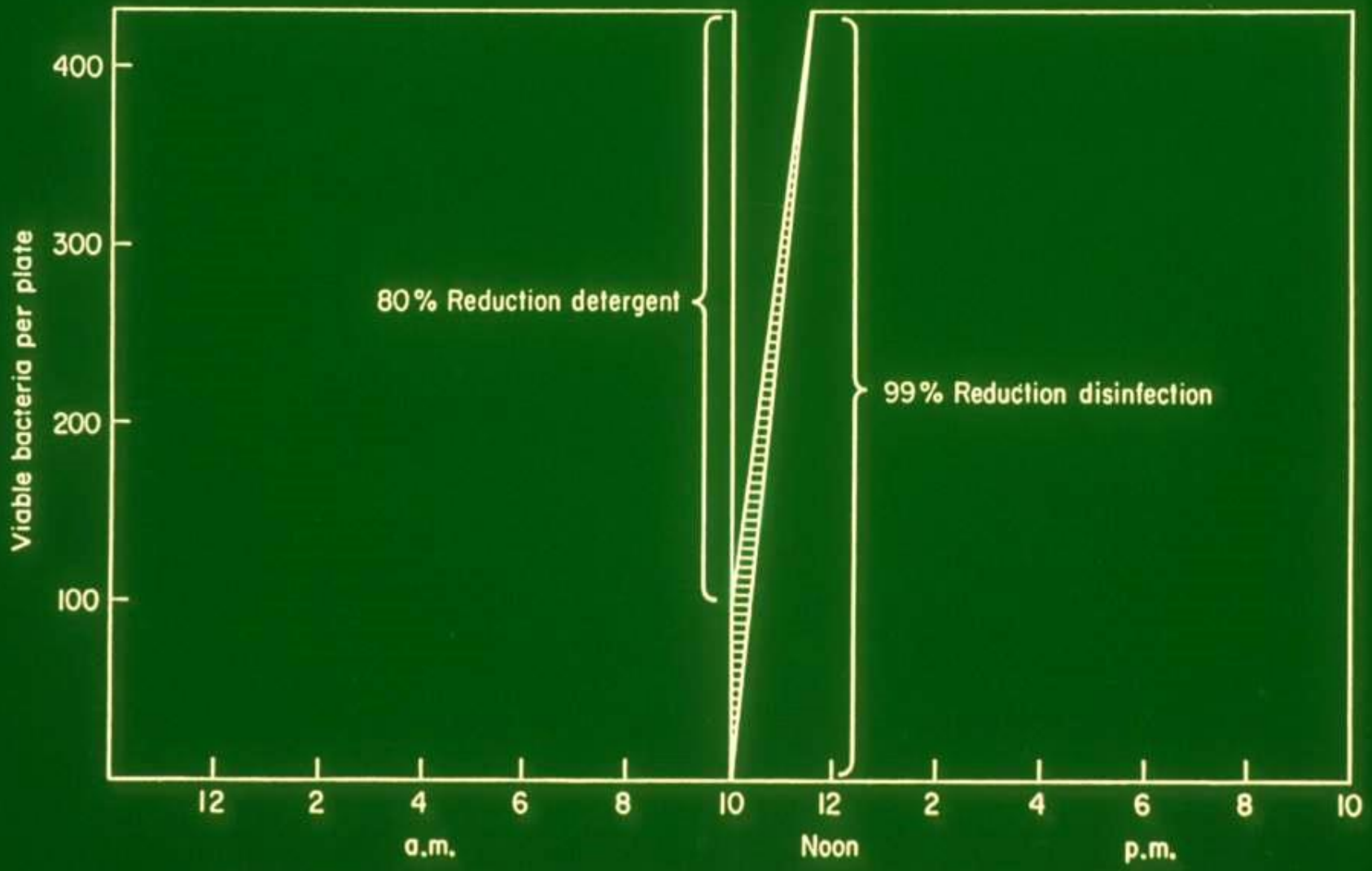

Diagram representing the bacteriological effect of floor cleaning at 10 am.

Consider Sars-CoV-2

- This is an envelope virus easily disrupted by detergents
- In wave 3 (UK Dec 2021- January 2022) Office of National Statistics estimated that around 1:25 people were positive for the SARS-CoV-2 virus
- The challenge here is not the level of decontamination or finding an effective disinfect it is the speed with which recontamination is occurring
- Using HPV would be effective but this takes half a day and recontamination could occur in minutes
- **Sometimes the simplest and quickest solution (which can be repeated at high frequency) is most effective**

CONSIDERATIONS WHEN CHOOSING A DISINFECTANT

Range of activity – bacterial endospores problematic

Rate of kill/ exposure time

Usability survey / staff acceptance

Toxicity, irritancy, sensitization

Compatibility (surfaces and other chemicals detergents)

Stability e.g. Inactivation by organic matter

Cost

- What IPC risks are we actually trying to mitigate?

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