What's lurking in the hospital environment?

The importance of cleaning and disinfection in infection prevention and control

16/06/15

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Room A

Room B

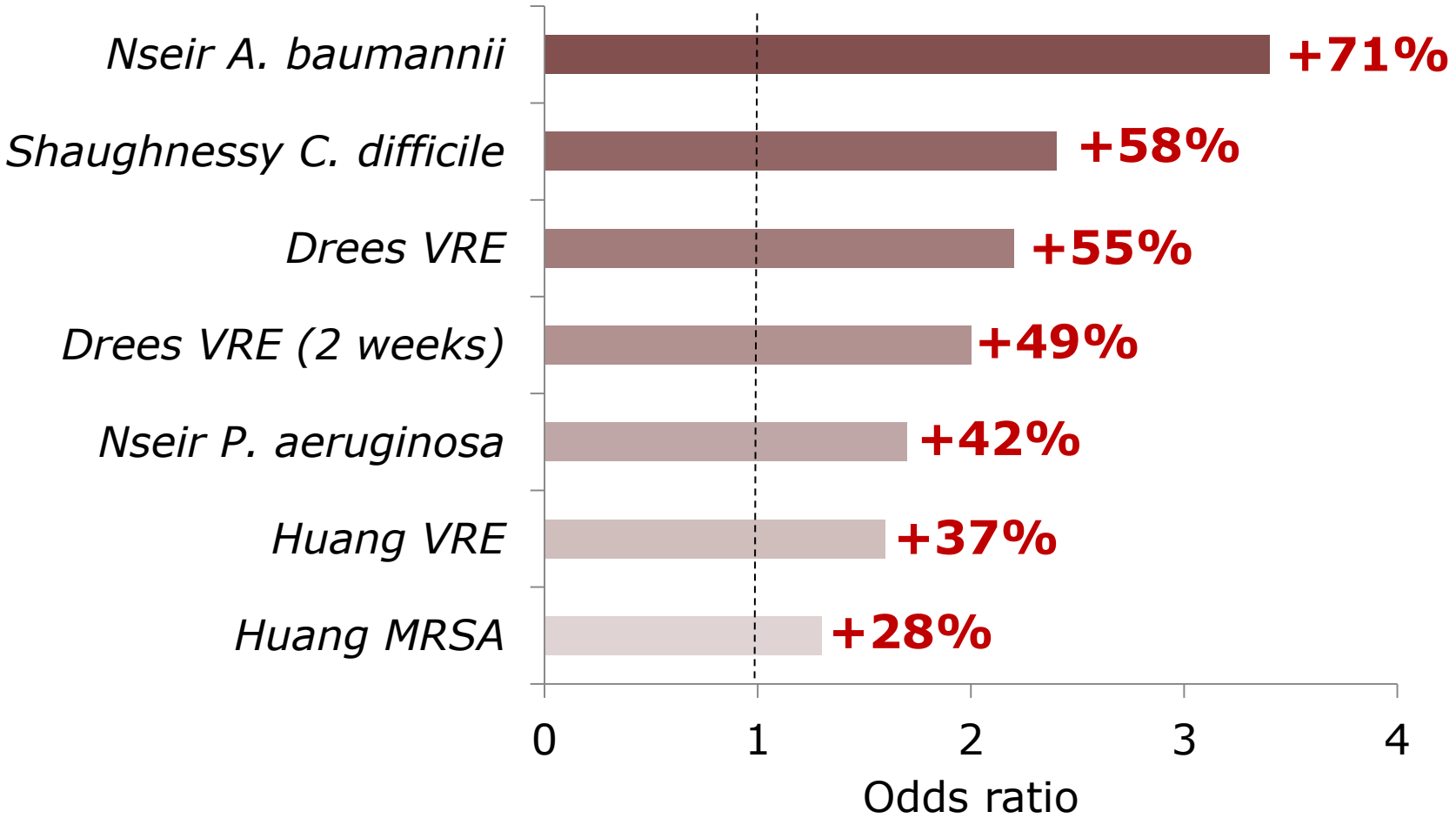
‘The room lotto’

Patient infected or colonised with a pathogen (e.g. *C. difficile*, MRSA, VRE, *A. baumannii* or *P. aeruginosa*)

Patient is discharged and the room is cleaned / disinfected; surfaces in the room remain contaminated with the pathogen

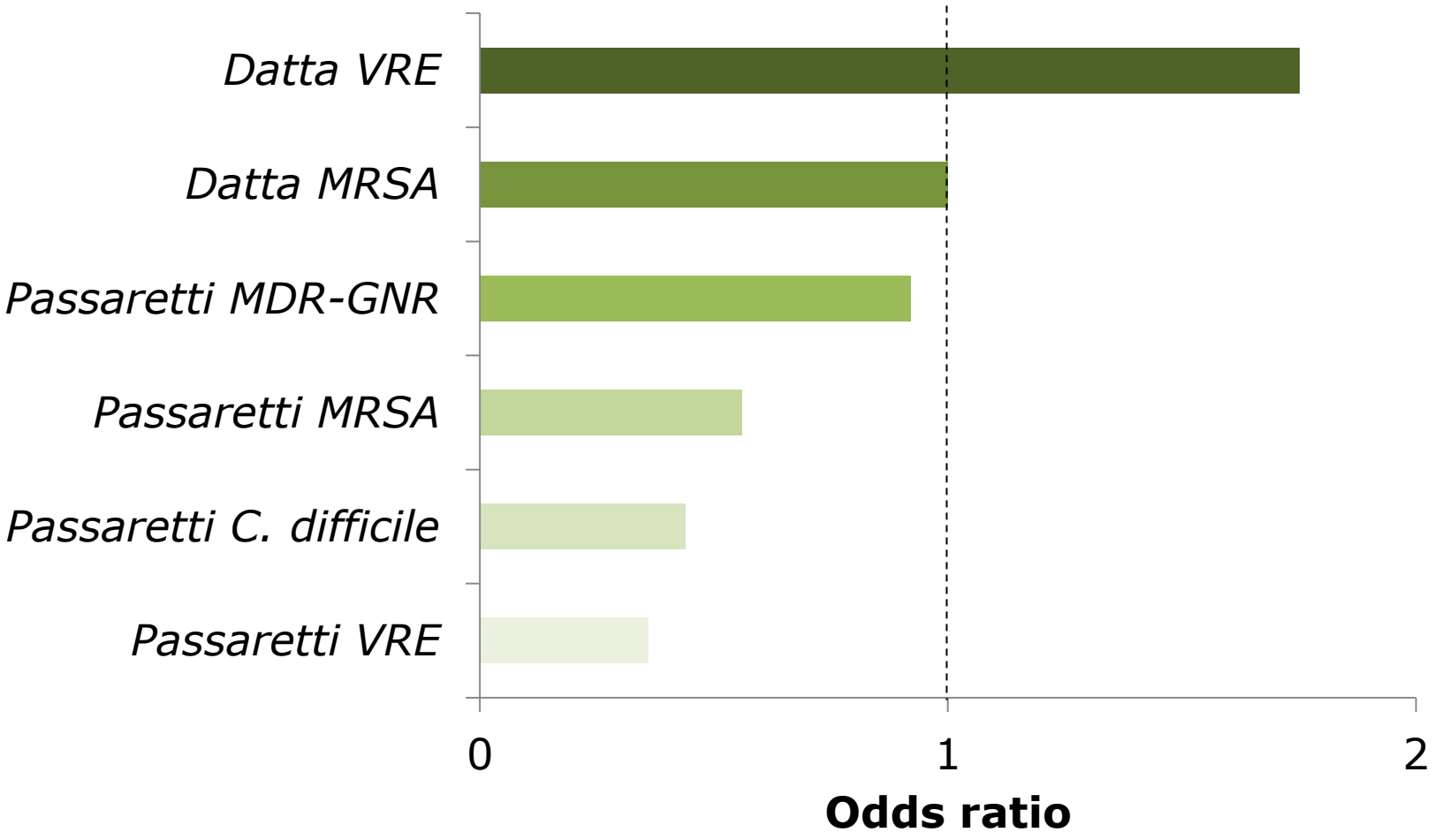
The next room occupant is at an increased risk of acquiring the pathogen

Increased risk from the prior room occupant



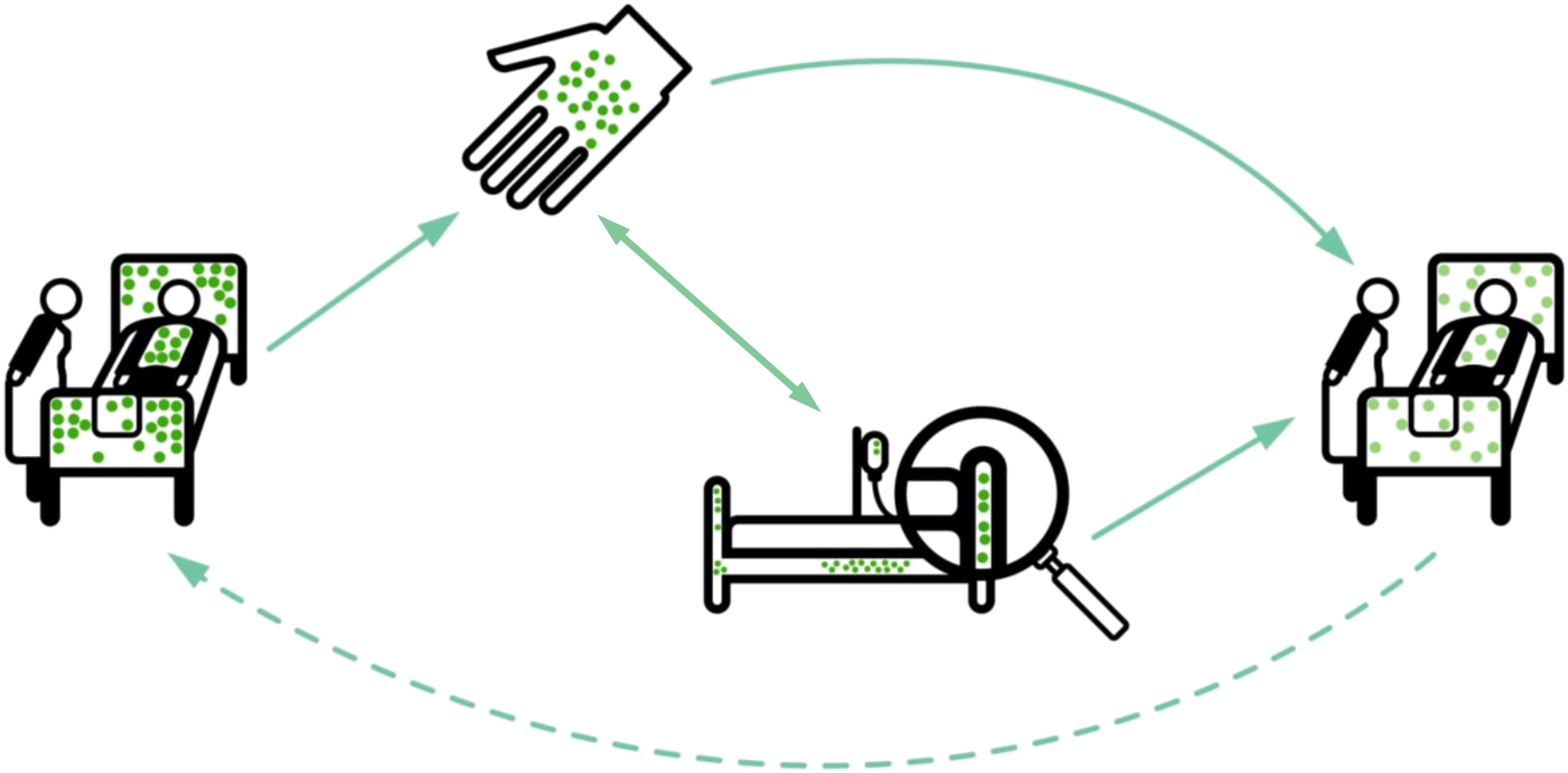
Otter *et al*. *Am J Infect Control* 2013;41(5 Suppl):S6-11.

Taking the ‘lotto’ out of the room



Datta *et al. Arch Intern Med* 2011;171:491-494.
Passaretti *et al. Clin Infect Dis* 2013;56:27-35.

Transmission routes



Otter *et al. Infect Control Hosp Epidemiol* 2011;32:687-699.

French *et al. J Hosp Infect* 2004;57:31-37.

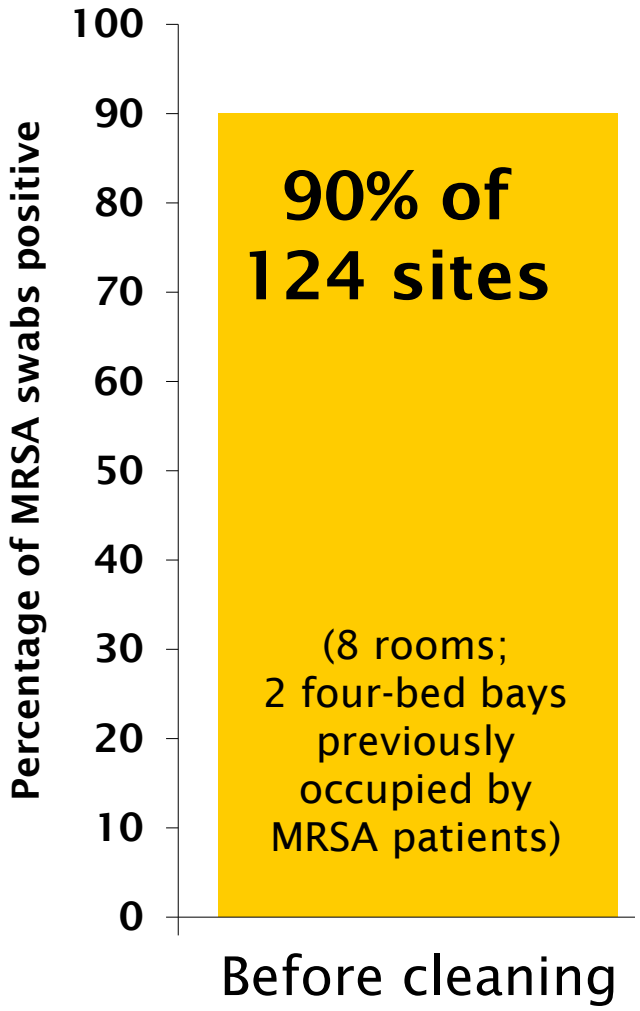
Surface survival

Organism	Survival time
Clostridium difficile (spores)	5 months
Acinetobacter spp.	3 days to 5 months
Enterococcus spp. including VRE	5 days – 4 years (!)[1]
Pseudomonas aeruginosa	6 hours – 16 months
Klebsiella spp.	2 hours to > 30 months
Staphylococcus aureus, inc. MRSA	7 days – 7 months
Norovirus (and feline calicivirus)	8 hours to > 2 weeks[2]
SARS Coronavirus	72 hours to >28 days[3]
Influenza	Hours to several days[4]

Adapted from Kramer *et al. BMC Infect Dis* 2006;6:130.

1. Wagenvoort et al. J Hosp Infect 2011;77:282-283.
2. Doultree *et al. J Hosp Infect* 1999;41:51-57.
3. Rabenau *et al. Med Microbiol Immunol* 2005;194:1-6.
4. Bean *et al. J Infect Dis* 1982;146:47-51.

Conventional terminal cleaning



French *et al. J Hosp Infect* 2004;57:31-37.

Pathogens can be transferred from hospital surfaces to HCW hands without direct patient contact[1-2]

52% of 23 HCW acquired VRE on their hands[3]	Contact with patient **or** surface = ~10% risk of acquiring VRE[3]
45% of 50 HCW acquired MRSA on their hands[4]	**40%** of 50 HCW acquired MRSA on their hands[4]
50% of 30 HCW acquired *C. difficile* on their hands[5]	**50%** of 30 HCW acquired *C. difficile* on their hands[5]
Compliance with hand hygiene: **50%**[6]	Compliance with hand hygiene: **80%**[6]

1. Boyce *et al. Infect Control Hosp Epidemiol* 1997;18:622-627.
2. Bhalla *et al. Infect Cont Hosp Epidemiol* 2004;25:164-167.
3. Hayden *et al. Infect Control Hosp Epidemiol* 2008;29:149-154.
4. Stiefel *et al. Infect Control Hosp Epidemiol* 2011;32:185-187.
5. Guerrero *et al. Am J Infect Control* 2012;40:556-558.
6. Randle *et al. J Hosp Infect* 2010;76:252-255.

Learning objectives

1. Understand the key data supporting the role of contaminated surfaces in the transmission of hospital pathogens
2. Become familiar with the various methods to improve the efficacy of hospital disinfection:
   - Tools such as ATP assays and fluorescent markers to evaluate the thoroughness of the cleaning process;
   - Methods to improve the education and training of cleaning staff.
3. Discuss the results of improved cleaning and disinfection in reducing transmission of pathogens
4. Understand other and emerging approaches including:
   - Measures to reduce and contain shedding more effectively;
   - New disinfectants, cleaning materials and consideration of automated systems;
   - Antimicrobial surfaces;
   - Improved design to improve ‘cleanability‘.

Improve existing procedures

Try something new!

Improve existing procedures

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Improve existing procedures

Education & training

Question	"Answer"
What to clean?	Focus of "high-touch" sites seems sensible
Who cleans what?	Checklists can help
What agent(s) to use?	Depends on the situation; sporicidal agent for *C. difficile*
What materials to use?	Microfibre may help Wipes have pros and cons "Bucket method" most effective
How to educate staff?	More than we currently do! Difficult task
Daily cleaning: how often?	Evidence for daily or twice daily
Terminal cleaning: optimal protocols?	More stringent protocol should be used for terminal disinfection

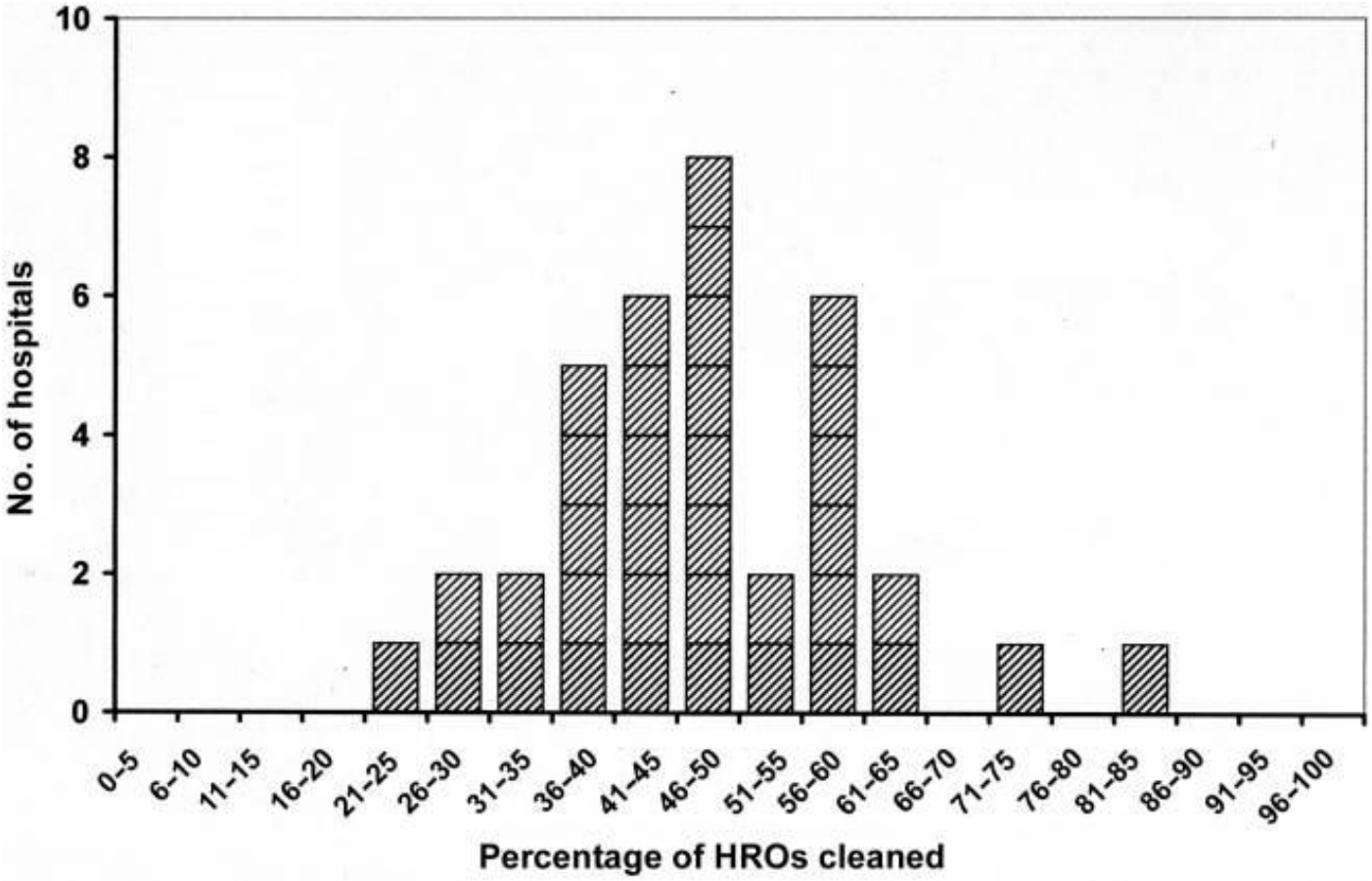
Improve existing procedures

Try something new!

Improve existing procedures

Why bother?

Baseline cleaning rates of 'high-risk objects' in 36 acute US hospitals, as determined by removal of a fluorescent marker.

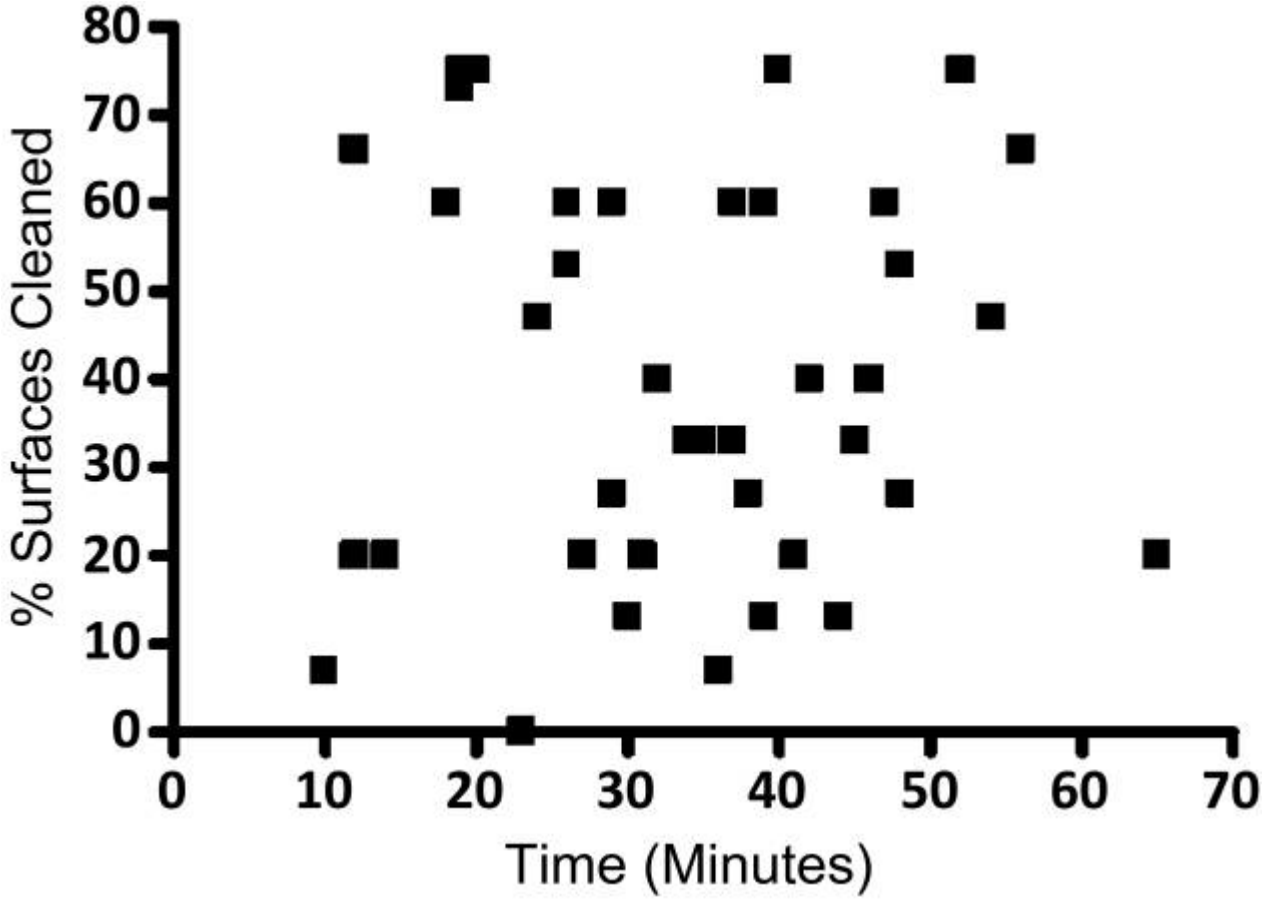


Carling *et al*. *Infect Control Hosp Epidemiol* 2008;29:1035-1041.

Improve existing procedures

Why bother?

The time taken to clean a room does not correlate with the thoroughness of cleaning, as determined by removal of a fluorescent marker



Rupp *et al*. *Infect Control Hosp Epidemiol* 2013;34:100-102.

Improve existing procedures

Visual assessment

- Visual assessment of hospital cleaning is performed by measuring the apparent cleanliness of a room against a checklist.[1,2]
- A room needs to be visually clean to be acceptable to the current and subsequent occupant.

Visual assessment of hygiene does not correlate with microbial contamination, and can thus be a misleading measure of cleanliness[3-5]

1. Sherlock *et al. J Hosp Infect* 2009;72:140-146.
2. Mulvey *et al. J Hosp Infect* 2011;77:25-30.
3. Griffith *et al. J Hosp Infect* 2007;66:352-359.
4. Cooper *et al. Am J Infect Control* 2007;66:352-359.
5. Griffith *et al. J Hosp Infect* 2000;45:19-28.

Improve existing procedures

Microbiological samples

- Microbiological surface cultures can be qualitative (pathogen presence or absence) or quantitative (aerobic colony counts)
- Several different sampling methods available; usually swabs (with or without enrichment) or contact plates

- Quality standards for both aerobic colony counts (<2.5 cfu / cm^2) and specific indicator organisms (<1 cfu / cm^2) have been proposed.[1,2]

Cost and practicality mean that routine microbiological sampling is rarely performed

1. Mulvey *et al. J Hosp Infect* 2011;77:25-30.
2. Malik *et al. Am J Infect Control* 2003;31:181-187.

Improve existing procedures

ATP assessment

- Adenosine triphosphate (ATP) is the "energy currency" of all living cells.
- Surfaces can be swabbed and a hand-held sensor can give a real-time quantitative measurement of ATP from the surface.
- Several "quality standards" have been set as relative light unit (RLU) thresholds, ranging from 100-500.[1-3]

There is no direct correlation between RLU and microbial contamination, but "hygiene fails" determined by aerobic colony count and ATP do correlate[1,2]

1. Boyce *et al. Infect Control Hosp Epidemiol* 2011;32:1187-1189.
2. Mulvey et al. *J Hosp Infect* 2011;77:25-30.
3. Whiteley *et al*. *Healthcare Infection* 2012;17:91-97.

Improve existing procedures

Fluorescent markers

- Fluorescent material in the form of gel, powder or lotion can be applied to a surface and its removal assessed by a 'black light'
- The % removal of the spots is used to evaluate cleaning performance.[1,2]
- Educational interventions can improve significantly the removal of the market spots.[2-3]

The removal of marked spots has been shown to correlate with microbial contamination in some studies;[2-3] cleaning staff may "get wise" to the location of the spots and preferentially target them[4]

1. Boyce *et al. Infect Control Hosp Epidemiol* 2011;32:1187-1189.
2. Carling *et al. Infect Control Hosp Epidemiol* 2008; 29:1035-1041.
3. Munoz-Price *et al. Infect Control Hosp Epidemiol* 2012;33:897-904.
4. Rutala *et al. Infect Control Hosp Epidemiol* 2011;32:743-747.

Improve existing procedures

Method comparison

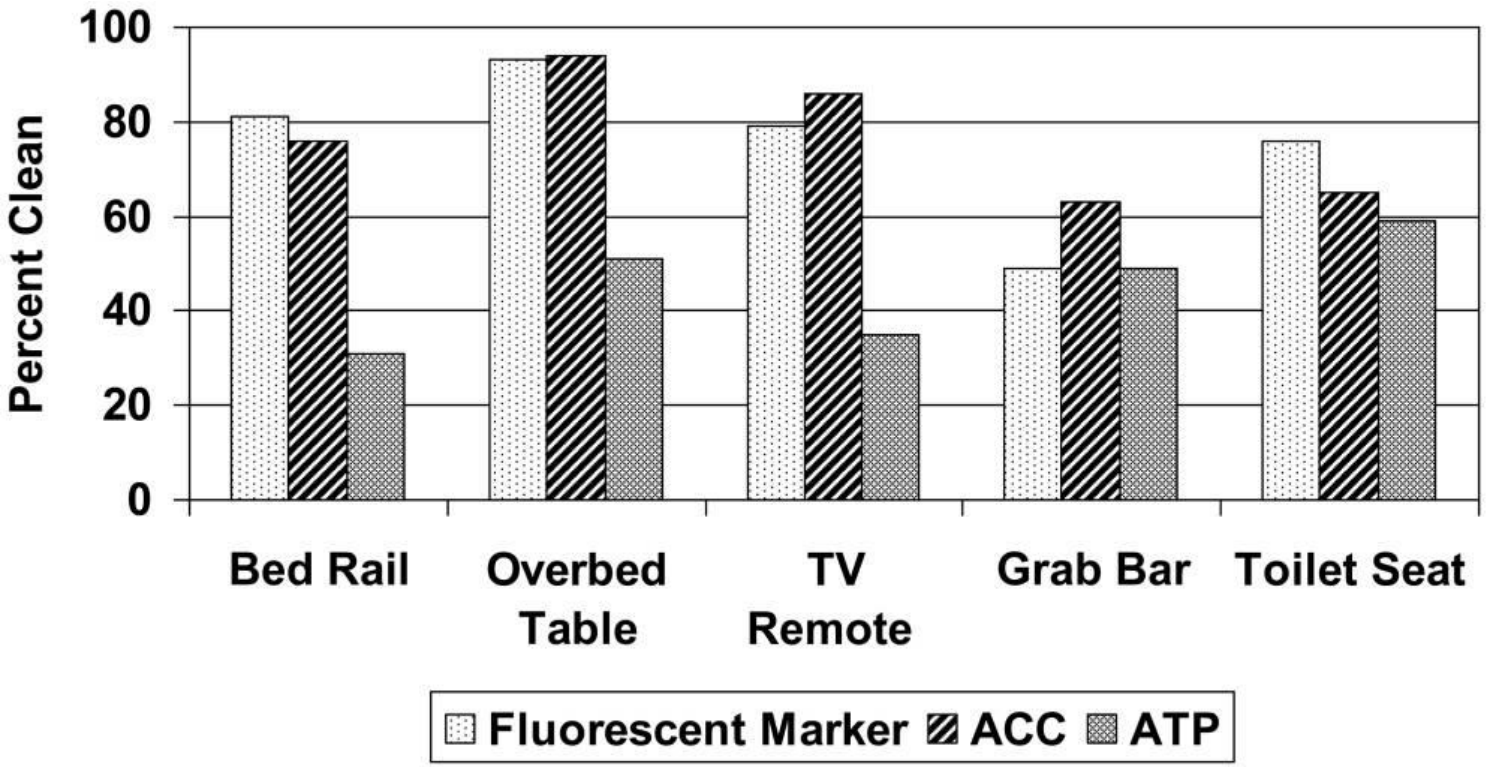
	Visual	Micro	ATP	Fluorescent
Ease of use	High	Low-Moderate	High	High
Quantitative	No	Yes/No	Yes	No
Correlation with microbial contamination	Poor	Accurate	Indirect	Indirect
Identifies pathogens	No	Yes/No	No	No
Risk of "gaming" by staff	Low	Low	Low	Moderate
Identifies 'dirty' surfaces*	Yes	No	Yes	No
Published evidence of attributable clinical impact	No	Yes	No	No

* Non-microbial soiling

Improve existing procedures

Method comparison

- 5 sites in 100 patient rooms assessed before and after terminal clean
- "Clean" defined as <2.5 cfu/cm^2, complete removal of fluorescent marker and ATP score of <250 RLU



Boyce *et al. Infect Control Hosp Epidemiol* 2011;32:1187-1189.

Improve existing procedures

Method comparison

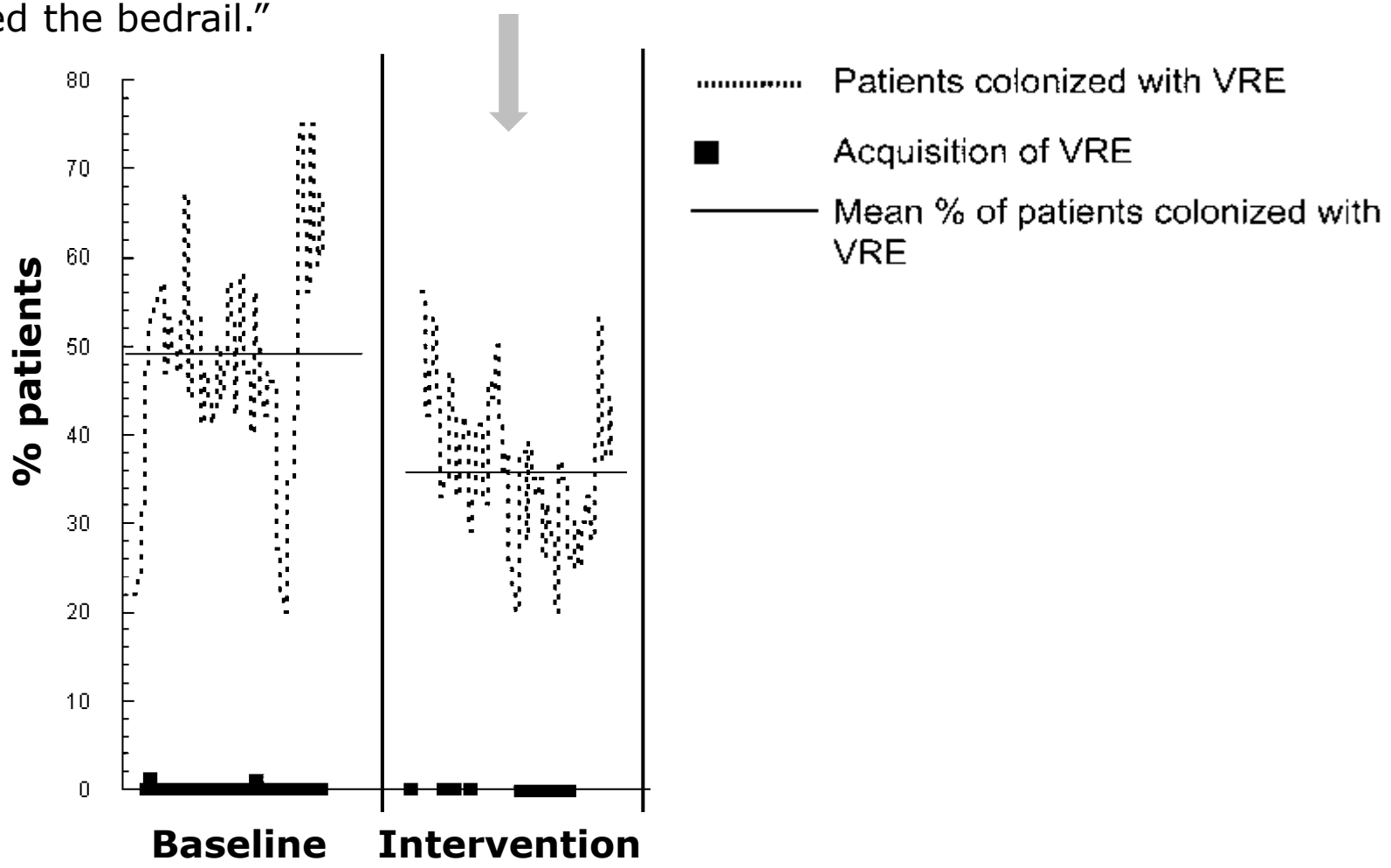
- 5 sites in 50 patient rooms assessed before and after terminal clean
- "Gold standard = <2.5 cfu/cm^2 compared with complete removal of fluorescent marker and ATP score of <250 RLU

	Test	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Overall N = 250	Dazo	68	50	90	19
	ATP	78	38	90	20
	Visual	95	9	9	23
Baseline dirty n = 103	Dazo	75	40	84	28
	ATP	76	35	83	26
	Visual	94	10	81	29

Luick *et al. Am J Infect Control* 2013 in press.

Impact of environmental hygiene intervention on VRE incidence

Research staff monitored cleaners' work overtly, using a checklist. Cleaners were given immediate, specific feedback about their performance, e.g., "You missed the bedrail."



Hayden *et al. Clin Infect Dis* 2006;42:1552-1560.

Improve existing procedures

Try something new!

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Source control

Daily bathing of patients using chlorhexidine reduces the acquisition of MDROs,[1,2] including *C. difficile*.[3]

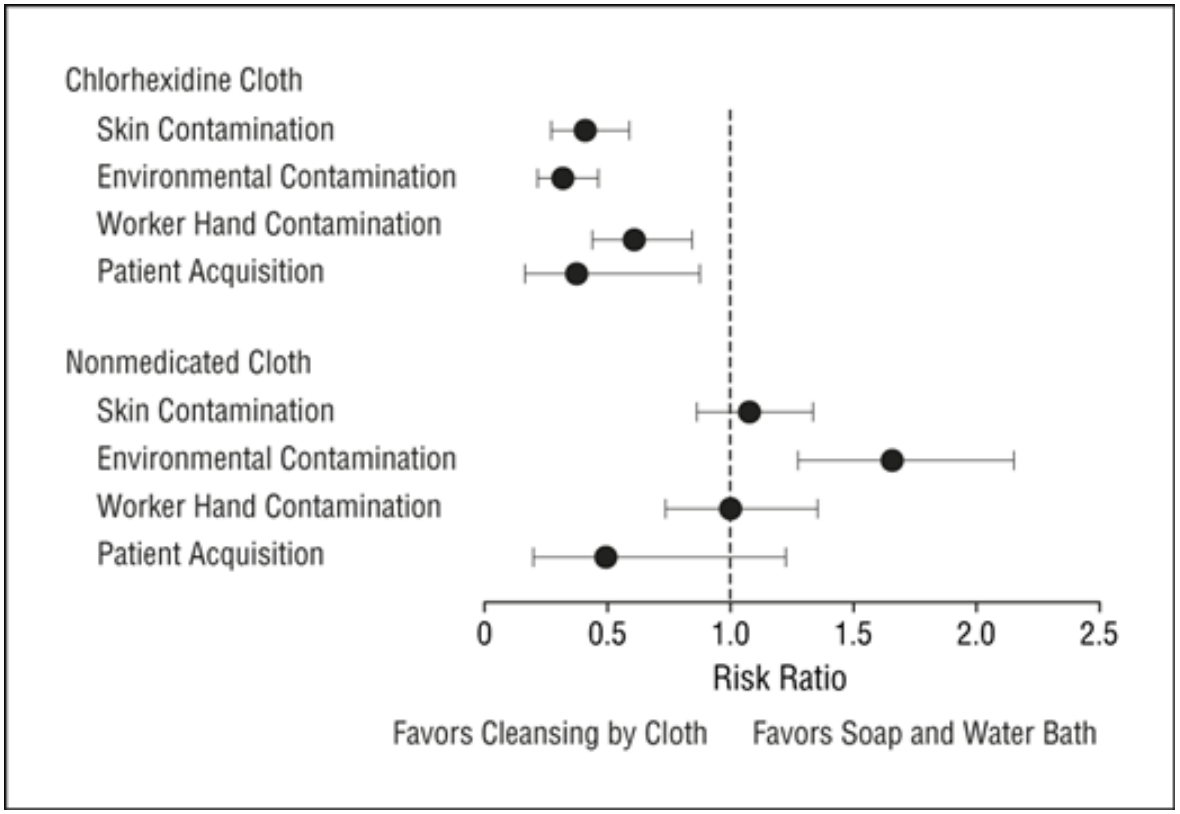
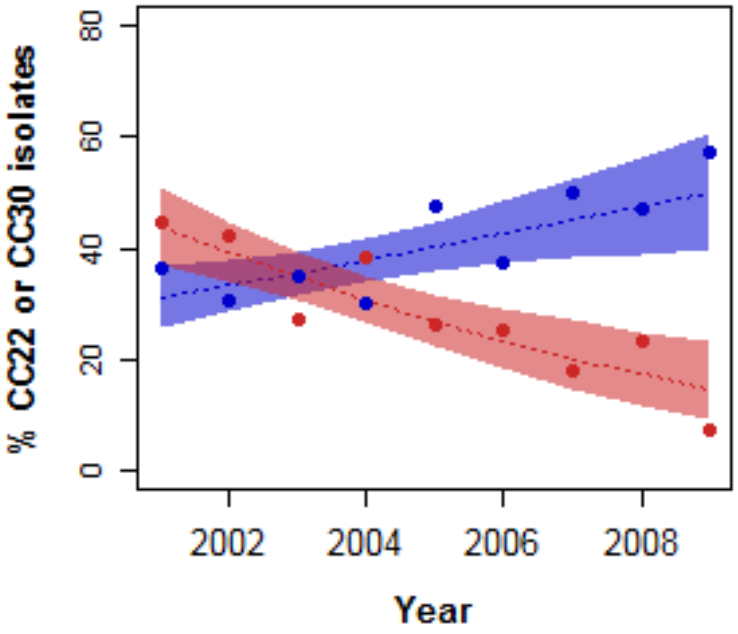


Figure from Vernon *et al.*[2]

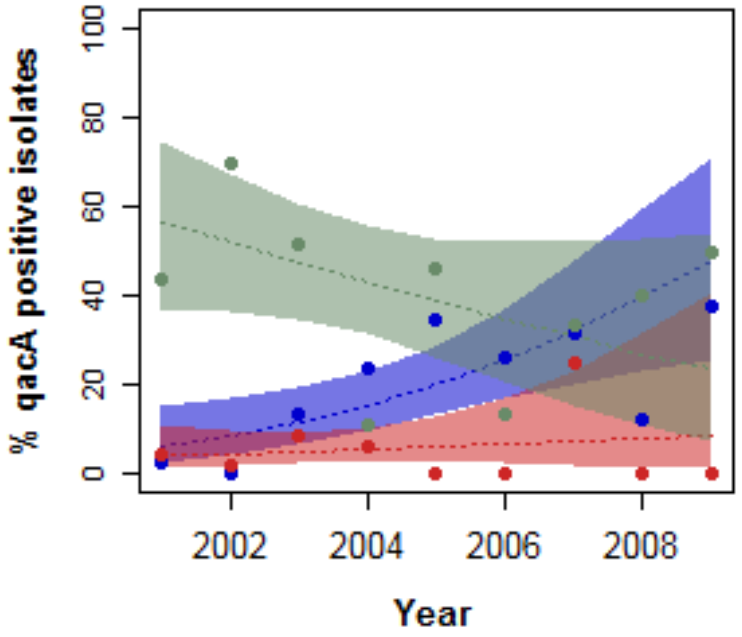
1. Climo *et al. N Engl J Med* 2013;368:533-542.
2. Vernon *et al. Arch Intern Med* 2006;166:306-312.
3. Rupp *et al. Infect Control Hosp Epidemiol* 2012;33:1094-1100.

Try something new!

Source control



Proportion of MRSA bloodstream infections caused by CC22 (blue) and CC30 (red)



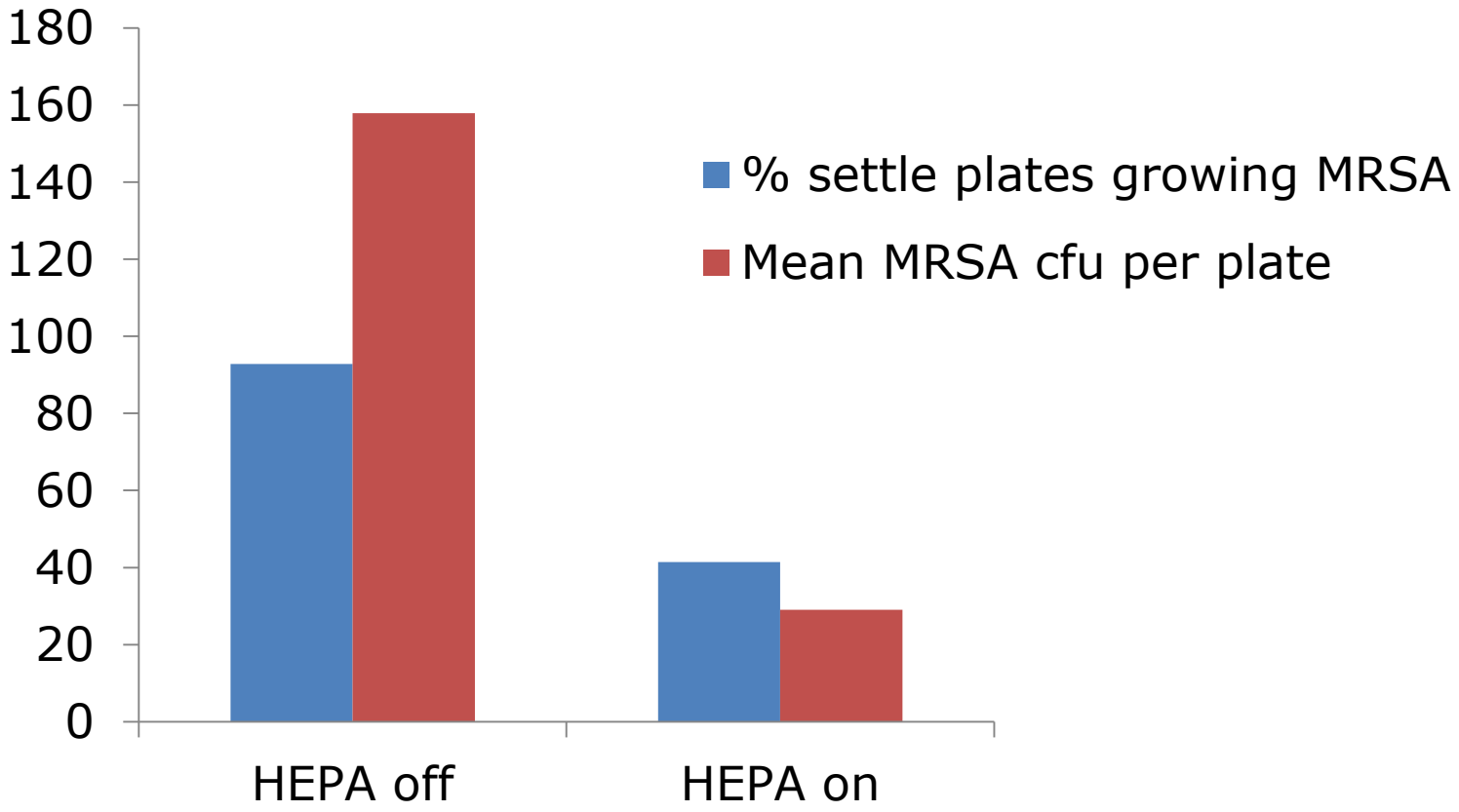
Carriage of *qacA* CC22 (blue), CC30 (red) and other (green) clones

Otter *et al*. *J Antimicrob Chemother* 2013;68:992-999.

Try something new!

Air control

MRSA contamination of settle plates in multiple locations in the rooms of three patients with MRSA



Boswell & Fox. *J Hosp Infect* 2006;63:47-54.

Try something new!

Antimicrobial surfaces

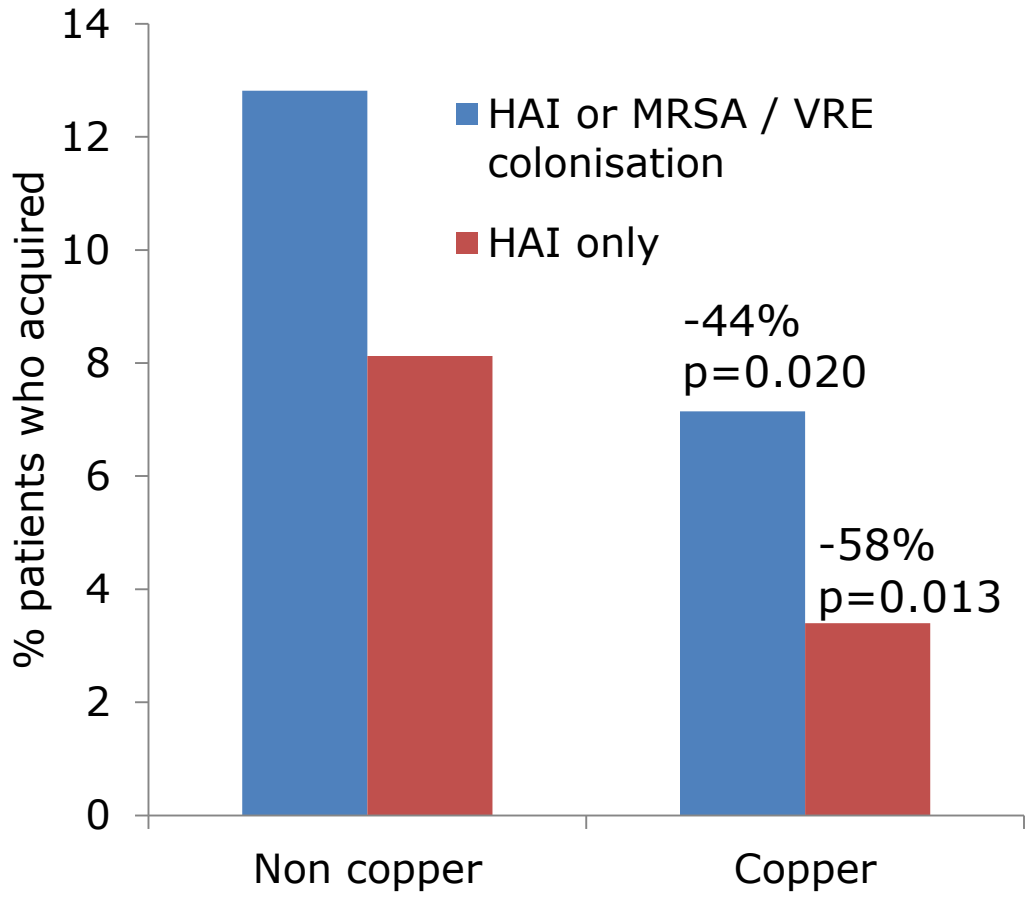
Candidate	Pros	Cons
Metal		
Copper	Rapidly microbicidal Reduces acquisition	? Sporicidal Acceptability / retrofitting
Silver	Rapidly microbicidal	? Sporicidal Tolerance development
Chemical		
Organosilane	Easy to apply	Limited microbicidal activity Durability
Light-activated	Broadly microbicidal	? Sporicidal
Topography		
"Liquid glass"	Reduces deposition Improves 'cleanability'	Not microbicidal
Sharklet pattern	Reduces deposition Reduced biofilms	Not microbicidal

Page *et al. J Mat Chem* 2009

Try something new!

Copper

614 pts in 3 hospitals randomised to 'copper' or 'non-copper' ICU rooms



Bedrails
Overbed tables
IV poles
Visitor chair arms
Nurse call button*
Computer mouse*
Computer palm rest*
Rim of monitor*

(* = some rooms only)

Salgado et al. *Infect Control Hosp Epidemiol* 2013;34:479-486.

Improve existing procedures

Try something new!

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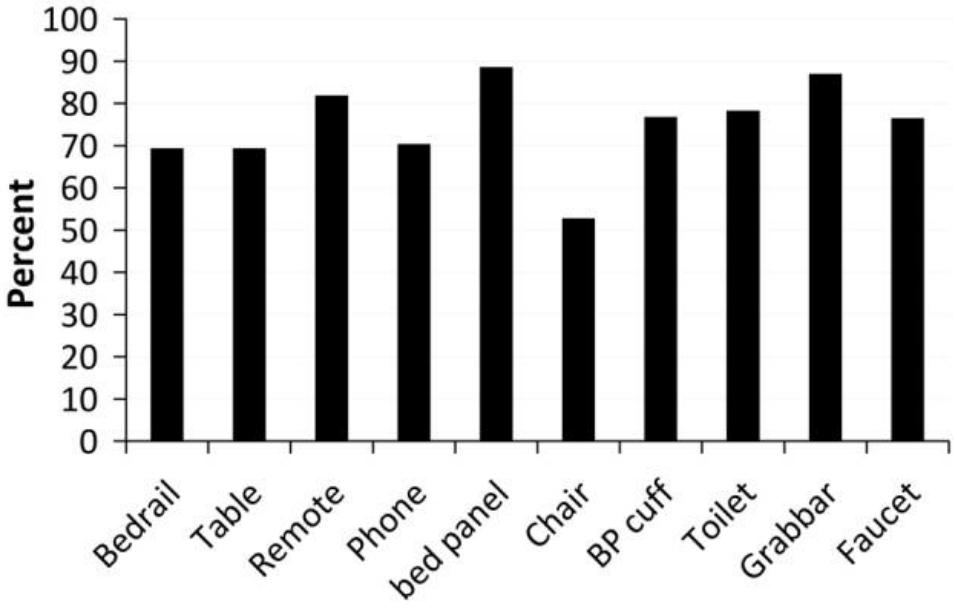
Wipes

- 99% of sites <2.5 cfu/cm^2
- 75% of sites no growth after cleaning (figure)

Evaluated hydrogen peroxide impregnated wipes by sampling 10 sites in 72 rooms before and after cleaning.



Boyce & Havill. *Infect Control Hosp Epidemiol* 2013;34:521-523.

Try something new!

"No touch" disinfection

Hydrogen peroxide vapour (HPV)

Aerosolised hydrogen peroxide (aHP)

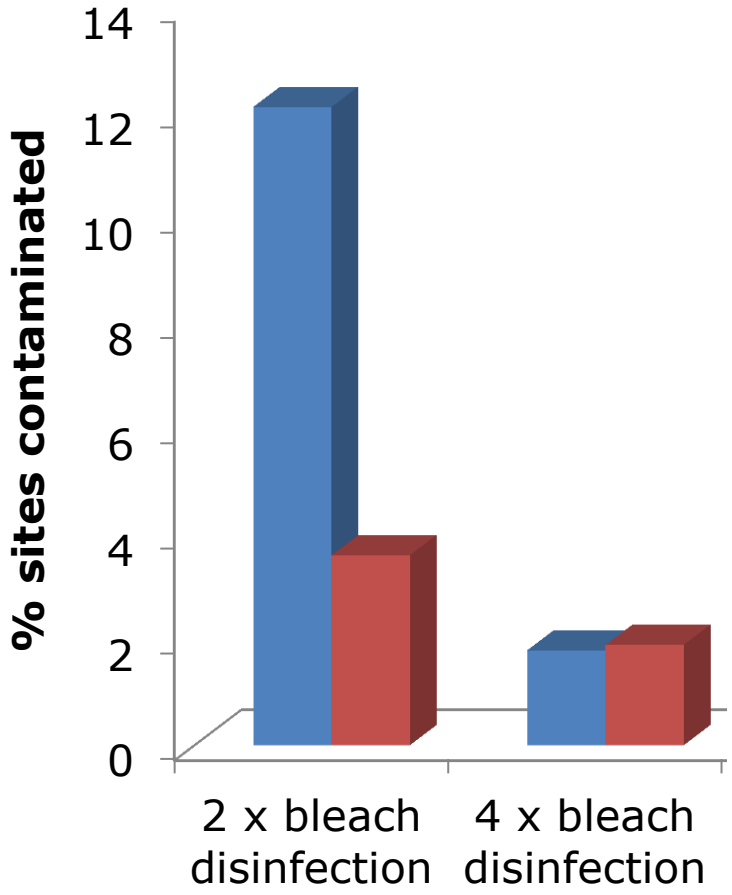
Ultraviolet radiation C (UVC)

Pulsed-xenon UV (PX-UV)

Otter *et al*. *J Hosp Infect* 2013;83:1-13.

Try something new!

Reduce contamination



- *% sites contaminated with A. baumannii*
- *% sites contaminated with MRSA*

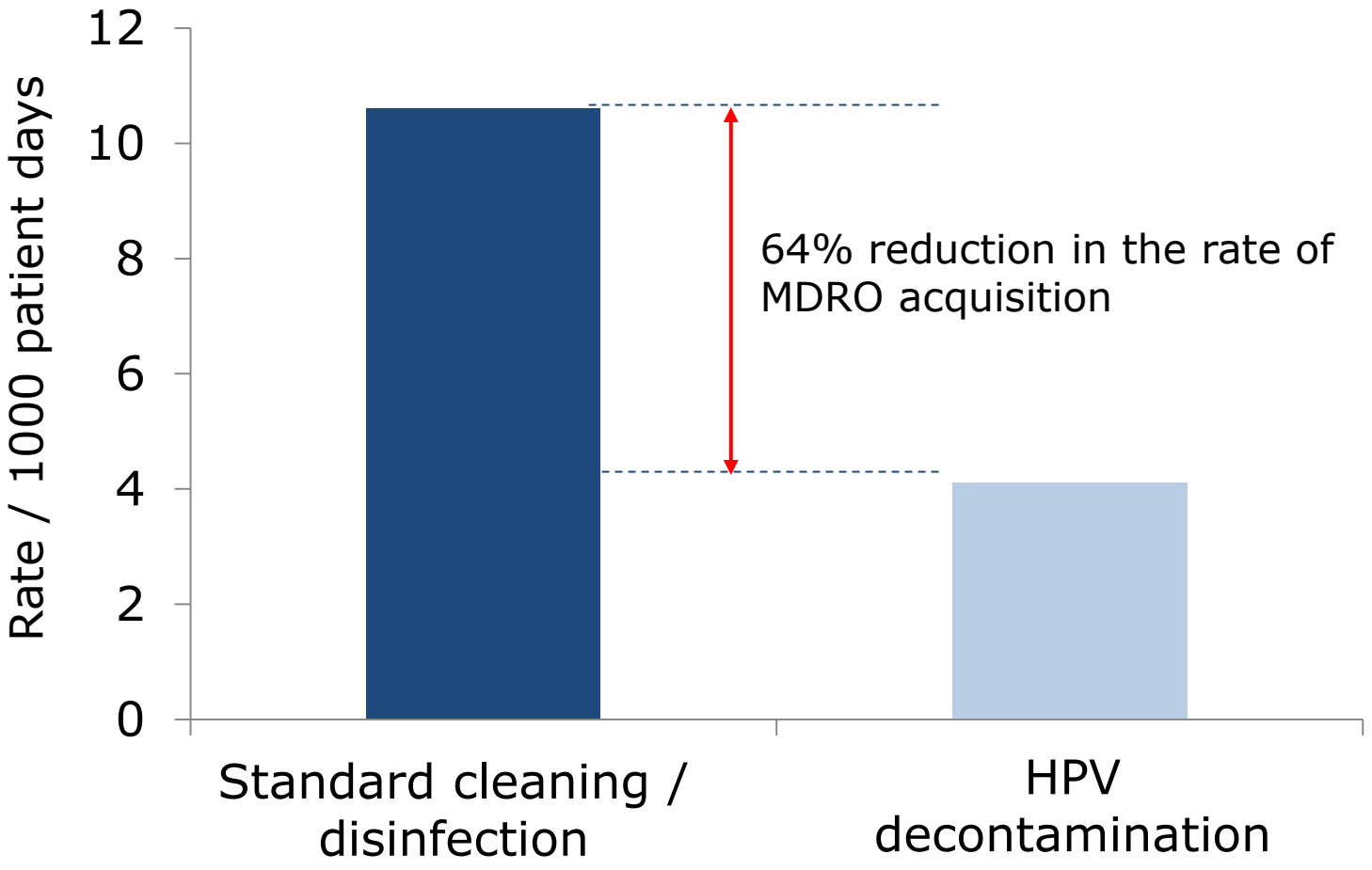
- 140 samples from 9 rooms after 2xbleach
- 5705 samples from 312 rooms after 4xbleach
- 2680 sites from 134 rooms after HPV

Manian *et al. Infect Control Hosp Epidemiol* 2011;32:667-672.

Try something new!

Reduce transmission

Patients admitted to rooms decontaminated using HPV were 64% less likely to acquire any MDRO (incidence rate ratio [IRR]=0.36, CI=0.19-0.70, p<0.001)



Passaretti *et al. Clin Infect Dis* 2013;56:27-35.

Improve existing procedures

Try something new!

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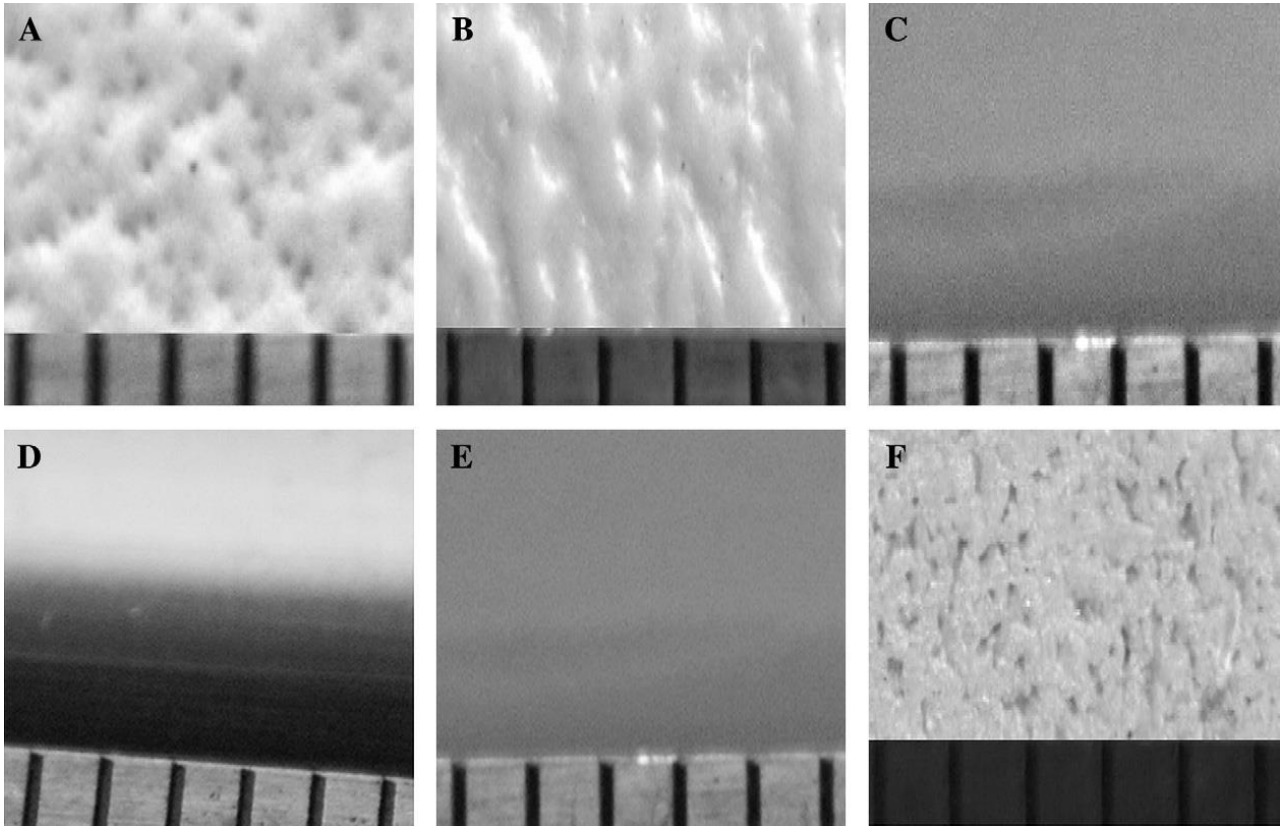
Design

The surface finish of 6 hospital bedrails; ease of cleaning was inversely proportional to the transfer of *S. aureus* from the surfaces



Ali *et al. J Hosp Infect* 2012;80:192-198.

Try something new!

"Design bugs out!"

Design Bugs Out – Product Evaluation Report. The Healthcare Associated Infection Technology Innovation Programme. UK Department of Health. 2011.

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2. Become familiar with the various methods to improve the efficacy of hospital disinfection:
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