The role of dry surface contamination in healthcare infection transmission

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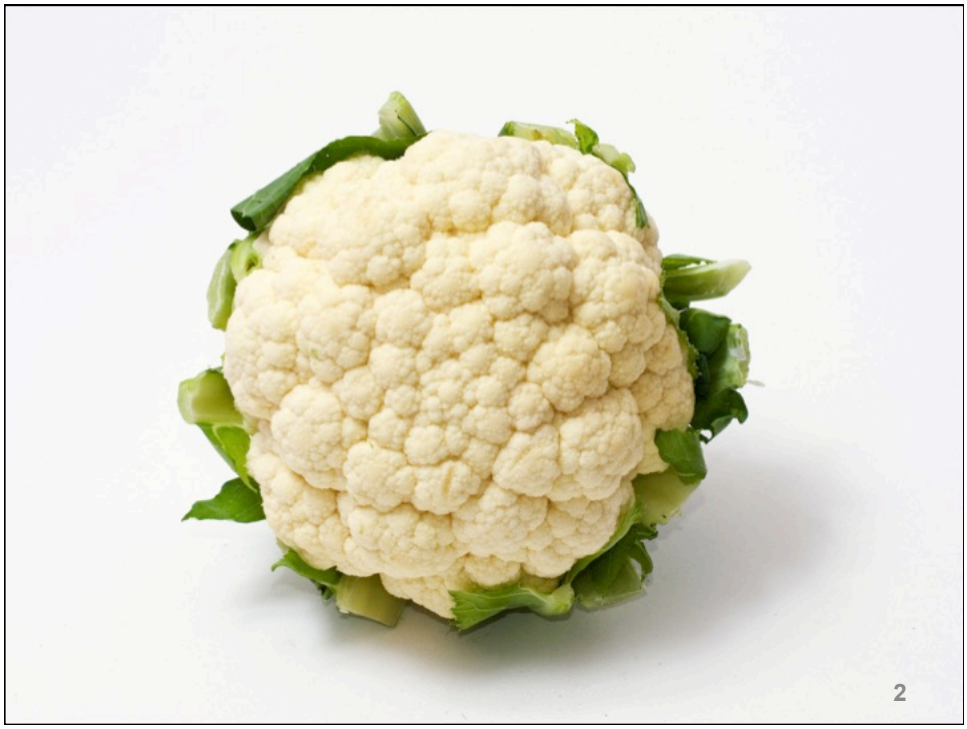
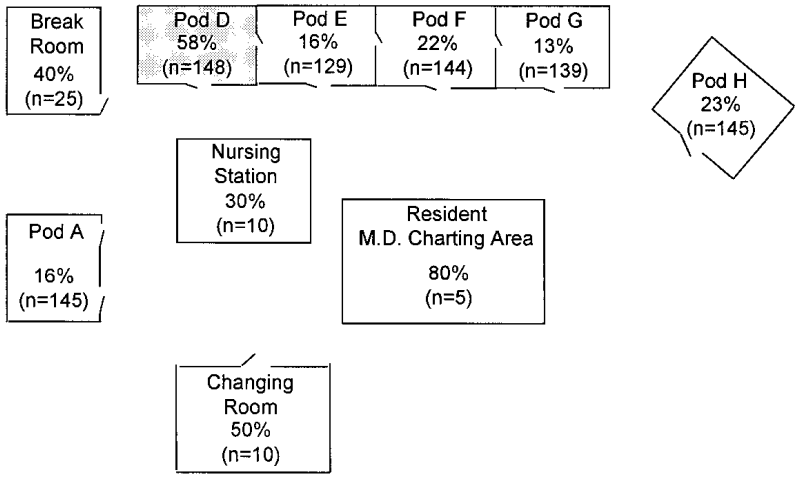
www.webbertraining.com February 28, 2017



Transfer of a surrogate marker in a NICU



Oelberg *et al*. *Pediatrics* 2000;105:311-315.

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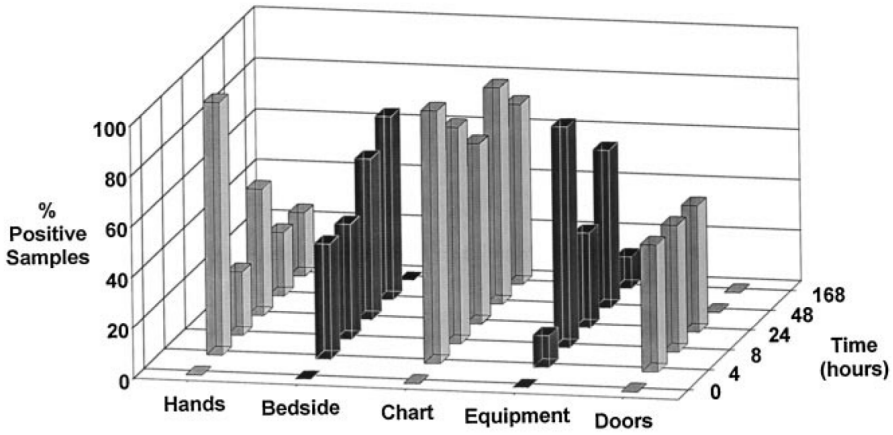
Transfer over time: inoculated pod



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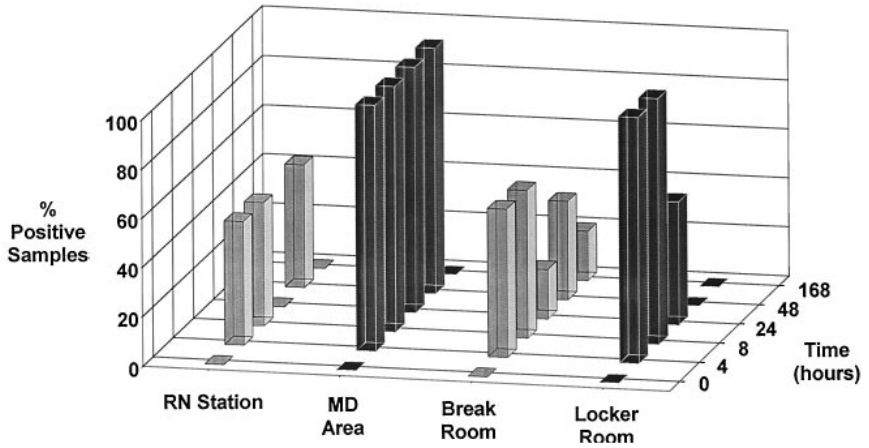
Transfer of a surrogate marker in a NICU



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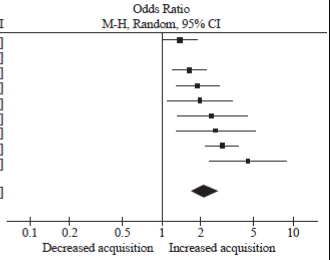
Your hospital room can make you sick!

Study or Subgroup	Decreased acquisition Events	Total	Control Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Huang (MRSA)	57	1454	248	8697	16.2%	1.39 [1.04, 1.86]
Nseir (ESBL producing Gram neg)	8	50	50	461	0.0%	1.57 [0.70, 3.52]
Huang (VRE)	58	1291	256	9058	16.2%	1.62 [1.21, 2.16]
Ajao (Klebsiella sp. or Escherichia coli)	32	648	235	8723	14.2%	1.88 [1.29, 2.74]
Nseir (Pseudomonas)	21	85	61	426	10.4%	1.96 [1.12, 3.45]
Drees (VRE)	19	138	31	500	9.7%	2.42 [1.32, 4.43]
Shaughnessy (Clostridium difficile)	10	91	77	1679	8.3%	2.57 [1.28, 5.15]
Mitchell (MRSA)	74	884	163	5344	16.4%	2.90 [2.18, 3.86]
Nseir (Acinetobacter)	16	52	41	459	8.6%	4.53 [2.32, 8.86]
Total (95% CI)		4643		34886	100.0%	2.14 [1.65, 2.77]
Total events	287		1112			

Heterogeneity: $Tau^2 = 0.09$; $Chi^2 = 21.32$, df = 7 (P = 0.003); $I^2 = 67\%$
Test for overall effect: Z = 5.74 (P < 0.00001)



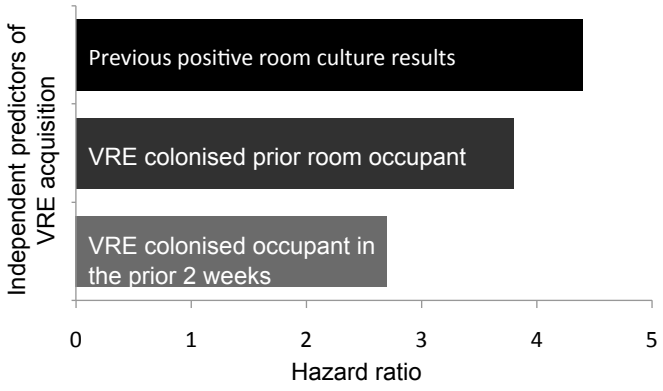
Mitchell et al. *J Hosp Infect* 2015;91:211-217.

6

An environmental 'dose-response'?

Setting & design: 14-month prospective study on 2 ICUs, Boston, USA.

Methods: All patients were screened on admission and twice weekly, and the environment was screened weekly for VRE. The 50 patients who acquired VRE were compared with the 588 who did not.



Drees *et al. Clin Infect Dis* 2008;46:678-685.

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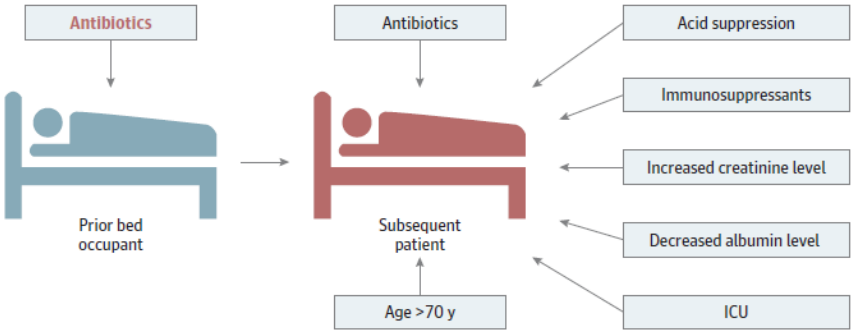
Chased by an antibiotic-induced *C.difficile*-shaped shadow!

Significant risk factors for CDI.



Freedberg *et al. JAMA Intern Med* 2016 in press.

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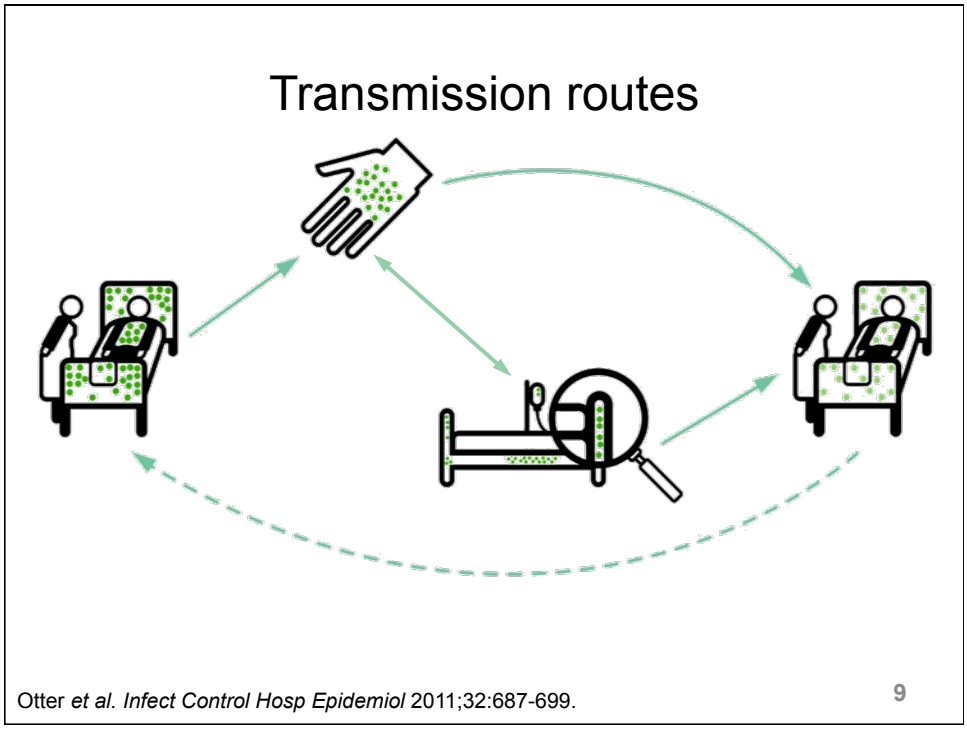
Transmission routes
Otter *et al. Infect Control Hosp Epidemiol* 2011;32:687-699.
9


86%
58%
93%
85%
59%
96%
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.

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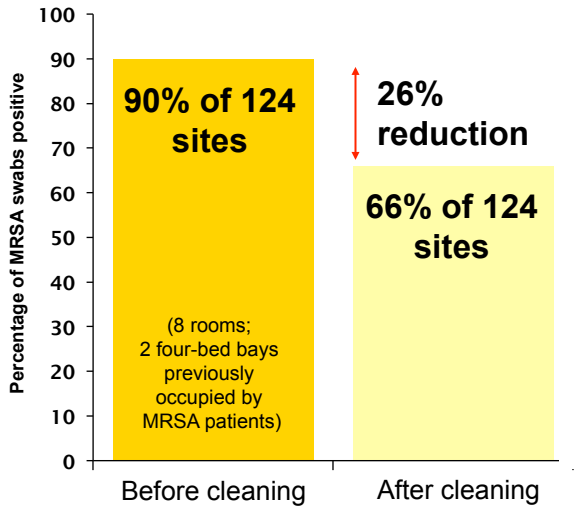
Terminal cleaning



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

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Surface -> Hand -> Patient

Pathogens can be transferred from 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.

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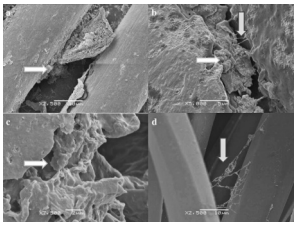
Rethinking the 'inanimate' environment



- Scanning electron microscopy identified biofilm on 5/6 dry hospital surfaces from an Australian ICU (including MRSA on 3/5).[1]
- Followup study identified biofilm on 41/44 (93%) of surfaces in an ICU; MRSA from 18%, ESBL from 11% and VRE from 8% of the samples.[2]

Could explain why vegetative bacteria can survive on dry hospital surfaces for so long

Be part of the reason why they are so difficult to remove or inactivate using disinfectants

Explain (to some degree) the difficulty in recovering environmental pathogens by surface sampling

1. Vickery *et al. J Hosp Infect* 2012;80:52-55.
2. Hu *et al. J Hosp Infect* 2015;91:35-44.

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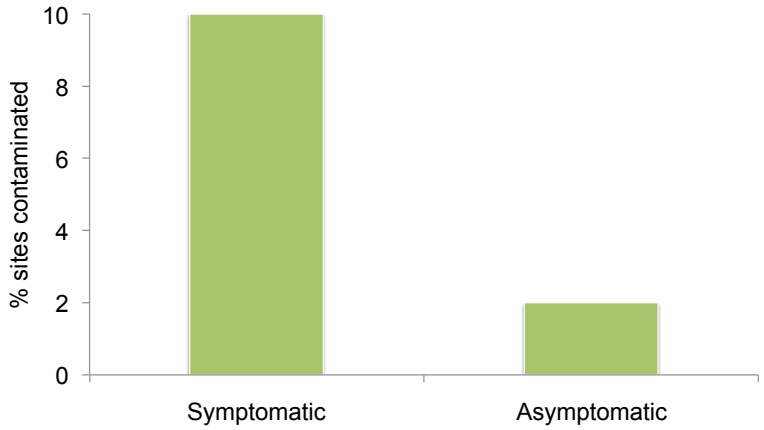
"It's airborne"

Detection of *C. difficile* in the air samples from the rooms of 50 patients.



Best *et al*. *Clin Infect Dis* 2010; 50: 1450-7.

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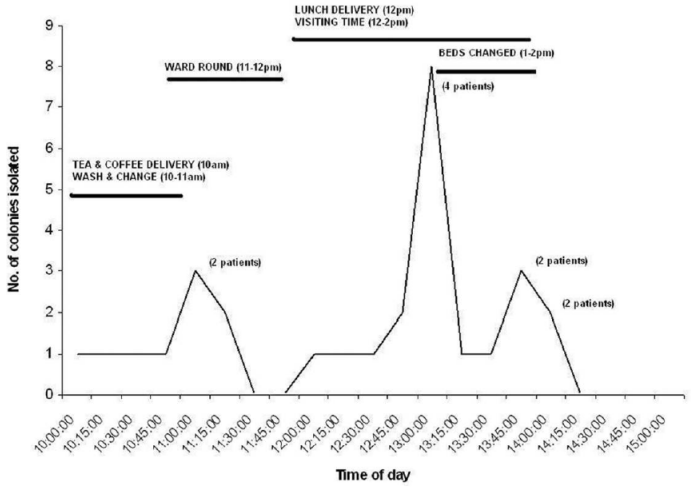
"It's airborne"

Results of intensive air sampling surrounding 10 patients. *C. difficile* was detected in the air in 7/10 patients.



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Improve existing procedures

Try something new!









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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

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Improve existing procedures

Try something new!








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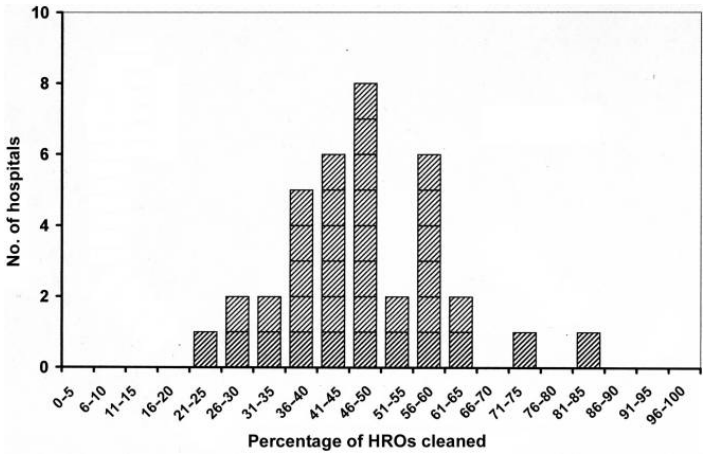
Improve existing procedures

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.

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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

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Improve existing procedures

Try something new!

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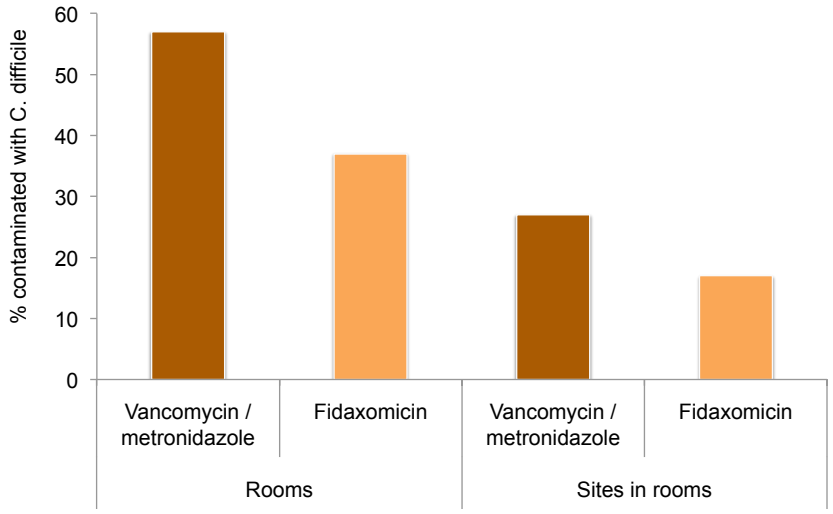
Contamination-sparing therapy?

n = 66 patients (rooms) and 264 surfaces for vancomycin / metronidazole, and 68 patients (rooms) and 272 surfaces for fidaxomycin. p<0.05 for both rooms and surfaces.



Biswas *et al. J Hosp Infect* 2015;90:267-270

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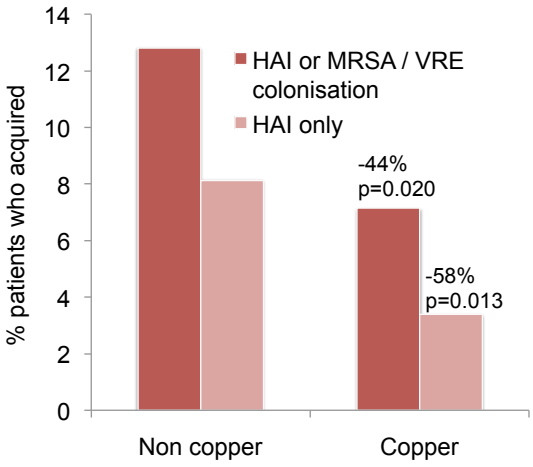
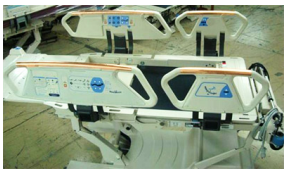
Antimicrobial surfaces (e.g. copper)

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.

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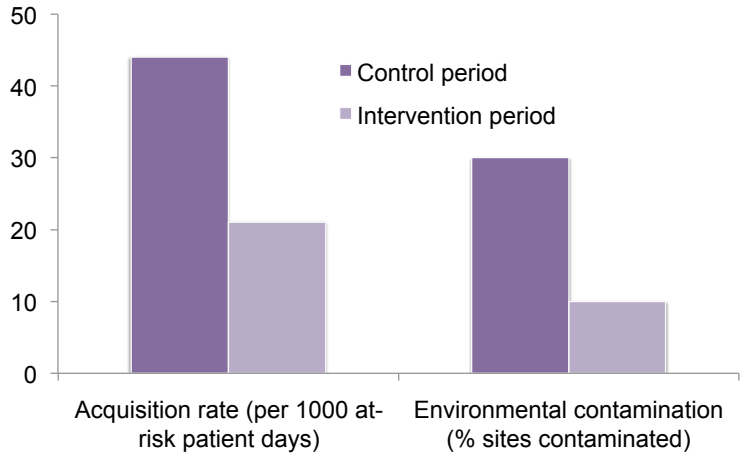
Candidate	Application	Pros	Cons
Metals			
Copper	Manufactured in / liquid disinfectant	Rapidly microbicidal; large evidence-base; evidence of reduced acquisition.	Sporicidal activity equivocal; cost, acceptability and durability may be questionable.
Silver	Manufactured in / liquid disinfectant	Broadly microbicidal.	? sporicidal; tolerance development; relies on leaching so surface loses efficacy over time.
Chemicals			
Organosilane	Liquid disinfectant	Easy to apply.	Limited microbicidal activity; questionable "real-world" efficacy.
Light-activated (e.g. titanium dioxide or photosensitisers)	Manufactured in / liquid disinfectant	Broadly microbicidal; can be activated by natural light.	? sporicidal; requires light source for photoactivation (some require UV light); may lose activity over time.
Physical alteration of surface properties			
"Liquid glass" (silicon dioxide)	Liquid application	Reduces deposition; improves 'cleanability'.	Not microbicidal; some evidence of reduced contamination; unknown required frequency of application.
Sharklet pattern	Manufactured-in	Reduces deposition; reduced. biofilms.	Not microbicidal; not feasible to retrofit.
Advanced polymer coatings (e.g. PEG)	Manufactured-in	Reduces deposition; some can be 'doped' with copper or silver.	Not microbicidal; may be expensive; scale up to large surfaces questionable; not feasible to retrofit.
Diamond-like carbon (DLC) films	Manufactured-in	Reduces deposition; can be 'doped' with copper or silver.	Not microbicidal; likely to be expensive; feasibility of scale up to large surfaces questionable; not feasible to retrofit.

Control contamination at the source

Pre-post study in a 16-bed ICU in Korea; CHG daily bathing implemented for 12 months after 14-month pre-intervention period. Significant reduction in rate of carbapenem-resistant *Acinetobacter baumannii* acquisition and environmental contamination.



Chung *et al. Am J Infect Control* 2015;43:1171-1177.

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Improve existing procedures

Try something new!

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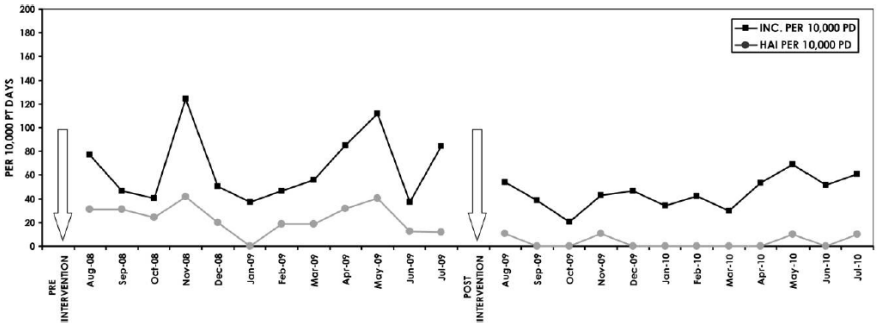
Wiping away infection

Impact of changing from QAC to bleach wipes for daily disinfection of all rooms. Cleaning thoroughness was 97-98% throughout the study using ATP benchmarking (<250 RLUs).



2.4
cases / 1000 patient days

0.4
cases / 1000 patient days

Orenstein *et al*. *Infect Control Hosp Epidemiol* 2011;34:521-523.

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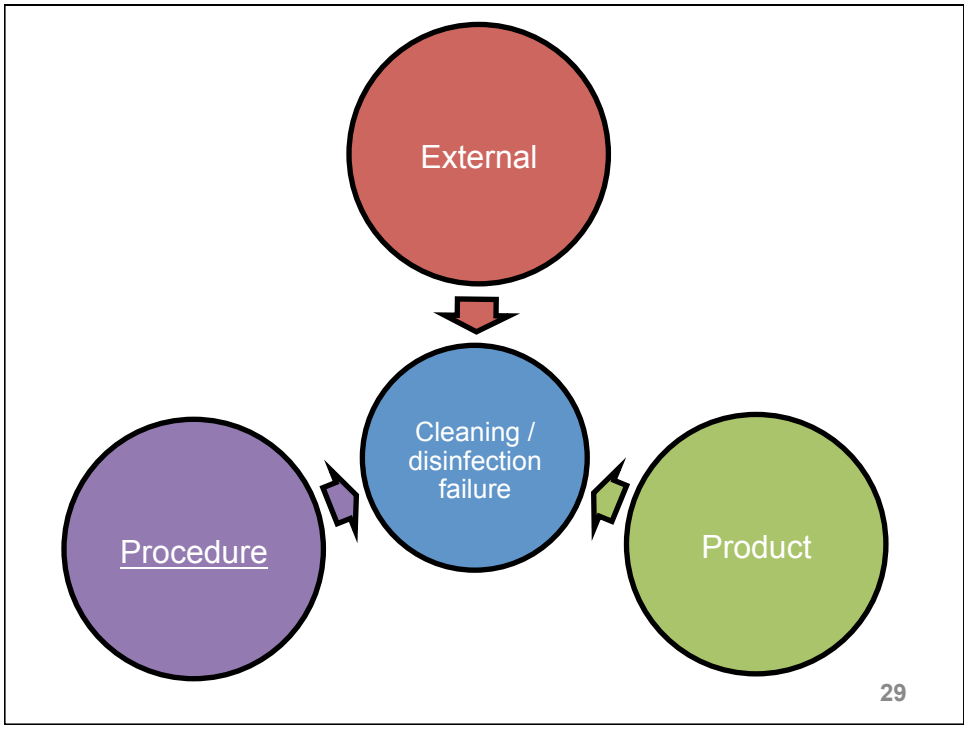

'Given the choice of improving technology or improving human behavior, technology is the better choice'.

Dr Bob Weinstein

Weinstein RA. *Emerg Infect Dis* 1998;4:416-420.

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Automated room decontamination (ARD)

Hydrogen peroxide vapour 30% H_2O_2 (HPV)

Aerosolised hydrogen peroxide 5-6% H_2O_2 (AHP)

Ultraviolet radiation (UVC)

Pulsed-xenon UV (PX-UV)

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

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ARD systems - overview

	HPV 30-35% H_2O_2 vapour	AHP 5-6% H_2O_2 + Ag aerosol	UVC UVC (280 nm)	PX-UV Pulsed-xenon UV
Efficacy	1 >6-log reduction	2 ~4-log reduction	3 ~2-4 log reduction	4 ~1-3 log reduction
Distribution	1 Homogeneous	2 Non-homogenous	3 Line of sight issues	3 Line of sight issues
Ease of use	4 Multiple units; sealing / monitoring	3 Sealing & monitoring	2 Multiple positions; no sealing / monitoring	2 Multiple positions; no sealing / monitoring
Cycle time	3 ~1.5 hrs single room	4 >2 hrs single room	1 ~10-30 mins	1 ~10-30 mins
Purchase cost	2	1	3	3
Running cost	4	3	1	1

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

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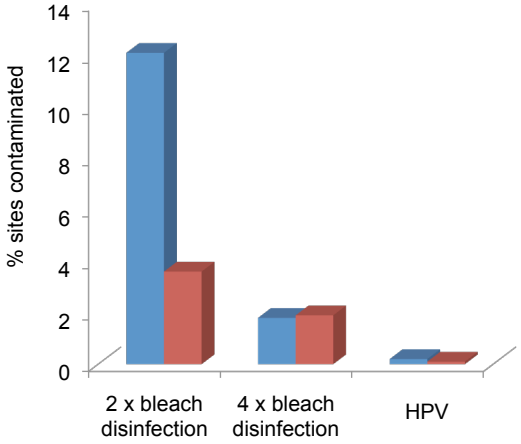
Persistent contamination – sorted!



- 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.

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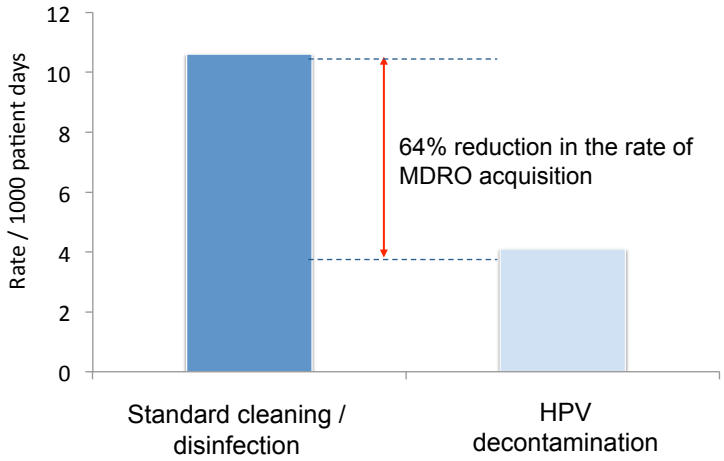
HPV: clinical impact

30-month prospective cohort intervention study performed on 6 high-risk units (5 ICUs) including 8813 patients at Johns Hopkins Hospital.



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

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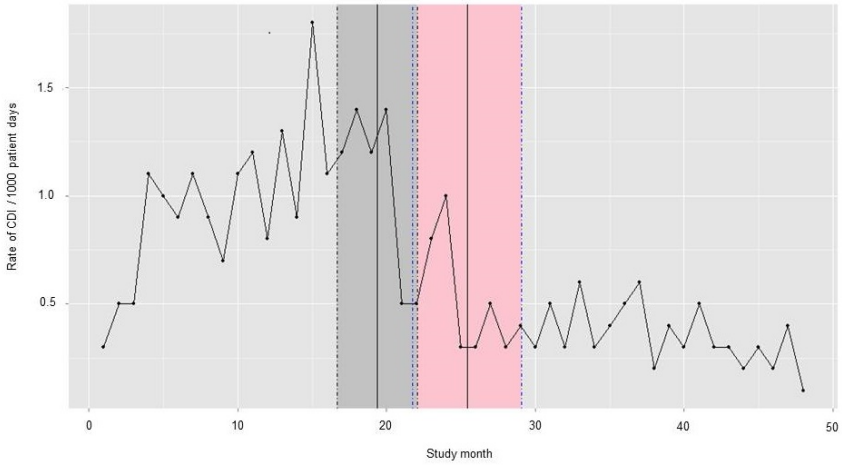
HPV: clinical impact

2 years before HPV, 2 years during HPV. Breakpoint model indicated significant reduction in rate of CDI when HPV implemented (1.0 to 0.4 per 1000 patient days, 60% reduction).



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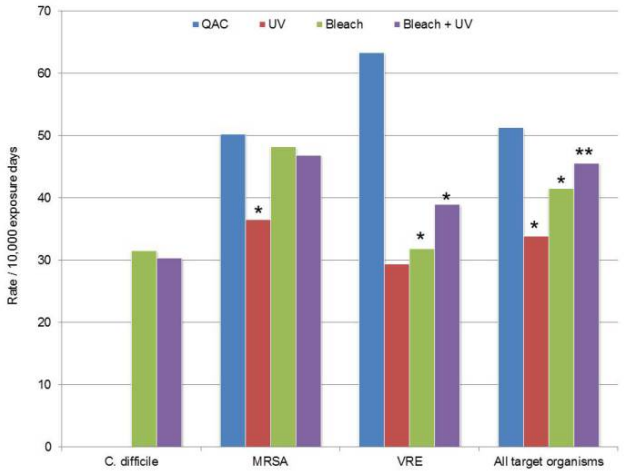
McCord *et al. J Hosp Infect* 2016.

UVC: clinical impact

Cluster randomised study over >2 years across 9 hospitals including >25,000 exposed patients (admitted into a room where the previous occupant was known to have an MDRO). * = statistically significant reduction in the per-protocol analysis. ** = statistically significant when rooms occupied by patients with *C. difficile* removed from the analysis.



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Anderson *et al. Lancet* in press.

UVC vs. HPV

Characteristics	HPV	UV systems
Cycle time (for single room)	90 mins	15 mins to >1hr
Practicalities	Door and air vent sealing and leak detection required	No door and air vent sealing or leak detection required
Distribution	Homogeneous	Affected by line of sight
Microbiological efficacy	Elimination of pathogens from surfaces; 6-log sporicidal reduction	Does not eliminate pathogens from surfaces; 1-3 log sporicidal reduction
Evidence of clinical impact	Published evidence	Emerging evidence
Cost	Lower purchase cost; higher running costs	Higher purchase cost; lower running costs

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

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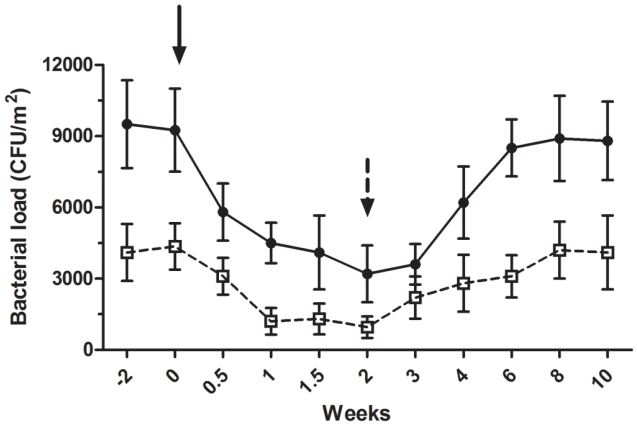
Spread contamination to stop contamination?

Bacterial load of coliforms (black circles) and *S. aureus* (white circles). Black arrow = beginning of the "live" cleaning agent; black dotted arrow = conventional cleaning agent.



Vandini *et al*. PLoS One 2014;26;9(9):e108598.
More here if you're interested.

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Improve existing procedures

Try something new!

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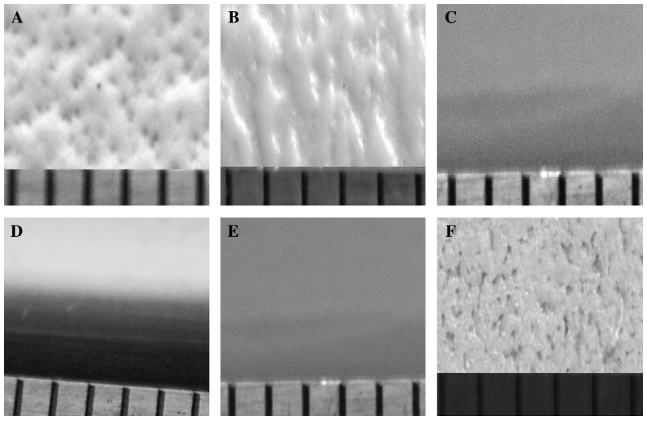
Try something new! Microbe unfriendly design

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.

40

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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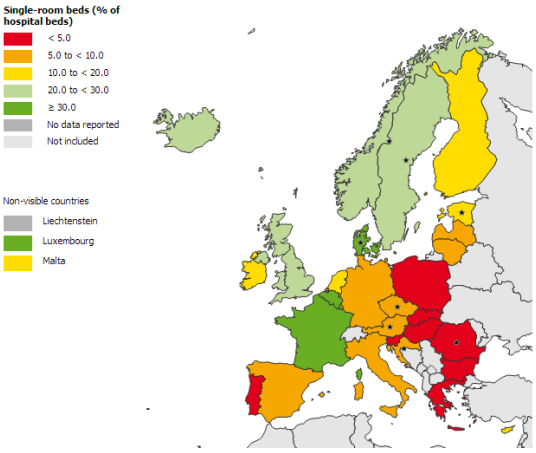
Try something new!

Single room shortage



ECDC Point Prevalence Survey of healthcare-associated infections and antimicrobial use in acute care hospitals (HAI-Net PPS) in the period 2011-2012 as reported to TESSy as of 2013-02-06 14:06:48

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Try something new!

Single rooms vs. bays

Single Rooms	Bays
Reduced HCAI[1-6] ▪ Better hand hygiene compliance ▪ Improved air containment	Reduced risk of adverse events[11-12] ▪ Fall risk, tracheostomy, confused ▪ Better observation by staff
Some patients more satisfied[5-9] ▪ Improved privacy ▪ Less disturbance from others	Patients report:[11-14] ▪ Reduced feelings of isolation ▪ More social and HCW contact
Fewer "mix up" errors[10-11] through uninterrupted patient contact	Reduced staffing levels and patient: HCW ratios[14,15]

1. Teltsch *et al. Arch Intern Med* 2011; 171: 32-38.
2. van de Glind *et al. Health Policy* 2007;84:153-161.
3. Borg MA. *J Hosp Infect* 2003;54:316–318.
4. Haill *et al. J Hosp Infect* 2012;82:30-35.
5. King *et al. Building and Environment* 2013;59:436-447.
6. Moore *et al. J Hosp Infect* 2010;76:103-107.
7. Jolley S. *Nursing Standard* 2005;20:41–48.
8. Barlas *et al. Ann Emerg Med* 2001;38:135–139.
9. Lawson & Phiri. *Health Serv J* 2000;110:24–26.
10. Ulrich *et al.* White Paper #5. The Center for Health Design. 2008.
11. Maben J. *Nurs Manag* 2009;16:18-19.
12. Stelfox *et al. JAMA* 2003;290:1899–1905.
13. Tarzi *et al. J Hosp Infect* 2001;49:250-254.
14. Young & Yarandipour. *Health Estate* 2007;61:85-86.
15. Mooney H. *Nursing Times* 2008;104:14-16.

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Try something new!

'Privatization' of an ICU

Intervention

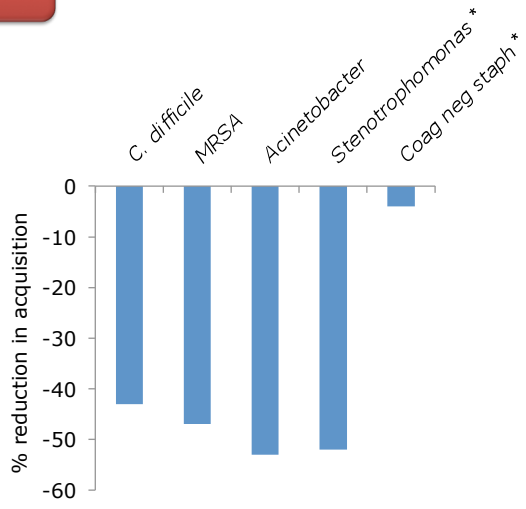
24 bed ICU
2x10 bed and 4xsingle rooms

Converted to 100% single rooms in 2002

Comparison

25 bed ICU
2, 5, 6 or 8 bed rooms

No change in unit configuration



Change in the acquisition rate ratio before and after privatisation; * = not statistically significant.

Teltsch *et al. Arch Intern Med* 2011;171:32-38.

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The role of dry surface contamination in healthcare infection transmission

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Imperial College London

The Role of Dry Surface Contamination in Healthcare Infection Transmission
Dr. Jon Otter, Imperial College London
A Webber Training Teleclass

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