How Should We Clean 21st Century Hospitals?
Dr. Stephanie Dancer, NHS Scotland
Teleclass Sponsored by Diversey Inc. www.diversey.com

Properties of hospital pathogens

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Survival time</th>
<th>Infectious dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>7 days to 7 months</td>
<td>4 cfu’s</td>
</tr>
<tr>
<td>Acinetobacter</td>
<td>3 days to 5 months</td>
<td>250 cfu’s</td>
</tr>
<tr>
<td>C.difficile</td>
<td>5 months</td>
<td>7 spores</td>
</tr>
<tr>
<td>VRE</td>
<td>5 days to 4 months</td>
<td>&lt;10^3 cfu’s</td>
</tr>
<tr>
<td>Norovirus</td>
<td>8 hours to 7 days</td>
<td>10-100 virions</td>
</tr>
</tbody>
</table>


Where are the pathogens in a hospital?

Frequently touched surfaces!

Do HCWs acquire pathogens from surfaces or patients?

Every surface you touch...

Fingertips from 500 HCWs were MRSA positive:

- 6% after clinical contact
- 7% after contact with the environment
- 4% after no specific contact

MRSA was recovered after using:
- alcohol rub (3%)
- chlorhexidine (6%)
- soap & water (3%)
and on 5% occasions with NO hand hygiene!

HCWs touch environmental sites all the time

Hand contamination with MRSA was similar after contact with patients’ skin and frequently touched environmental surfaces in patient rooms

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What’s on YOUR hands??!

Even if you always keep your hands clean, any benefits from hand hygiene are eroded if there is MRSA or C.difficile on the very next surface you touch.

Bobulesky G et al, CID 2007; Ferr et al, LID 2001

A Room with a View

40x30 min covert observation periods following entries into one isolation room

Sequential hand-touch recording strategy

<table>
<thead>
<tr>
<th>Near Touch Sites</th>
<th>Clinical Equipment</th>
<th>Far Touch Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Member</td>
<td>Alcohol Gel Before Entry</td>
<td>Patient Contact</td>
</tr>
<tr>
<td>Junior Doctor</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Senior Doctor</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Staff Nurse</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Auxiliary Nurse</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Cleaner</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Caterer</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Pharmacist</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Relative</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

Audit of sequential hand-touch...

Who touches what?

Overall compliance with hand hygiene among 154 staff before and after entry was 25%
Over half (58%) of 77 clinical staff touched the patient;
Most frequently handled items inside room: IV drip & BP stand
Outside the room: computer, notes trolley and telephone

Since hand hygiene compliance is so low, could we target high risk sites for cleaning?
……who cleans these?

Smith et al, ECCMID 2011

Dynamic transmission cycle of hospital pathogens

Patients (infected and/or colonised)


Hands (whose?)

Environment including air

Which comes first? Patient or environment?

Fig 1. Temporal relationships between indistinguishable environmental and patient strains of MRSA, S.aureus and CNS from SICU

White et al, AmJIC 2008

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Could patients' hands constitute a missing link?

Cleaning patients' hands reduces MRSA infection rates
Gagne et al, J Hosp Infect 2010

Role of the air?

Just hanging around.... airborne spores

<table>
<thead>
<tr>
<th>Spore length</th>
<th>Terminal velocity (mm/s)</th>
<th>Fallout time (hours) from a height of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 m        2 m        3 m        4 m</td>
</tr>
<tr>
<td>0.79 mm*</td>
<td>0.02</td>
<td>13.9       27.8       37.4      55.6</td>
</tr>
<tr>
<td>1.04 mm*</td>
<td>0.035</td>
<td>7.9        15.9       19.8      31.7</td>
</tr>
<tr>
<td>1.14 mm*</td>
<td>0.04</td>
<td>6.9        13.9       17.4      27.8</td>
</tr>
<tr>
<td>1.42 mm*</td>
<td>0.066</td>
<td>4.2        8.4        10.5      16.8</td>
</tr>
<tr>
<td>1.99 mm*</td>
<td>0.13</td>
<td>2.1        4.3        6.4       8.5</td>
</tr>
</tbody>
</table>

* Shortest overall spore length
* Average spore lengths for 3 tested strains
* Longest overall spore length
Snelling et al, ICHE 2010

Are shiny floors enough?

How well is environmental cleaning being done?

How well are hand-touch sites cleaned?
Fluorescent gel placed on sites in side-rooms
After patient discharge, a site is considered cleaned if the fluorescent material is removed or disrupted

‘Although 40% sites were cleaned properly, they tended to be the more traditional sites (toilets and sinks) whereas sites such as telephones, doorknobs and other hand-touch surfaces were scarcely cleaned at all’

Carling et al, Am J Infect Control, 2006

How clean are hospital surfaces?

82-91%  Visually clean
10-24%  ATP clean
30-45%  Microbiologically clean

What is clean?
“what an individual thinks it is”

We should not define cleanliness without indicating how we would assess it

Griffith CJ et al, J Hosp Infect 2000

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Surface evaluation using ATP bioluminescence

Swab surface → Luciferase tagging of ATP → Hand held luminometer

Used in the commercial food preparation industry to evaluate surface cleaning before reuse and as an educational tool for more than 30 years

ATP values for sites on medical (M) & surgical (S) wards

<table>
<thead>
<tr>
<th>Site</th>
<th>Before</th>
<th>After</th>
<th>Site Mean ATP Before</th>
<th>Site Mean ATP After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locker (M)</td>
<td>Range</td>
<td>Mean</td>
<td>15-506</td>
<td>10</td>
</tr>
<tr>
<td>Locker (S)</td>
<td>Range</td>
<td>Mean</td>
<td>5-325</td>
<td>13</td>
</tr>
<tr>
<td>L Bed (M)</td>
<td>Range</td>
<td>Mean</td>
<td>6-243</td>
<td>180</td>
</tr>
<tr>
<td>L Bed (S)</td>
<td>Range</td>
<td>Mean</td>
<td>4-186</td>
<td>106</td>
</tr>
<tr>
<td>O/B Table (M)</td>
<td>Range</td>
<td>Mean</td>
<td>28-625</td>
<td>116</td>
</tr>
<tr>
<td>O/B Table (S)</td>
<td>Range</td>
<td>Mean</td>
<td>8-598</td>
<td>246</td>
</tr>
<tr>
<td>R Bed (M)</td>
<td>Range</td>
<td>Mean</td>
<td>3-409</td>
<td>145</td>
</tr>
<tr>
<td>R Bed (S)</td>
<td>Range</td>
<td>Mean</td>
<td>0-268</td>
<td>118</td>
</tr>
</tbody>
</table>

Median ATP before and after cleaning

Site Value

Locker (M) 120
Locker (S) 69
L Bed (M) 105
L Bed (S) 131
O/B Table (M) 181
O/B Table (S) 309
R Bed (M) 132
R Bed (S) 57

Mulvey et al, JPH 2011

Would microbiological standards help?

5 cfu/cm² 45 cfu/cm²

Microbiological standards for surface hygiene in hospitals

Standard 1
There should be <1 cfu/cm² pathogen (MRSA; C.difficile; VRE; etc) in the clinical environment

Standard 2
The Aerobic Colony Count (ACC) or total microbial growth level from a hand contact surface should be <5 cfu/cm²

These standards are based upon food industry counts as applied to food preparation surfaces but could be utilised for frequent hand touch surfaces in hospitals

Dancer S, J Hosp Infect 2004

Application of standards on a ward

S.aureus & MRSA prefer lockers, overbed tables and beds; finding these at a site was significantly associated with higher aerobic colony counts from that site (p=0.001)

Dancer SJ et al, IJEHR 2008

Application of standards on ICU

25% of 200 samples failed the standards, mostly hand-touch sites

Hygiene fails were associated with bed occupancy and incidence of ICU-acquired infection

Hygiene standards reflect patient activity and provide a means to risk manage infection

White et al, AmJIC, 2008

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Is there a relationship between microbiological standards and ATP levels from surfaces?

Measuring ATP levels can tell you how good the general cleaning is AND it encourages cleaners to improve their cleaning efficiency (Boyce et al, ICHE 2009) …

…..but there is no point routinely measuring ATP levels from hospital surfaces if there isn’t going to be any benefit for patients

Relationship between aerobic colony count and its pass or fail using either ATP levels (grey bars; fail >250 relative light units) or visual assessment (black bars)

What is the evidence for cleaning as a viable control mechanism for MRSA?

We introduced one extra cleaner into two wards from Monday to Friday, with each ward receiving extra detergent-based cleaning for six months in a prospective cross-over design.

Ten hand-touch sites on both wards were screened weekly and patients were monitored for MRSA infection throughout the year-long study.

Patient and environmental MRSA isolates were characterized using DNA fingerprinting.

What did we find?

One extra cleaner was responsible for a 33% reduction in colony counts on hand-touch sites; and 27% reduction in new MRSA infections, despite busier wards and more MRSA patient-days.

Adjusting for MRSA patient-days and based upon 9 new MRSA infections found during control periods, we expected 13 new infections during enhanced cleaning periods rather than the four that actually occurred.

DNA fingerprinting confirmed indistinguishable strains from both hand-touch sites and patients - some of these were isolated months apart.

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Percentage of fails using ATP and visual assessment for each range of aerobic colony count Lewis et al, JHI 2009

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Total aerobic colony counts (ACC) from ten hand-touch sites on two matched surgical wards; the study cleaner moved from Ward A to Ward B at week 13.

Dancer et al, BMC Med, 2009

Figure 1: % Hygiene failures for three ATP benchmarks according to microbial growth

Mulvey et al, J Hosp Infect, 2011

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**Was the extra cleaning cost effective?**

- The study cleaner earned £12,320 per annum
- Consumables were £1,100
- Average cost of one hospital-acquired MRSA surgical site infection at least £9,000
- Enhanced cleaning spared 5-9 patients MRSA
- The hospital thus saved £45,000-£81,000 minus the costs of cleaners and consumables
- Overall savings estimated as £31,600 - £67,600 for two wards over a 1 year period

Dancer et al, BMC Med 2009

**Disinfectants vs Detergents**

Disinfectants do not degrade
They are expensive & toxic
Incite mutation and resistance

Are there less toxic alternatives?
Microfibre: recontamination; decontamination
Moore & Griffith, JHI 2006; Wren et al, JHI 2008; Bergen et al, JHI 2009

- Steam: operator dependent; electrical items; aerosol potential
  Meunier et al, Pathol Biol 2008; Griffith & Dancer, JHI 2009

- Hydrogen peroxide: expensive; confined areas; not fabrics
  Shapey et al, JHI 2008

- UV light: expensive; hidden corners; inadequate for C.difficile spores
  Havill et al, SHEA 2010; Mecheon et al, JHI 2010

**Cleaning works for VRE as well**

- decreased surface contamination with VRE;
- less frequent VRE contaminated HCW hands
- a significant reduction in VRE cross-transmission
  Hayden et al, CID 2006

**What does bleach do to microfibre?**

Scanning electron micrographs of ultra microfibre (UMF) cloths treated for 16 h. The UMF fibres are intact after exposure to water but the fibres have been severed after exposure to Chlor-Clean. Magnification: ×400.

Gant VA et al, J Hosp Infect 2010

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Randomized cross-over cleaning study on two London ICU's

- Disinfectant and microfibre used for enhanced cleaning
- High risk sites cleaned twice per day
- Less MRSA in the environment
- Less MRSA on doctors' hands

**No effect on patient MRSA acquisition!**

Too much disinfectant used during routine periods?
Confounded by people-traffic and airborne spread?
Hawthorne effect by staff?
Length of stay?

Wilson et al Crit Care Med 2011
Dancer et al Crit Care Med 2011

Impact of hypochlorite disinfection on MRSA rate

Mahamat et al, JHI 2011

C. difficile on surfaces before and after cleaning, and after 10% bleach disinfection

Eckstein et al, BMC Infect Dis, 2007

Wiping Out Clostridium difficile

Clostridium difficile infection incidence for units A and B combined, before and after the intervention

HAI, hospital-acquired infection; INC, overall infection incidence; PD, patient days; PT, patient.
Orenstein et al, ICHE 2011

Is the frequency of cleaning important?

Contact plates from patient locker surface
**Left to right: Pre clean, 1 hour, 2 hour, 3 hour assessment**

Mike Rollins, Osprey

MRSA rapidly recontaminates high-touch sites after cleaning

Hardy KJ et al, JHI 2007

MRSA contamination of ICU environmental sites before and after cleaning

<table>
<thead>
<tr>
<th>Site or Equipment</th>
<th>Sampling times at which MRSA was recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infusion pumps; syringe-driver</td>
<td>2, 3, 4, 5, 6 and 7 hours</td>
</tr>
<tr>
<td>Handles; bedside stand; cot sides; computer</td>
<td>7 hours</td>
</tr>
<tr>
<td>Cot sides</td>
<td>2 hours</td>
</tr>
<tr>
<td>Pumps; syringe-driver; cot sides</td>
<td>3 hours</td>
</tr>
<tr>
<td>Bench top; ventilator; cot sides</td>
<td>1 and 5 hours</td>
</tr>
<tr>
<td>MRSA negative sites</td>
<td>5 hours</td>
</tr>
</tbody>
</table>

How important is the frequency of cleaning?

Abdeyab et al, ICHE 2009

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Do wipes reduce bacterial counts when swiped across plastic surfaces?

Swiping plastic surfaces with any type of moist wipe decreases the bacterial burden

When surfaces are swiped 3 or more times, a detergent wipe is just as effective as disinfectant wipes. However, if a health care worker cleans a plastic object only once, then a disinfectant wipe should be used

Beware! If you keep using the same wipe again, it will accumulate microbes

Cleaning… near-patient hand-touch sites

New disinfectants on the block

Chemzyme Plus
A new study has found a cleaning liquid containing good bacteria reduced ‘bad’ bacteria by 1,000-fold compared with standard cleaning techniques

Aqualution
Electrolyised water
Also eradicates ‘bad’ bacteria with hypochlorous acid as active ingredient; non-toxic

Antimicrobial surfaces

- Resist microbial adhesion
  Polyethylene glycol;
  Biomimetic polymers;
  Diamond-like carbon films

- Antimicrobial surfaces
  Biocide-releasing (Triclosan, Silver, Copper, Bacteriophage);
  Microbicidal on contact (Polycationic surfaces);
  Light-activated (Photosensitive material – titanium dioxide)

- Nanocoating (nanotubes plus lysostaphin)

Are all surfaces equal?

Copper surfaces in rooms in intensive-care units reduced the amount of bacteria by 97% and the rate of hospital-acquired infections by 41%

Antimicrobial coatings must not undermine the success of traditional hygiene methods and neither should conventional cleaning and hygiene practices be relaxed if antimicrobial coatings are employed


Survival of MRSA on silicone elastomer surfaces exposed to 28-W fluorescent light

Bars represent mean number of MRSA recovered:
A. after a 24-hour incubation
B. after a 6-hour incubation expressed as a percentage of initial MRSA inoculum at time zero

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Just a quick blast...
The efficacy of any cleaning/disinfectant agent tested is dependent on physical action...
Alfa MJ et al, BMC Infect Dis 2010

Cleaning in the 21st century: what's best?

DETERGENT!
TARGETED!
FREQUENTLY!

In some situations we still need disinfectants, preferably non-toxic; we should find the evidence for soap and water first, before powerful disinfectants destroy our environment
Dancer S.J. EJCMID 2011

Thank you!
NB. No relevant disclosures

COMING SOON ...

10 November 11  Infection Prevention Challenges in Home Care
Speaker: Mary McGrath, Home Health System Inc.

17 November 11  Overview of the New HCPAC Norovirus Guidelines
Speaker: Dr. Tamara MacC, Centers for Disease Control, Atlanta
Sponsor: Virox Technologies Inc. (www.virox.com)

01 December 11  Strategies for Improving Hand Hygiene Compliance in the ICU
Speaker: Dr. Alexandre R. Marra, Hospital Israelita-Albert Einstein, Brazil
Sponsor: Deb Ltd (www.debgroup.com)

07 December 11  (Free WHO Teleclass) Best Practice for Cleaning, Disinfection, and Sterilization in Healthcare
Speaker: Prof. William Rutala, University of North Carolina
Sponsor: World Health Organization First Global Patient Safety Challenge: Clean Care is Safer Care (www.who.int/gpsc/en)

15 December 11  Surgical Implants Being Reprocessed: Pandora’s Surgery Box is Opened!
Speaker: Dr. Michelle Alfa, Diagnostic Services of Manitoba

www.webbertraining.com/scheduled.htm

COMING SOON

Coming December 1, 2011 ....
2012 Teleclass Schedule

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