What’s lurking in the hospital environment?

The importance of cleaning and disinfection in infection prevention and control

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Room A

Room B

2x
‘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

- **Nseir A. baumannii**: +71%
- **Shaughnessy C. difficile**: +58%
- **Drees VRE**: +55%
- **Drees VRE (2 weeks)**: +49%
- **Nseir P. aeruginosa**: +42%
- **Huang VRE**: +37%
- **Huang MRSA**: +28%

Taking the ‘lotto’ out of the room

Datta VRE
Datta MRSA
Passaretti MDR-GNR
Passaretti MRSA
Passaretti C. difficile
Passaretti VRE

Transmission routes

## Surface survival

<table>
<thead>
<tr>
<th>Organism</th>
<th>Survival time</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Clostridium difficile</em> (spores)</td>
<td>5 months</td>
</tr>
<tr>
<td><em>Acinetobacter</em> spp.</td>
<td>3 days to 5 months</td>
</tr>
<tr>
<td><em>Enterococcus</em> spp. including VRE</td>
<td>5 days – 4 years (!)(^1)</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>6 hours – 16 months</td>
</tr>
<tr>
<td><em>Klebsiella</em> spp.</td>
<td>2 hours to &gt; 30 months</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em>, inc. MRSA</td>
<td>7 days – 7 months</td>
</tr>
<tr>
<td>Norovirus (and feline calicivirus)</td>
<td>8 hours to &gt; 2 weeks(^2)</td>
</tr>
<tr>
<td>SARS Coronavirus</td>
<td>72 hours to &gt;28 days(^3)</td>
</tr>
<tr>
<td>Influenza</td>
<td>Hours to several days(^4)</td>
</tr>
</tbody>
</table>

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

Conventional terminal cleaning

Pathogens can be transferred from hospital surfaces to HCW hands without direct patient contact\textsuperscript{1-2}

<table>
<thead>
<tr>
<th>Percentage of HCWs Acquiring Pathogens</th>
<th>Contact with Patient or Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>52% of 23 HCWs acquired VRE on their hands\textsuperscript{3}</td>
<td>Contact with patient \textbf{or} surface = \textasciitilde10% risk of acquiring VRE\textsuperscript{3}</td>
</tr>
<tr>
<td>45% of 50 HCWs acquired MRSA on their hands\textsuperscript{4}</td>
<td>40% of 50 HCWs acquired MRSA on their hands\textsuperscript{4}</td>
</tr>
<tr>
<td>50% of 30 HCWs acquired \textit{C. difficile} on their hands\textsuperscript{5}</td>
<td>50% of 30 HCWs acquired \textit{C. difficile} on their hands\textsuperscript{5}</td>
</tr>
<tr>
<td>Compliance with hand hygiene: 50%\textsuperscript{6}</td>
<td>Compliance with hand hygiene: 80%\textsuperscript{6}</td>
</tr>
</tbody>
</table>

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

Try something new!

- Improve existing procedures
- Try something new!
## Improve existing procedures

### Education & training

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

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.

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$^{3-5}$

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 / cm²) and specific indicator organisms (<1 cfu / cm²) have been proposed.¹,²

Cost and practicality mean that routine microbiological sampling is rarely performed

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 correlate¹,²

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\(^4\)

## Improve existing procedures

<table>
<thead>
<tr>
<th></th>
<th>Visual</th>
<th>Micro</th>
<th>ATP</th>
<th>Fluorescent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of use</td>
<td>High</td>
<td>Low-Moderate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Quantitative</td>
<td>No</td>
<td>Yes/No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Correlation with microbial contamination</td>
<td>Poor</td>
<td>Accurate</td>
<td>Indirect</td>
<td>Indirect</td>
</tr>
<tr>
<td>Identifies pathogens</td>
<td>No</td>
<td>Yes/No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Risk of “gaming” by staff</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Identifies ‘dirty’ surfaces*</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Published evidence of attributable clinical impact</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

* Non-microbial soiling
Improve existing procedures

- 5 sites in 100 patient rooms assessed before and after terminal clean
- “Clean” defined as <2.5 cfu/cm², complete removal of fluorescent marker and ATP score of <250 RLU

5 sites in 50 patient rooms assessed before and after terminal clean

“Gold standard = <2.5 cfu/cm² compared with complete removal of fluorescent marker and ATP score of <250 RLU

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall N = 250</td>
<td>Dazo</td>
<td>68</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>ATP</td>
<td>78</td>
<td>38</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Visual</td>
<td>95</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Baseline dirty n = 103</td>
<td>Dazo</td>
<td>75</td>
<td>40</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>ATP</td>
<td>76</td>
<td>35</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Visual</td>
<td>94</td>
<td>10</td>
<td>81</td>
</tr>
</tbody>
</table>

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.”

Improve existing procedures

Try something new!

[Images of different objects and a checklist]
Daily bathing of patients using chlorhexidine reduces the acquisition of MDROs,\textsuperscript{1,2} including \textit{C. difficile}.\textsuperscript{3}

Figure from Vernon \textit{et al.}\textsuperscript{2}

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

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

Air control

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

### Antimicrobial surfaces

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>Rapidly microbicidal</td>
<td>? Sporicidal</td>
</tr>
<tr>
<td></td>
<td>Reduces acquisition</td>
<td>Acceptability / retrofitting</td>
</tr>
<tr>
<td>Silver</td>
<td>Rapidly microbicidal</td>
<td>? Sporicidal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tolerance development</td>
</tr>
<tr>
<td><strong>Chemical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organosilane</td>
<td>Easy to apply</td>
<td>Limited microbicidal activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Durability</td>
</tr>
<tr>
<td>Light-activated</td>
<td>Broadly microbicidal</td>
<td>? Sporicidal</td>
</tr>
<tr>
<td><strong>Topography</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Liquid glass”</td>
<td>Reduces deposition</td>
<td>Not microbicidal</td>
</tr>
<tr>
<td></td>
<td>Improves ‘cleanability’</td>
<td></td>
</tr>
<tr>
<td>Sharklet pattern</td>
<td>Reduces deposition</td>
<td>Not microbicidal</td>
</tr>
<tr>
<td></td>
<td>Reduced biofilms</td>
<td></td>
</tr>
</tbody>
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614 pts in 3 hospitals randomised to ‘copper’ or ‘non-copper’ ICU rooms

Improve existing procedures

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- Improve existing procedures
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Try something new!

Wipes

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

- 99% of sites <2.5 cfu/cm²
- 75% of sites no growth after cleaning (figure)

Try something new!

“No touch” disinfection

- Hydrogen peroxide vapour (HPV)
- Aerosolised hydrogen peroxide (aHP)
- Ultraviolet radiation C (UVC)
- Pulsed-xenon UV (PX-UV)

Try something new!

Reduce contamination

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

% sites contaminated with A. baumannii

% sites contaminated with MRSA

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)

Improve existing procedures

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

Try something new!

“Design bugs out!”

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