Clostridium difficile and Environmental Cleaning
Professor Mark Wilcox
A Webber Training Teleclass

Objectives
1. Discuss role of environment in HAI and in CDi
2. Describe the nosocomial spread of CDi
3. Discuss evidence for use of hypochlorite cleaning to reduce CDi incidence

Incidence of C. difficile diarrhoea
- Most published studies on CDD incidence report whole hospital as opposed to unit specific rates
- CDD incidence in 15 secondary and 6 tertiary hospitals in Sweden
  - Rehabilitation and Geriatrics ~1 per 100 admissions
  - Whole hospital rate ~0.2 per 100 admissions
- CDD is endemic in many/most elderly medicine units (e.g. 2.2-5.1 cases per 100 admissions)

Evidence for role of environmental contamination
- ... in the aetiology of hospital-acquired infection is poor
- Attempts to reduce infection rates by enhancing environmental cleaning alone generally unsuccessful
- Evidence for enhanced environmental contamination
  - Environmental persistence of C. difficile spores
  - Endemicity of C. difficile
  - Enhanced virulence of particular C. difficile strains
  - Sporulation of C. difficile can actually be enhanced when cultured in faeces exposed to non-chlorine based hospital cleaning agents

Evidence for role of environmental contamination
- Effect of floor cleaning on bacterial recovery
- Recomination after cleaning:
  - Surgical ward
  - Operating theatre

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**Clostridium difficile**

- spore
- environment

PubMed ... 9 hits

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**C. difficile environmental epidemiology**

- in areas where carriers had diarrhoea, 85 (9.3%) of 910 cultures of floors/other surfaces were CD positive
  - areas where no known carriers 2.6% of sites CD positive (P<0.005)

- CD was isolated from hands and stools of asymptomatic hospital personnel sewage and soil from the home of a patient

- CD inoculated onto a floor persisted there for five months


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**C. difficile**

- water
  - river (88%)
  - lake (47%)
  - sea (44%)
  - swimming pool (50%)
  - mains tap 1/18 (6%)
- soil (21%)
- raw vegetables (2%)
- private residences (2%)
- dogs (10%), cats (2%)
- [4 hospital environments (20%)]


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**Comparison of C. difficile environmental recovery rates with four different culture methods**

<table>
<thead>
<tr>
<th>Method</th>
<th>% Recovery of C. difficile</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCEY</td>
<td>30</td>
</tr>
<tr>
<td>alk. thiog. + CCEY</td>
<td>25</td>
</tr>
<tr>
<td>CCEY + lysozyme</td>
<td>20</td>
</tr>
<tr>
<td>alk. thiog. + CCEY</td>
<td>15</td>
</tr>
</tbody>
</table>

P = 0.004


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**Prospective study of antibiotic induced risk of CDi results**

- a highly significant increased incidence of C. difficile colonisation in patients who received CTX as opposed to PT (26/34 vs. 3/14, p<0.001)
- a highly significant increased incidence of C. difficile diarrhoea in patients who received CTX as opposed to PT (18/34 vs. 1/14, p=0.006)


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**Prospective study of antibiotic induced risk of CDi environmental CD contamination**

**Ward A**

- winter (CTX) study period marked increase in environmental CD contamination (13% to 56%, p=0.0001)
- summer (PT) study period marked decrease in environmental CD contamination (56% to 31%, p=0.03)


**Ward B**

- winter (PT) study period no significant increase (26% to 40%, p=0.17)
- summer (CTX) study period no significant increase (40% to 38%, p=1.00)

Why is *C. difficile* so difficult?

Environmental *C. difficile* infection in hospital environments can have serious consequences. For example, *C. difficile* was responsible for a significant outbreak in an elderly medical ward, as reported by Fawley, Wilcox et al. (Epidemiol Infect 2001; 126: 343-50).

The table below shows the percentage of environmental sites positive for *C. difficile* and the number of personnel positive for *C. difficile*.

<table>
<thead>
<tr>
<th>Bay floors</th>
<th>08/97</th>
<th>09/97</th>
<th>10/97</th>
<th>11/97</th>
<th>12/97</th>
<th>01/98</th>
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<tbody>
<tr>
<td>Radiators</td>
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<td></td>
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<tr>
<td>Bed frames</td>
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<tr>
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<tr>
<td>Sluice floor</td>
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<tr>
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<tr>
<td>Side room floors</td>
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<td></td>
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<tr>
<td>Side room curtain rails</td>
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</table>

Environmental *C. difficile*

Elderly Med ward

<table>
<thead>
<tr>
<th>6/10</th>
<th>13/10</th>
<th>27/10</th>
<th>5/12</th>
<th>4/1</th>
<th>31/1</th>
<th>9/4</th>
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</thead>
<tbody>
<tr>
<td>bay floors</td>
<td>+</td>
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<td>+</td>
<td>+</td>
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<td>+</td>
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<tr>
<td>toilet floors</td>
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<td>+</td>
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</tbody>
</table>

Environmental *C. difficile* colonization in hospital environments can vary greatly. For instance, the prevalence of *C. difficile* in the environment was significantly higher in Bay floors compared to Toilet floors (Fawley, Wilcox et al. Epidemiol Infect 2001; 126: 343-50).

The table above shows the percentage of environmental sites positive for *C. difficile* and the number of personnel positive for *C. difficile*.

% environmental sites +ve

<table>
<thead>
<tr>
<th>0</th>
<th>1-25</th>
<th>26-50</th>
<th>&gt;50</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/25</td>
<td>0/11</td>
<td>1/12 (8)</td>
<td>9/25 (36)*</td>
</tr>
</tbody>
</table>

*P < 0.01

Correlation between environmental C. difficile colonisation and clinical incidence of disease

Ward A

Ward B

P = 0.05

P > 0.6


Frequency of C. difficile culture-positive environmental sites commonly associated with patients and healthcare workers on study wards A and B

Environmental C. difficile in isolation rooms prevalence study results

2/33 rooms no C. difficile recovered
5/33 rooms C. difficile positive for 1 week
10/33 positive for 2 weeks
12/33 positive for 3 weeks
4/33 positive for 4 weeks
after 4 weeks 26% of sites still C. difficile +ve


Summary distribution of environmental C. difficile in side rooms by week over one month

Evidence for role of hypochlorite to control CDi (i)

- Kaatz et al. reported an outbreak of CDI
- ended following introduction of disinfection with hypochlorite (unbuffered hypochlorite - 500 ppm available chlorine)
- surface contamination decreased to 21% of initial levels
- phosphate buffered hypochlorite (1600 ppm available chlorine, pH 7.6) was even more effective
- use resulted in a 98% reduction in surface contamination

Evidence for role of hypochlorite to control CDi (ii)

- Mayfield et al. found that incidence of CDI in patients on a bone marrow transplant unit decreased significantly following substitution of a quaternary ammonium solution by hypochlorite for environmental disinfection
- after quaternary ammonium solution based cleaning was reintroduced, CDI incidence increased almost to baseline level
- environmental C. difficile prevalence was not measured
- antibiotic use altered during the study period
- results were not reproducible for patients on other units
**Role of hypochlorite for environmental cleaning**

- health & safety
- sustainability – toxicity
- environmental cost – toxicity
- effectiveness vs organic load
- combination products

**Risk of CDi**

- Elderly patient
- Antibiotic exposure
- Gut flora inhibition
- Exposure to CD
- Antibiotic resistant CD strain
- Virulent CD strain
- Poor host response

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