Debate – High Tech Decontamination of the Environment

H Humphreys, M Kiernan, P Carling, P Hoffman

Broadcast live from the 2014 conference of the Healthcare Infection Society, in Lyon

Debate – High-Tech Decontamination of the Environment

Motion
“This house believes that hospitals which do not use high tech decontamination are doing their patients a disservice”

Speaking in favour of the motion:
Prof. Hilary Humphreys and Prof Phillip Carling

Speaking against the motion:
Mr. Martin Kiernan (for Prof Markus Dettenkofer) and Mr. Peter Hoffman

www.webbertraining.com November 18, 2014

declaration

The views expressed are in a personal but professional capacity & do not necessarily reflect those of the RCSI or Beaumont Hospital

I have recent research collaborations with Pfizer (Ireland). I have also recently received lecture & other fees from AstraZeneca & Astellas.

why must we do better?

1. The healthcare environment is complex & represents a serious risk given patient vulnerability & microbial ingenuity

2. Current approaches are inadequate & endanger patients

3. Technological advances can make us less dependant on failed solutions

the challenges in surface decontamination

The patient
High CFU (50/cm²) on skin of VRE patients

The pathogen
Many pathogens survive on dry surfaces for long periods

Practice
Previous occupancy of a room with a patient colonised with certain microbes increases the risk for subsequent patients

infect control hosp epidemiol 2011;32: 689-699

Survival of Microbes on Surfaces

• No difference between resistant & antibiotic susceptible variants
• Humid conditions enhance survival
• Inoculum size & the presence of protein affect survival

<table>
<thead>
<tr>
<th>Bacterium</th>
<th>Survival range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter spp.</td>
<td>3 days to 5 months</td>
</tr>
<tr>
<td>Clostridium difficile (spores)</td>
<td>5 months</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>1.5 hours to 16 months</td>
</tr>
<tr>
<td>Enterococci (including VRE)</td>
<td>5 days to 4 months</td>
</tr>
<tr>
<td>Klebsiella spp.</td>
<td>2 hours to over 30 months</td>
</tr>
<tr>
<td>Staphylococcus aureus (including MRSA)</td>
<td>7 days to 7 months</td>
</tr>
</tbody>
</table>
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Bacteria in Biofilm on Surfaces

MRSA Spread from Patients
- 92/939 (10%) patients +ve for MRSA in extensive screening study
- 65/1,252 (5%) environmental sites positive adjacent to MRSA patients; mattresses, 14% & air, 8%

Increased Acquisition Risk from Prior Room Occupant
Studies as of October 2014

What do we currently use?
A wide variety of chemicals as disinfectants

What can we do?
- Do what we currently do but do it better?
- Don’t rely on human frailty by using walk away technology
  - Alter the surface components
  - Hydrogen peroxide & UV radiation

Antifouling Coatings against Proteins, Bacteria & Marine Organisms

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Copper & HCAI
1. Copper has been used as an antimicrobial agent for centuries
2. Documented efficacy in vitro
3. Clinical trials show reduced microbial numbers & beginning to show reduced infection rates

Copper & Clostridium difficile
Stainless steel had no activity against C. difficile
2-3 log reduction in spores at 3 h with no impact from soil load

<table>
<thead>
<tr>
<th>Surface/exposure time</th>
<th>Mean C. difficile cfu/mL remaining (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td>NCTC 11204 027</td>
</tr>
<tr>
<td>0 min</td>
<td>7.6 x 10⁸ (6.8--8.3) 5.6 x 10⁸ (5.5--5.6)</td>
</tr>
<tr>
<td>30 min</td>
<td>7.3 x 10⁸ (6.8--7.8) 3.2 x 10⁸ (2.4--4.0)</td>
</tr>
<tr>
<td>Copper</td>
<td>0 min 1.2 x 10⁶ (1.0--1.4) 4.6 x 10⁵ (3.6--5.6)</td>
</tr>
<tr>
<td>30 min</td>
<td>0⁰ 0⁰</td>
</tr>
</tbody>
</table>

Copper Surface & HAI Rates
- Three medical centres, ICUs, coffee-alloy surfaces, weekly sampling of objects

- 650 patients (unique identifiers) initially randomized
- 64/14 randomized unique patients included in analysis
- Exclusion: 22 missing primary outcome only 3 missing study rooms only 21 missing both
- 364 assigned to receive care in ICU rooms with copper surfaced objects
- 319 assigned to receive care in ICU rooms without copper surfaced objects
- 157 received care in rooms where all six copper-surafced objects remained in room for entire LOS
- 277 received care in rooms where no copper surfaced object was placed in room for entire LOS

Copper Surfaces & HAI Rates

Organism | No. of samples | Log reduction (direct) |
----------|----------------|------------------------|
MRSA      | 40             | 3.85                   |
VRE       | 32             | 3.25                   |
MDR A. baumannii | 37 | 3.79                   |
C. difficile spores | 35 | 2.43                   |

Room Decontamination with UV Radiation
William A. Rutala, PhD, MPH; Maria E. Gergen, MT (ASCP); David J. Weber, MD, MPH

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Endemic C. difficile & Enhanced Terminal Cleaning

- No change in hand hygiene practice
- Antimicrobial use largely unchanged but levofloxacin use increased

Hydrogen Peroxide (HPO) & the Hospital Environment

<table>
<thead>
<tr>
<th>Study &amp; Microbe</th>
<th>Site sampled</th>
<th>Sampling method</th>
<th>Decontamination Method</th>
<th>Result (+ve)</th>
</tr>
</thead>
<tbody>
<tr>
<td>French et al. MRSA</td>
<td>Floors, beds, lockers, taps.</td>
<td>Moistened swabs</td>
<td>HPO vapour</td>
<td>66% to 1.2%</td>
</tr>
<tr>
<td>Bryce et al. C. difficile</td>
<td>Room, bathrooms</td>
<td>Moistened cellulose sponges</td>
<td>HPO vapour</td>
<td>25.6% to 6%</td>
</tr>
<tr>
<td>Bates et al. Serratia spp., pluggers, curtains</td>
<td>Not stated</td>
<td>HPO vapour</td>
<td>8.2% to 6%</td>
<td></td>
</tr>
<tr>
<td>Otter et al. VRRE</td>
<td>Floors, beds, frames, etc</td>
<td>Moistened swab</td>
<td>HPO vapour</td>
<td>6.7% to 6%</td>
</tr>
</tbody>
</table>

Endemic C. difficile & Enhanced Terminal Cleaning

Conclusions

1. Current approaches do not prevent patients acquiring HCAI from the healthcare environment
2. Microbes in the hospital are adaptable
3. New technologies have proven antimicrobial activity & reduce infection rates
4. Trials are challenging & difficult to do
5. Vacating rooms should be possible if it were not for our over-crowded hospitals
6. Don’t rely on human frailty

Thank You

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Against the motion
Martin Kiernan - @emrsco15
Nurse Consultant
Southport and Ormskirk Hospital NHS Trust, UK

Disclosures
- Have been a member of advisory boards for Pfizer and Vernacare and have presented at educational meetings that have been supported by Advanced Sterilisation Products, Johnson and Johnson and GAMA healthcare
- The views presented before you are my own

Linking the Environment and Infection
- We have moved forward
  - Dettenkofer (2004) AJIC
  - Quality of evidence poor, no convincing evidence that disinfection of surfaces reduces infection
  - Donskey (2013) AJIC
  - High quality studies support environmental decontamination as a control strategy
- Debate continues
  - But not as much as it used to...
  - Cleaning was not considered to be an evidence-based profession

UV-visible marker showing failure of terminal cleaning
Carling PC et al, ICHE 29:1-7 (2008)

- Ultraviolet marker was used to test whether items felt to be high touch in patient isolation rooms would be cleaned
  - Overall, 49% of objects/surfaces were not cleaned (range 35-81%)
  - Wide variation in cleaning particular items
  - Poor were toilet handles, bedpan cleaners, light switches and door handles – under 30%

Hands are still an issue
- Door knobs, bed rails, curtains, instrument dials, computer keyboards contaminated by hands
- MRSA on the door handles of 19% of rooms with MRSA
  - 42% of nurses contaminated gloves with MRSA with no direct patient contact but did touch the environment in rooms of MRSA patients
  - Boyd JM, Potter-Bynoe G et al ICHE 1997;18(9):622-7
- High-tech disinfection impossible with patients in situ

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Evidence for cleaning as a control mechanism for MRSA?
- One extra cleaner into two wards (Mon-Fri); each ward receiving extra detergent-based cleaning for six months in a prospective cross-over design
- Ten hand-touch sites on both wards screened weekly
- Patients monitored for MRSA infection
- Patient and environmental MRSA isolates were characterized using DNA finger-printing

Was the extra cleaning cost effective?
- Costing exercise
- Cleaner earned £12,320 a year and the consumables were £1,100
- One MRSA surgical site infection estimated at £9,000
- Reduction by 5-9 cases
- Hospital saved £45,000-£81,000 without the additional costs of cleaner/consumables
- Annual saving for two wards was between £31,600 - £67,600

Is our focus wrong?
- There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don’t know we don’t know
- Rumsfeld, 2002

Quarterly C. difficile
England >2y: 2004-2014

Quarterly MRSA Bacteraemia
England: 2001-14

What did they find?
- Extra cleaner responsible for
  - 33% reduction in colony counts on hand-touch sites
  - 27% reduction in new MRSA infections
  - Despite busier wards and more MRSA patient-days
- They expected 13 infections during enhanced cleaning periods but 4 occurred
- Molecular studies demonstrated identical strains from hand-touch sites and patients
- Some of which were months apart

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**We only act on what we know**

- Contamination of the environment with C. difficile spores more common in symptomatic cases than asymptomatic carriers: 49% v 29%
- But still significant in the asymptomatic group
  - Kim et al J. Infect Dis 1981
- We tend to focus high-tech solutions on what we know and not what we do not

**Transmission MDR Organisms**


- Prospective cohort study: successive occupiers of ICU room at risk from previous occupants
  - Pseudomonas aeruginosa (OR 2.3, p<0.02)
  - Acinetobacter baumannii (OR 4.2, p<0.001)
- ‘Quality’ audits showed that 56% of rooms were not cleaned correctly
  - Failure in room door knobs (45%), monitor screens (27%) and bedside tables (16%)

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**Missing information**

- What did the ‘quality’ audits consist of?
  - Methodology, what was looked at, etc
  - No attempt to look at the results of the cleaning audits to see if transmissions occurred when cleaning was poor
  - No description of any divisions in cleaning duties
  - Cleanliness of clinical equipment not mentioned

**Who is really caring for the environment of care?**


- Procedures for cleaning patient care environments, but often confusion about the division of labour when it comes to cleaning responsibilities
- Systems to monitor cleaning effectiveness are frequently suboptimal
  - Implemented ATP monitoring and reported improvement
  - Looked at ‘housekeeping’ items only

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**Audit of Equipment**

Anderson RE, Young V et al, JHl 78(3) 2011

- Many items of clinical equipment in patient care do not receive appropriate cleaning attention
- Average ATP score indicated that surfaces cleaned by professional cleaning staff were 64% lower than those by other staff (P<0.019)
- Nurses don’t clean very well – of 27 items cleaned by clinical staff, 89% failed the benchmark

**‘Low Risk’ items**

Creamer E., Humphreys, H; JHl (2008) 69 pp 8-23

- “While designated a low-risk item, it is clearly evident that the hospital bed poses a potential risk of infection to patients if not adequately decontaminated”
- Regular, e.g. weekly, decontamination is advised
  - Ideally decontaminate a bed by thermal disinfection between patients
  - If endemic with MRSA and VRE at least try to ensure that the critical components, e.g. mattresses and pillows, are processed in a thermal disinfection unit

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Examination of Pillow Cores
- Patient pillows and control (unused) tested
- Pillow seams and label tags were found to be mechanism for contamination allowing for drainage wicking from outside the pillow to the pillow core
- Multiple pathogens found growing within pillow cores of all patient pillows
- correlation to organisms from colonised and infected patients
- Pillows do not just go under heads..

CPE contamination
- Large outbreak of KPC in Germany
- Environmental reservoir sought
- Ward pillows and mattresses not externally positive
- Attributed to frequent steam cleaning of pillows and mattresses
- Positioning pillows for ARDS internally contaminated and remained so for 6 months

Levels of evidence
- We seem to need high quality evidence that high tech disinfection is effective because of the cost
- Yes the total spend on low tech may be the same and do we know whether this is effective?
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Using wipes for cleaning
- Common use but label claims may be misleading
- Mode of action, technique, absorption etc etc
- No evidence for use against biofilms
- Repeatedly using a wipe transfers organisms and C. difficile spores from contaminated to clean areas in significant numbers
  - Siani H, Cooper C et al. AJIC 2011;39(3):212–218
  - Cadnum J, Hurtless K et al. ICHE 2013; 34(4) 441-2

Please vote against the motion
- Please note the question
- That hospitals that do not use high technology solutions are doing their patients a disservice
- I have yet to see a study that has looked at Hospitals using High Tech vs Low Tech
- Concentrating the same effort (and spend) on low technology and education (convincing) may have the same (or better) effect
- High-tech should not be the backstop for poor practice

This house believes that hospitals which do not use high tech decontamination are doing their patients a disservice*

Phil Carling
Professor of Clinical Medicine
Boston University School of Medicine
Boston Medical Center, Boston, Massachusetts

9th International Healthcare Infection Society International Conference
18th November 2014

"Hospitals which do not use high tech decontamination are doing their patients a disservice."
You have heard the scientific evidence for our position….

We would respectfully disagree
"Evidence of the effectiveness and cost-effectiveness of these technologies and their contribution to reductions in HCAI is not currently available."


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Now to look at the evidence

Introducing the Super Heroes!!

What’s not to like about new toys?

These new machines are cool!! (D. Anderson, MD 2013)

High-tech house cleaning
Advanced disinfection systems wield lethal weapons against pathogens

Evaluating Non-touch Technologies

Cool Pictures

While our colleagues may suggest to you that good clinical studies are needed

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While our colleagues may suggest to you that good clinical studies are needed

We say why??

1. Well designed patient room mock-up studies show they work fairly well.

2. There are plenty of published reports which say HPV and UVC work in clinical settings

Although it has been suggested that all of these reports relate to outbreaks, were not controlled and did not measure the impact of improved pre-cleaning…we would ask you to not take too seriously some of the limitations of evaluating outbreaks.

Problems with studying outbreaks

• “Post Hoc” reasoning
• Regression to the mean
• Single interventions are often not truly single when addressing an outbreak
• Defining an “outbreak”

Although it has been suggested that all of these reports relate to outbreaks, were not controlled and did not measure the impact of improved pre-cleaning…we would ask…

What is an “Outbreak”?

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The impact of HP vapor on C. difficile

The impact of HP vapor on C. difficile

C. Difficile rates in all clinical intervention studies since 2007 (per 10,000 PTD)

Boyce Study
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What about controlled studies?

4. Controlled studies are not the answer

A. Given the cost, is it surprising that manufacturers are not interested?
B. A single 5 hospital crossover study has just been completed in the USA and the results should start to be published in about a year although it may be difficult to draw unequivocal answers from it. Should our patients be forced to wait?

Can 20% of US Hospitals be wrong?

“Despite the high cost of these machines and significant personnel and logistical costs, we now have the opportunity to say we are using the best modern technology for our patients.”

Copper non-use guilt

Our colleagues may tell you about performance improvement programs for housekeepers with impressive results in terms of thoroughness of cleaning.

- But do we really want to empower these people??
- Think of the potential cost!

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While there is increasing evidence that daily cleaning is effective in clinical studies and that there is no role for machines in daily cleaning….We have solutions!

Move the patient out of their room each morning (HPV) or shield the patient from UV rays with special blankets and eye shields (blinders)(UV).

Leadership

While there is increasing evidence that daily cleaning is effective in clinical studies and that there is no role for machines in daily cleaning….We have solutions!

Move the patient out of their room each morning (HPV) or shield the patient from UV rays with special blankets and eye shields (blinders)(UV).

Empower patients to clean their own room as we are empowering them to optimize their own hand hygiene.

It has been rumored that there are logistical issues and hidden costs of actually using NTT or the need for complex systems to broadly implement its use given the fact that patients are discharged at all hours of the day and night.

We are beginning to get some answers.

Nurses and EVS directors did encounter delays in D/C management when using UV-C….
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Finally, since our colleagues may quote some of the work our group has done, I thought it might be helpful for me to show you this first:
The Iowa Disinfection Cleanliness Project: Opportunities, Successes and Challenges of a Structured Intervention Project in 50 Hospitals

Finally, since our colleagues may quote some of the work our group has done, I thought it might be helpful for me to show you this first:

Speaking against: “This house believes that hospitals which do not use high tech decontamination are doing their patients a disservice”

Peter Hoffman
Consultant Clinical Scientist
Antimicrobial Resistance and Healthcare Infections Reference Unit
Public Health England

A very broad topic
• I intend to address three technologies and show how, on a theoretical and evidential basis, they do not contribute to infection prevention in healthcare.

Antimicrobial surface coatings
• It is possible to buy many items with “proven” antimicrobial coatings:
  ➢ Bedside lockers, pens, paper, document files, commodes, bedpan processors, paints, curtains, ceiling tiles, waste bins, socks, flooring, and many, many more .........

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Antimicrobial surfaces

• These are most usually surfaces that contain a chemical disinfectant.
• That disinfectant will need to migrate from the surface into its target.
• So it must be soluble, but not too soluble or it will be all lost within the first few times that object is cleaned.
• Low solubility means that only low amounts will be released at a given time and available to act as a disinfectant.

ISO 22196 - outline

- The test inoculum is applied as a liquid to the test surface
- Inoculum cultured after 24 hours exposure; survivors enumerated
- If there is a reduction of 1,000-fold (3 log10) or greater, the test has been passed.

- ISO 22196 uses a bacterial inoculum that is 1 part of nutrient broth in 500 parts of distilled water – virtually no organic matter.
- How does this relate to reality?
- Organic matter inactivates disinfectants, particularly low concentrations of disinfectant
- This is not how patients produce contamination.
- It is highly probable that the very low concentration of disinfectant in liquids on antimicrobial surfaces would be inactivated by the organic matter present in most real-life contamination.

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- The liquid inoculum is applied to the test surface, then covered by a film and put inside a petri dish that is then closed. The inoculum remains liquid throughout the test.
- So disinfectant can migrate out of the surface and into its target for the whole of the test period
- How does this relate to reality?
- Real life contamination is usually deposited on a surface by dry contact, or by slightly moist contact that will dry rapidly.
- This test uses far more effective contact between disinfectant and target than will occur in the majority of real-life instances.
- The test exposure period is 24 hours, after which a pass will occur if there is a greater than 1,000-fold (3 log_{10}) reduction in the bacterial challenge.
- How does this relate to reality?
- There are many important instances where sequential contacts occur far more rapidly than 24 hours.
- To demonstrate disinfectant activity after 24 hours does not show practically useful activity.

- The test exposure is at 37°C, not normal room temperature.
- How does this relate to reality?
- The hotter the environment, the faster the microbicidal activity.
- Use of an elevated temperature will exaggerate any microbicidal effect.

- Other microbes?
- Viruses (e.g. noro, BBVs, etc.): Some, particularly the non-enveloped viruses such as noro, are not susceptible to some of the antimicrobials in coatings. BBVs would be deposited in high organic matter.
- Bacterial spores (e.g. Clostridium difficile): These are highly unlikely to be susceptible to the antimicrobials in coatings.

- The hazard is that, if users are convinced that the products do what they think they do, cleaning or disinfection will not take place.
  “...... but it kills all the germs. Why do I need to clean it?”

Photocatalytic antibacterial surfaces

Microbicidal action from hydroxyl radicals resulting from UV on titanium dioxide.


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BS ISO 27447:2009
• Uses 1 in 500 dilution of bacterial suspension in water as inoculum (no spores, no viruses)
• Done in a petri dish lined with wet filter paper, the inoculum covered by a thin film then petri dish closed with a “moisture conservation glass” – does not dry for the whole exposure period
• Exposure period 8 hours and upwards

Photocatalytic antibacterial surfaces
• There is nothing within current testing methods that suggests photocatalytic antibacterial surfaces in healthcare will have significant activity a reasonable time-frame and in their typical use conditions

Hydrogen peroxide non-contact systems
• The systems divide into those that use gaseous H₂O₂ – essentially fumigation (“vapour”) and those that use a fine spray: fogging (“mist”, “droplets”).
• The fumigant will disperse & penetrate better, no shadowing
• But does it make a difference?

An Evaluation of Environmental Decontamination With Hydrogen Peroxide Vapor for Reducing the Risk of Patient Acquisition of Multidrug-Resistant Organisms
Catherine R. Haas,
John Grady,
Kim Stumer,
Wesley S. Jackson,
Lovelace Medical Center

Aims
• To evaluate the use of hydrogen peroxide fumigation equipment for decontamination of ICUs
• To evaluate the impact of hydrogen peroxide fumigation equipment on MRSA, VRE, and C. difficile acquisition rates

Methods
• Surgical Intensive Care Unit (SICU)
• Standardized decontamination protocol at start and end of study
• Air sampling at start of study

Results
• MRSA acquisition rate: 0/23 patients (0.0%)
• VRE acquisition rate: 0/23 patients (0.0%)
• C. difficile acquisition rate: 0/23 patients (0.0%)

All MDRO?
• Discussion: “MRSA, MDR-GNR, and C. difficile acquisitions were not independently reduced when HPV was used”
• Results: “The significant reduction in MDRO acquisitions was mainly driven by the reduced incidence of VRE acquisition, which was approximately 5 times less likely in the MDRO-HPV cohort”

Study design

<table>
<thead>
<tr>
<th>Intervention wards (H₂O₂ fumigation)</th>
<th>Surgical ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention wards (H₂O₂ fumigation)</td>
<td>Neurosurgical ICU</td>
</tr>
<tr>
<td>Intervention wards (H₂O₂ fumigation)</td>
<td>“High risk” surgical unit</td>
</tr>
<tr>
<td>Control wards (conventional environmental decontamination)</td>
<td>Medical ward</td>
</tr>
<tr>
<td>Control wards (conventional environmental decontamination)</td>
<td>Cardiac thoracic surgical unit</td>
</tr>
<tr>
<td>Control wards (conventional environmental decontamination)</td>
<td>Surgical oncology</td>
</tr>
</tbody>
</table>

Discussion: “Our study has several limitations … neither rooms nor units were randomly assigned the intervention, which may have introduced bias”

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Hydrogen peroxide fumigation against *C. difficile*

- "Intervention. Intensive HPV decontamination of 5 high-incidence wards followed by hospital-wide decontamination of rooms vacated by patients with *C. difficile*-associated disease."
- Incidence of *Clostridium difficile* associated disease (CDAD) was significantly lower during the intervention period than during the pre-intervention period on those 5 wards (1.28 vs 2.28 per 1,000 patient days) and hospital-wide (0.84 vs 1.36).

Hospital-wide *C. diff* incidence

**Methods:**

- “Because there may be seasonal variation in the incidence of CDAD, we compared the incidence of CDAD during the 10-month intervention period with the incidence during the same 10-month period in the preceding year.”

**Summary**

- There is pressure on IPC Teams to recommend the application of technology, particularly during stressful situations.
- The literature is over-optimistic (good news gets published, no news & bad news tend not to be).
- The evidence for high tech decontamination interventions does not stand up to scrutiny.
- Do not be made to feel guilty by not using it.