The Year in Infection Control
From ECCMID to ECCMID...

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Overview

Traditional infection control...

*C. difficile* – what really works?

Unusual outbreaks...

The age of sequencing...
Traditional infection control...
Workload even affects hand hygiene in a highly trained and well-staffed setting: a prospective 365/7/24 observational study

S. Scheithauer, B. Batzer, M. Dangel, J. Passweg, A. Widmer

The higher the workload, the lower the compliance (R=-0.411; p<0.001)...
Hand hygiene in intensive care units: a matter of time?

J.T. Stahmeyer, B. Lutze, T. von Lengerke, I.F. Chaberny, C. Krauth

- **7.6s:** Average duration of hand disinfection
- **10 min/patient/shift:** Time spent on hand hygiene
- **64 min/patient/shift:** Estimated time spent with adherence to guidelines

Compliance with hand hygiene guidelines is time consuming and needs to be considered in staff planning.
“We only hire people who are willing to take on more than they can handle.”
KEEP CALM AND LET OTHERS DO THE WORK
Enhanced performance feedback and patient participation to improve hand hygiene compliance of health-care workers in the setting of established multimodal promotion: a single-centre, cluster randomised controlled trial

Andrew James Stewardson, Hugo Sax, Angèle Gayet-Ageron, Sylvie Touveneau, Yves Longtin, Walter Zingg, Didier Pittet

67 randomised

22 assigned enhanced performance feedback and patient participation

- Additional patient participation:
  - Remind HCW to perform hand hygiene
  - Performance of hand hygiene (patient indications)

24 assigned enhanced performance feedback

- Monitoring
  - Immediate verbal feedback
  - Individualized written advice

21 assigned to standard multimodal promotion

- Monitoring
  - Annual feedback to department heads/directors/executive board

Hand hygiene compliance increased in all groups.
Neither intervention had a clinically significant effect compared to the control group.
Improvement in control wards might reflect cross-contamination.

<table>
<thead>
<tr>
<th></th>
<th>Number of hand hygiene actions</th>
<th>Number of hand hygiene opportunities</th>
<th>Mean compliance* (95% CI)</th>
<th>Absolute change* † (95% CI)</th>
<th>Odds ratio* (95% CI)</th>
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<tbody>
<tr>
<td><strong>Overall hand hygiene</strong></td>
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<tr>
<td>Control</td>
<td></td>
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</tr>
<tr>
<td>Baseline</td>
<td>935</td>
<td>1430</td>
<td>66% (62-70)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Intervention</td>
<td>1631</td>
<td>2239</td>
<td>73% (70-77)</td>
<td>7% (4-10)</td>
<td>1.41 (1.21-1.63)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>631</td>
<td>949</td>
<td>70% (66-75)</td>
<td>4% (0-8)</td>
<td>1.21 (1.00-1.47)</td>
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<tr>
<td>Enhanced performance feedback</td>
<td></td>
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<tr>
<td>Baseline</td>
<td>1040</td>
<td>1629</td>
<td>65% (62-69)</td>
<td></td>
<td>1</td>
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<tr>
<td>Intervention</td>
<td>2160</td>
<td>2920</td>
<td>75% (72-77)</td>
<td>10% (7-13)</td>
<td>1.61 (1.41-1.84)</td>
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<tr>
<td>Follow-up</td>
<td>1356</td>
<td>1956</td>
<td>72% (68-75)</td>
<td>7% (4-10)</td>
<td>1.38 (1.19-1.60)</td>
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<tr>
<td>Enhanced performance feedback plus patient participation</td>
<td>1024</td>
<td>1594</td>
<td>66% (62-70)</td>
<td></td>
<td>1</td>
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<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td>11% (8-14)</td>
<td>1.73 (1.51-1.98)</td>
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<tr>
<td>Intervention</td>
<td>2107</td>
<td>2767</td>
<td>77% (74-80)</td>
<td></td>
<td>1.36 (1.18-1.57)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>1485</td>
<td>2100</td>
<td>72% (69-76)</td>
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</table>

Significant increase in hand hygiene adherence (OR 1.68, 95%CI 1.45-1.79)

Text message feedback should be incorporated into multimodal approaches for improving hand hygiene compliance...
“If you can’t stand my constant yapping, should I just text you?”
Simpler...
Faster...
Better?
Research note

Simplifying the WHO ‘how to hand rub’ technique: three steps are as effective as six—results from an experimental randomized crossover trial

S. Tschudin-Sutter 1,*, M.L. Rotter 2, R. Frei 1, D. Nogar 1, P. Häusermann 3, A. Strand 1, D. Pittet 4, A.F. Widmer 1
Assessment of simplified three-step technique compared to the conventional WHO six-step technique in terms of bacterial count reduction...
Logarithmic reduction factor in the intervention group as compared to the WHO reference group:

median 4.45, IQR 4.04-5.15 vs.
median 3.91, IQR 3.69-4.62

The proposed 3-step technique is easier to perform and could improve adherence to the execution of hand hygiene action.
The mean bacterial reduction after 15s of hand rubbing was 0.11 log$_{10}$ lower (95% CI, −0.46 to 0.24) than after 30 s, demonstrating non-inferiority...
Relationship between hospital ward design and healthcare-associated infection rates: a systematic review and meta-analysis

Andrea Stiller*, Florian Salm, Peter Bischoff and Petra Gastmeier

“Is it true the building’s sinking?”
Location of hand rub dispensers:
Significant improvement of hand hygiene compliance/agent consumption with the implementation of accessible dispensers near the patient bed (3 studies).

Single- vs. multi bedrooms and colonization with (multi-)drug resistant pathogens or infection with any pathogen:
Enhanced terminal room disinfection and acquisition and infection caused by multidrug-resistant organisms and *Clostridium difficile* (the Benefits of Enhanced Terminal Room Disinfection study): a cluster-randomised, multicentre, crossover study


To determine the effect of three enhanced strategies for terminal room disinfection (disinfection of a room between occupying patients) on acquisition of:

- methicillin-resistant *Staphylococcus aureus* (MRSA)
- vancomycin-resistant enterococci (VRE)
- *C. difficile*
- multidrug-resistant *Acinetobacter*
Standard terminal disinfection:
• quaternary ammonium
• bleach for *C. difficile*

Enhanced terminal disinfection with UV-C following:
• quaternary ammonium
• bleach for *C. difficile*

Enhanced terminal disinfection with bleach

Enhanced terminal disinfection with UV-C following bleach
<table>
<thead>
<tr>
<th>Intention-to-treat analysis (RR/95%CI)</th>
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<tr>
<td>All target organisms</td>
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<tr>
<td><em>C. difficile</em></td>
</tr>
<tr>
<td>MRSA</td>
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<tr>
<td>VRE</td>
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</table>

<table>
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<tr>
<th>Per-protocol analysis (RR/95%CI)</th>
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<tbody>
<tr>
<td>All target organisms</td>
</tr>
<tr>
<td><em>C. difficile</em></td>
</tr>
<tr>
<td>MRSA</td>
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<tr>
<td>VRE</td>
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</tbody>
</table>

- Patients admitted to rooms previously occupied by patients harbouring target organism were 10–30% less likely to acquire the same organism if the room was terminally disinfected using an enhanced strategy.
- The largest risk reduction occurred when a UV-C device was added to the standard disinfectant strategy.
"Let me guess... it's contagious!"
With contact precautions:

- 28.5% intensive care unit and 19% medicine/surgery beds were on CP for MRSA/VRE.
- Estimated nursing time spent donning personal protective equipment for MRSA/VRE was 45,277 hours/year (estimated cost, $4.6 million).

With CP: 0.40/100 admissions
After CP: 0.32/100 admissions, p=0.09

Chlorhexidine gluconate bathing expanded to all units

With CP: 0.48/100 admissions
After CP: 0.40/100 admissions, p=0.14
Transmissibility of *Clostridium difficile* Without Contact Isolation: Results From a Prospective Observational Study With 451 Patients

Andreas F. Widmer,1 Reno Frei,2 Stefan Erb,1 Anne Stranden,1 Ed J. Kuijper,3 Cornelis W. Knetsch,3 and Sarah Tschudin-Sutter1

Providing:
- Non-hypervirulent PCR ribotypes (027 and 078).
- Absence of stool incontinence.
- Strict adherence to standard precautions.
- Allocation of dedicated toilets.
- 91.3% of beds in 1-2-bed rooms.

Rate of transmission: 1.3% (6/451)
C. difficile – what really works?
Decline of CDI incidence 80% after 2006 after implementation of national control policies including:

- Avoidance of cephalosporins, clindamycin
- Minimization of quinolone use
- Improved infection prevention and control strategies
• *C. difficile* decline was driven by elimination of fluoroquinolone-resistant isolates:
• Restricting fluoroquinolone prescribing appears to explain the decline in incidence of CDI, above other measures.

**Antimicrobial stewardship should be a central component of *C. difficile* infection control programmes.**

Effect of a national 4C antibiotic stewardship intervention on the clinical and molecular epidemiology of *Clostridium difficile* infections in a region of Scotland: a non-linear time-series analysis

Timothy Lawes, José-Maria Lopez-Lozano, Cesar A Nebot, Gillian Macartney, Rashmi Subbanna-Sharma, Karen D Wares, Carolyn Sinclair, Ian M Gould

- National antibiotic stewardship intervention limiting the use of 4C antibiotics (fluoroquinolones, clindamycin, co-amoxiclav, and cephalosporins).
- Reduction by 50% in both hospital and community settings.
- CDI prevalence density fell by 68% (mean reduction 1.01/1000 occupied bed-days, 0.27–1.76, p=0.008) in hospitals and 45% (0.083, 0.045–0.121 cases per 100'000 inhabitant-days, p<0.0001) in the community, during antibiotic stewardship.
Unusual outbreaks and new challenges in infection control...
Chasing *mycobacterium chimaera*...
Mycobacterium chimaera outbreak

• At least 70 cases of invasive infections after open-chest heart surgery reported from
  – Switzerland
  – The European Union
  – The United States
  – Australia and New Zealand
• Associated with heater-cooler devices (HCDs) as functional part of extracorporeal circulation connected to the cardiopulmonary bypass machine.
• Clinical presentation as prosthetic valve endocarditis, disseminated infections, or infections of vascular grafts.
• Mortality approximately 50%.

M. chimaera in the exhaust air of contaminated HCDs when water is contaminated.

Airborne transmission to patients may occur potentially due to a single colony forming unit settling on prosthetic material, followed by in situ replication and subsequent dissemination.
The source of the outbreak...

- Outbreak investigation revealed a common link to the LivaNova 3T heater-cooler device (London, United Kingdom; formerly Sorin Group, Milan, Italy).
- Sequencing data from different centers revealed close relatedness of strains recovered from patients and water and air samples from the device.
- Testing at the LivaNova manufacturing site in Germany confirmed the presence of *M. chimaera* in samples taken in the pump assembly area and in brand new HCDs.

A hospital independent common source at the manufacturing site is responsible for most of the outbreak.

*Perkins KM, et al. MMWR 2016;65:1117–1118*
**Mycobacterium chimaera** Spread from Heating and Cooling Units in Heart Surgery

- 48 *M. chimaera* samples from Australia and New Zealand (5 patient samples).
- *M. chimaera* isolates associated with heating and cooling units across Australia and New Zealand were frequently indistinguishable at a core genome level.
- Comparisons of the *M. chimaera* genome data from one patient with recently released sequences from tests of heating and cooling units in the Northern hemisphere, revealed high level of DNA sequence conservation (median difference 6 SNPs).

Recent spread from a common source.

<table>
<thead>
<tr>
<th>Application</th>
<th>Recommendation</th>
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<tbody>
<tr>
<td>For all healthcare systems</td>
<td>Educate clinicians to consider <em>M. chimaera</em> or other NTM as infectious etiology in patients with a history of exposure to HCD and corresponding signs and symptoms.</td>
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<td>Screen patients with a history of open heart surgery, heart transplantation, or exposure to ventricular assist devices and one of the following conditions for mycobacteria:</td>
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<tr>
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<td>• Culture-negative prosthetic valve endocarditis</td>
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<td>• Culture-negative or treatment-refractory sternotomy wound infection, mediastinitis, or aortic graft infection</td>
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<td>• Fever of unknown origin</td>
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<td>• Vasculitis</td>
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<td>• Sarcoidosis</td>
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<tr>
<td>For all hospitals using HCDs</td>
<td><strong>Education of clinicians</strong></td>
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<td><strong>Screening of patients with exposure to heater-cooler units and corresponding signs and symptoms</strong></td>
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<td><strong>Separation of the heater-cooler devices from the operation room air (applies especially to LivaNova/Sorin HCDs)</strong></td>
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Separation of the heater-cooler device from the operation room...

- Despite intensified maintenance protocols (daily water changes with hydrogen peroxide and biweekly disinfection cycles), emergence of *M. chimaera* occurred in a new LivaNova 3T HCDs after 7–12 months.

- The construction of a custom built housing with active suction of the exhaust air out of the OR.

- Placement outside of the OR in a space with separate air ventilation.


**Candida auris**

- First description in 2009 in Japan as a cause of otitis media.
- Cause of otitis media in 15 patients from Korea.
- Subsequent cases of invasive infection (bloodstream) from
  - South Korea
  - India
  - South Africa
  - Kuwait
  - Pakistan
  - Venezuela
- Resistant to fluconazole, variable susceptibility to other azoles, amphotericin B, and echinocandins.
- Outbreak investigation was started in 2015...
Simultaneous Emergence of Multidrug-Resistant *Candida auris* on 3 Continents Confirmed by Whole-Genome Sequencing and Epidemiological Analyses

54 patients from Pakistan, India, South Africa, Venezuela

- 41% were receiving systemic antifungal therapy when *C. auris* was isolated.
- Median time from admission to infection: 19 days (IQR 9–36 days).
- 61% of patients had bloodstream infection.
- 59% died.
• Unique clades grouped by geographic region.

• Emerging healthcare-associated pathogen with high mortality.

• Limited treatment options.

• Recent, nearly simultaneous, independent emergence on 3 continents.
First seven U.S. cases of *C. auris* infection reported to CDC as of August 31, 2016.
Transmission of *C. auris* might have occurred in U.S. health care facilities.
Need for attention to infection control measures to control the spread of this pathogen.
First hospital outbreak of the globally emerging *Candida auris* in a European hospital

Silke Schelenz, Ferry Hagen, Johanna L. Rhodes, Alireza Abdulrasouli, Anuradha Chowdhary, Anne Hall, Lisa Ryan, Joanne Shackleton, Richard Trimlett, Jacques F. Meis, Darius Armstrong-James, and Matthew C. Fisher

- Ongoing outbreak of *C. auris* in a London cardio-thoracic center between April 2015 and July 2016.
- 50 patients affected.
- 44% of patients developed infection.
- 18% developed candidaemia.
• Minimum contact period with a positive case or a contaminated environment for the acquisition of *C. auris* was ≥4 h.

• Environmental sampling of the clinical area surrounding colonized patients demonstrated contamination with *C. auris* of the floor around bed sites, trollies, radiators, windowsills, equipment monitors and key pads, and also one air sample.

• High degree of relatedness suggests a **single introduction** of the infecting genotype into the hospital.
Infection control measures...

- **In the UK:**
  - Contact precautions
  - Decolonization with 2% chlorhexidine gluconate
  - Chlorhexidine impregnated disks for central vascular catheter exit sites
  - Cleaning and disinfection of the patient rooms and equipment using chlorine based products 3x/d times.
  - Terminal cleaning with chlorine based detergent disinfection with hydrogen peroxide vapour.

- **CDC**
  - Standard and contact precautions for patients colonized or infected with *C. auris*.
  - Daily and terminal cleaning of rooms including use of an EPA-registered disinfectant with a fungal claim.
Infection control in the age of sequencing...
Hospitalized 21 times and harbouring 9 organisms containing the $bla_{KPC-3}$ gene, belonging to 3 different species.

Mostly grouped with other patients carrying KPC-producing Enterobacteriaceae.
• While some of the strains and plasmids differed over time, the \( \text{bla}_{\text{KPC-3}} \) gene of all isolates revealed nucleotide identity of 100%.

• The diversity of KPC-producing Enterobacteriaceae may have arisen from the spread of the resistance element within the host, exposure to other KPC-colonized patients, or both.

Limitations of conducting investigations of carbapenemase outbreaks with traditional epidemiologic and molecular tools...
Comprehensive resistome analysis reveals the prevalence of NDM and MCR-1 in Chinese poultry production

Yang Wang¹, Rongmin Zhang¹, Jiyun Li¹, Zuowei Wu², Wenjuan Yin¹, Stefan Schwarz³,⁴, Jonathan M. Tyrrell⁵, Yongjun Zheng⁶, Shaolin Wang⁷, Zhangqi Shen⁷, Zhihai Liu⁷, Jianye Liu⁷, Lei Lei⁷, Mei Li⁵,⁷, Qidi Zhang⁸, Congming Wu¹, Qijing Zhang², Yongning Wu⁹, Timothy R. Walsh⁵* and Jianzhong Shen¹*

• To understand the epidemiology of multidrug-resistant E. coli (blaNDM and mcr-1 marker genes) in China, Shandong Province.
• Samples from poultry, dogs, sewage, wild birds and flies.
• Carbapenem-resistant Enterobacteriaceae (CRE): 33.2% of all samples, of which 23% were also positive for mcr-1.
“Common $bla_{NDM}$-positive *E. coli* shared among farms, flies, dogs and farmers, provides direct evidence of carbapenem-resistant *E. coli* transmission and environmental contamination.”

• This is the first published study linking flies to the spread of carbapenem resistance.
• Their ability to contaminate the environment gives rise to immense public health concerns....

From April 2017, China will implement the withdrawal of colistin as a growth promoter, removing over 8,000 tonnes per year from the Chinese farming sector...
In conclusion...

• When it comes to old foes, some of the targeted infection control interventions are being increasingly challenged, while horizontal prevention strategies, such as environmental cleaning, changes of infrastructure and universal decolonization, as well as antibiotic stewardship are gaining ground...

• We seem to need to rely on targeted interventions to deal with emerging pathogens and contamination of devices still plays an important role as a source for outbreaks in this day and age...

• Increasing availability of sequencing, provides the opportunity to track transmission chains and outbreaks across species and continents underscoring the need to link this data with relevant epidemiological observations to derive meaningful conclusions...
Thank you for your attention!