**Environmental Cleaning/Disinfection and Microbial Resistance**
**Prof. Markus Dettenkofer, University of Freiburg**
**Teleclass sponsored by Diversey (www.diversey.com)**

## Environmental Cleaning / Disinfection and Microbial Resistance

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## Cleaning

Cleaning in healthcare facilities:

- What must be cleaned ? Whatever is dirty or dusty !

*Franz Daschner Freiburg, Germany:*
*"A hospital must be an absolutely clean place"*



## Disinfection

- Elimination of pathogenic micro-organisms (excluding spores)
- Reduction level >= 5 log CFU (3 log CFU for surfaces)
- High-level disinfection: Killing of all microbial pathogens except large numbers of bacterial spores
- *Low-level disinfection:* Killing of most vegetative bacteria and lipid-enveloped viruses



## Commonly used Disinfectants (surfaces)

- Alcohols (ethanol, propanol) fast antimicrobial action (60% to 90% concentr.), excellent environmental properties
- Peracetic acid, hydrogen peroxide oxidizing high-level disinf., good environm. properties, corrosive
- Quaternary ammonium compounds (quats, i.e. benzalkoniumchloride) low-level disinf., allergens, environm. concerns
- Chlorine and chlorine-releasing compounds (i.e. sodium hypochlorite) high-level disinf. (>1,000 ppm); environmental concerns
- Glucoprotamine broad spectrum, good material compatibility, non-irritating



## How long do nosocomial pathogens persist on inanimate surfaces?

**A systematic review**

*"CONCLUSION:*
*The most common nosocomial pathogens may well survive or persist on surfaces for months …*
*and can thereby be a continuous source of transmission if no regular preventive surface disinfection is performed."* **?**

Kramer A et al.: BMC Infect Dis 2006; 6:130



## Patient environment



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## Pathogens in the hospital environment

- Some pathogens, notably *Pseudomonas spp.*, mostly in damp places (sinks, showers and baths)
- *C. difficile* and enterococci/VRE, prefer toilet areas or commodes
- Staphylococci (including MRSA) and *Acinetobacter* settle on surfaces such as shelves, equipment
- *Klebsiella spp.* and *Serratia spp.*: buckets, bowls, mops and liquids
- Norovirus: widely spread during outbreaks

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## Role of hospital surfaces in the transmission of emerging health care-associated pathogens: Norovirus, *C. difficile*, and Acinetobacter spp.

- Evidence suggests that environmental contamination plays a role in the nosocomial transmission of norovirus, *C. difficile*, and *Acinetobacter spp.*
- Infections have been associated with frequent surface contamination (hospital rooms and health care worker hands)
- In some cases, the extent of patient-to-patient transmission has been found to be directly proportional to the level of environmental contamination

Weber DL et al., AJIC 2010;38:S25

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## Multi-resistant Gram-negative versus Gram-positive bacteria in the hospital environment (I)

- 20 different locations around 190 patients surveyed (harbouring multi-resistant Gram-pos. or Gram-neg. bacteria)
- Detection rate for MRSA or VRE: 24.7% (174/705); multi-resistant Gram-neg. bacteria: 4.9% (89/1827) (P<0.001)
- Gram-pos. bacteria isolated more frequently than Gram-neg. from hands of patients (P<0.001) and personnel (P=0.115)

Lemmen SW et al.: JHI 2004; 56: 191

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## Multi-resistant Gram-negative versus Gram-positive bacteria in the hospital environment (II)

- Environmental contamination did not differ between ICUs and the general wards (GW)
- "… noteworthy because our ICUs are routinely disinfected twice a day, whereas GWs are cleaned just once a day with detergent."

Lemmen SW et al.: JHI 2004; 56: 191

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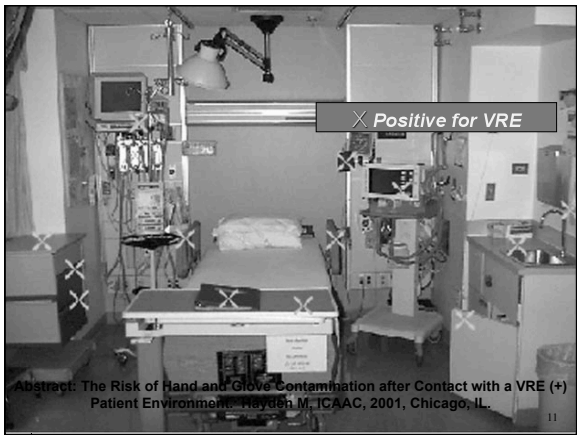


Abstract: The Risk of Hand and Glove Contamination after Contact with a VRE (+) Patient Environment. Hayden M. ICAAC, 2001, Chicago, IL.

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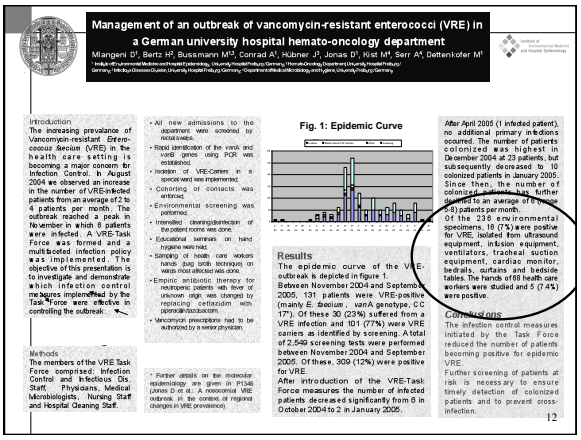

**Management of an outbreak of vancomycin-resistant enterococci (VRE) in a German university hospital hemato-oncology department**

Mlangeni D¹, Bertz H², Bussmann M³, Conrad A¹, Hübner J³, Jonas D¹, Kist M³, Serr A⁴, Dettenkofer M¹

Introduction
The increasing prevalance of Vancomycin-resistant *Enterococcus faecium* (VRE) in the health care setting is becoming a major conern for Infection Control. In August 2004 we observed an increase in the number of VRE-infected patients from an average of 2 to 4 patients per month. The outbreak reached a peak in November in which 8 patients were infected. A VRE-Task Force was formed and a multifaceted infection policy was implemented. The objective of this presentation is to investigate and demonstrate which infection control measures implemented by the Task Force were effective in controlling the outbreak.

Methods
The members of the VRE Task Force comprised: Infection Control and Infectious Dis. Staff, Physicians, Medical Microbiologists, Nursing Staff and Hospital Cleaning Staff.

- All new admissions to the department were screened by rectal swabs.
- Rapid identification of the vanA and vanB genes using PCR was established.
- Isolation of VRE-Carriers in a specialized ward was implemented.
- Cohorting of contacts was enforced.
- Environmental screening was performed.
- Intensified cleaning/disinfection of the patient rooms was done.
- Educational seminars on hand hygiene were held.
- Sampling of health care workers hands (pulp broth technique) on wards most affected was done.
- Empiric antibiotic therapy for neutropenic patients with fever of unknown origin was changed by replacing ceftazidim with piperacillin/tazobactam.
- Vancomycin prescriptions had to be authorized by a senior physician.

* Further details on the molecular epidemiology are given in P134B (Jonas D et al.: A nosocomial VRE outbreak in the context of regional changes in VRE prevalence)

Fig. 1: Epidemic Curve

Results
The epidemic curve of the VRE-outbreak is depicted in figure 1. Between November 2004 and September 2005, 131 patients were VRE-positive (mainly *E. faecium* , vanA genotype, CC 17). Of these 30 (23%) suffered from a VRE infection and 101 (77%) were VRE carriers as identified by screening. A total of 2,549 screening tests were performed between November 2004 and September 2005. Of these, 309 (12%) were positive for VRE.
After introduction of the VRE-Task Force measures the number of infected patients decreased significantly from 8 in October 2004 to 2 in January 2005.

After April 2005 (1 infected patient), no additional primary infections occurred. The number of patients colonized was highest in December 2004 at 23 patients, but subsequently decreased to 10 colonized patients in January 2005. Since then, the number of colonized patients has further declined to an average of expected 5-8) patients per month.
Of the 236 environmental specimens, 18 (7%) were positive for VRE, isolated from ultrasound equipment, infusion equipment, ventilators, tracheal suction equipment, cardiac monitor, bedrails, curtains and bedside tables. The hands of 68 health care workers were studied and 5 (7.4%) were positive.

Conclusions
The infection control measures initiated by the Task Force reduced the number of patients becoming positive for epidemic VRE.
Further screening of patients at risk is necessary to ensure timely detection of colonized patients and to prevent cross-infection.

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## Contamination after contact with VRE-colonized patients

- Observational study (routine clinical care)
- Medical ICU (700-bed, tertiary-care teaching hospital, Chicago)
- Proportions of body sites and environmental sites positive for VRE highly correlated (r = 0.7; P < .001)
- HCWs nearly as likely to have contaminated their gloved or ungloved hands after touching an environmental surface in the room of a VRE+ patient as after touching both the patient and the patient's environment
- Rates of contamination: 52% and 70%, respectively

Hayden MK et al.: ICHE 2008; 29: 149

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## Reduction in acquisition of VRE after enforcement of routine environmental cleaning measures (I)

- Effects of improved environmental cleaning (with and without promotion of hand hygiene) on spread of VRE in a medical ICU (748 admissions, 9-month)
- Baseline (period 1)
  improved environmental cleaning (period 2)
  "washout" (period 3)
  multimodal hand hygiene intervention (period 4)

Hayden MK et al.: CID 2006; 42: 1552

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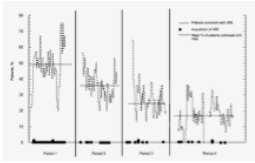
## Reduction in acquisition of VRE after enforcement of routine environmental cleaning measures (II)

- VRE acquisition rates:
  33.5 cases per 1000 patient-days at risk (period 1)
  16.8, 12.1, and 10.4 cases per 1000 pt.-days (periods 2, 3, 4)



Hayden MK et al.: CID 2006; 42: 1552

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## Reduction in acquisition of VRE after enforcement of routine environmental cleaning measures (III)

- Hazard ratio for acquiring VRE during periods 2-4: 0.36 (95% CI: 0.19-0.68)
- Only determinant explaining the difference in VRE acquisition was admission to the intensive care unit during period 1
- CONCLUSIONS: Decreasing environmental contamination may help to control the spread of some antibiotic-resistant bacteria in hospitals

Hayden MK et al.: CID 2006; 42: 1552

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## Environmental cleaning intervention and risk of acquiring MDROs from prior room occupants

[Datta R et al., Arch Intern Med 2011; 171: 491]

**METHODS:**

**Feedback: black-light marker, cleaning cloths saturated with disinfectant, increased education**

**RESULTS:**

**Acquisition of MRSA and VRE lowered: 3.0%=>1.5% for MRSA and 3.0%=>2.2% for VRE (P < .001, both)**

***Patients in rooms previously occupied by VRE carriers: increased risk of acquisition during baseline (4.5% vs 2.8%) and intervention periods (3.5% vs 2.0%, P < .001, both)***

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## Environmental cleaning intervention and risk of acquiring MDROs from prior room occupants

[Datta R et al., Arch Intern Med 2011; 171: 491]

**CONCLUSIONS:**

**Enhanced ICU cleaning (intervention methods may reduce MRSA and VRE transmission**

**It may also eliminate the risk of MRSA acquisition due to an MRSA-positive prior room occupant**

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## *Clostridium difficile* skin contamination in patients with *C. difficile*–associated disease

- Prospective study of 27 patients with CDAD
- *C. difficile* frequently contaminated multiple skin sites: groin, chest, abdomen, forearms, and hands
- *C. difficile* was easily acquired on investigators' hands
- Skin contamination often persisted on patients' chest and abdomen after resolution of diarrhea

Bobulsky GS et al., CID 2008; 46: 447

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## *Clostridium difficile* skin contamination in patients with CDAD

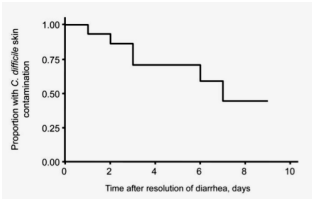


**Figure 2.** Kaplan-Meier estimation of time from resolution of diarrhea (day 0) to negative results of culture specimens of abdomen and/or chest skin of patients with *Clostridium difficile*–associated disease.

Bobulsky GS et al., CID 2008; 46: 447

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## Effect of detergent vs. hypochlorite cleaning on environmental contamination and incidence of *C. difficile* infection

- Cross-over study on two elderly medicine wards to determine whether cleaning with a hypochlorite disinfectant was better than using neutral detergent
- Significant decrease of CDI incidence on ward X, from 8.9 to 5.3 cases per 100 admissions ($P < 0.05$) using hypochlorite; incidence of CDI significantly associated with the proportion of culture-positive environmental sites ($P < 0.05$)
- Use of hypochlorite for environmental cleaning may significantly reduce incidence of CDI (but: potential for confounding factors)

Wilcox MH et al., Journal of Hospital Infection 2003; 54: 109–14

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Anesthesia Patient Safety Foundation

Section Editor: Sorin J. Brull

CME

### Multiple Reservoirs Contribute to Intraoperative Bacterial Transmission

Randy W. Loftus, MD,* Jeremiah R. Brown, PhD, MS,† Matthew D. Koff, MD, MS,* Sundara Reddy, MD,‡ Stephen O. Heard, MD,§ Hetal M. Patel, BS, MLT,* Patrick G. Fernandez, MD,* Michael L. Beach, MD,* Howard L. Corwin, MD,‖ Jens T. Jensen, MS,* David Kispert, BA,* Bridget Huysman, BA,* Thomas M. Dodds, MD,* Kathryn L. Ruoff, PhD,¶ and Mark P. Yeager, MD*

**BACKGROUND:** Intraoperative stopcock contamination is a frequent event associated with increased patient mortality. In the current study we examined the relative contributions of anesthesia provider hands, the patient, and the patient environment to stopcock contamination. Our secondary aims were to identify risk factors for stopcock contamination and to examine the prior association of stopcock contamination with 30-day postoperative infection and mortality. Additional microbiological analyses were completed to determine the prevalence of bacterial pathogens within intraoperative bacterial reservoirs. Pulsed-field gel electrophoresis was used to assess the contribution of reservoir bacterial pathogens to 30-day postoperative infections.

Loftus RW et al., Anesthesia-Analgesia 2012; 114: 1236

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## Multiple reservoirs contribute to intraoperative bacterial transmission

- Multicenter study: stopcock transmission events observed in 274 operating rooms; 1st and 2nd cases of the day in each OR studied in series to identify within- and between-case transmission
- Stopcock contamination detected in 23% (126 out of 548 cases)
- The environment was a more likely source of stopcock contamination than provider hands (RR 1.91, CI 1.09 - 3.35, P = 0.029) or patients (RR 2.56, CI 1.34 - 4.89, P = 0.002)
- Stopcock contamination associated with increased mortality (OR 58.5, CI 2.32 - 1477, P = 0.014)

Loftus RW et al., Anesth Analg 2012; 114: 1236-48

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## Surface disinfection
### German Guideline (2004)

Bundesgesundheitsbl - Gesundheitsforsch - Gesundheitsschutz 2004 · 47:51–61
DOI 10.1007/s00103-003-0752-9

Empfehlung

**Anforderungen an die Hygiene bei der Reinigung und Desinfektion von Flächen**

Empfehlung der Kommission für Krankenhaushygiene und Infektionsprävention beim Robert Koch-Institut (RKI)

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Tabelle 2
**Reinigungs- bzw. Desinfektionsmaßnahmen in verschiedenen Risikobereichen**

| Bereiche ohne Infektionsrisiko[a] | Bereiche mit möglichem Infektionsrisiko | Bereiche mit besonderem Infektionsrisiko | Bereiche mit Patienten, die Erreger so in oder an sich tragen, dass im Einzelfall die Gefahr einer Weiterverbreitung besteht |
|---|---|---|---|
| Alle Flächen: Reinigung | Flächen mit häufigem Hand-/Hautkontakt: Desinfektion (Kat. II), Fußböden: Reinigung, sonst. Flächen: Reinigung | Flächen mit häufigem Hand-/Hautkontakt: Desinfektion (Kat. IB), Fußböden: Desinfektion (Kat. II), sonst. Flächen: Reinigung | Flächen mit häufigem Hand-/Hautkontakt: Desinfektion (Kat. IB), Fußböden: Desinfektion (Kat. II), sonst. Flächen: Reinigung |

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## CONTRA surface disinfection?

- **Contra immediate removal of spillage (blood, urine, etc.) with a disinfectant/detergent? No**
- **Contra routine surface disinfection? (Yes)**

**Why?**

- ***"There is no difference in hospital-acquired infection rates when floors are cleaned with detergent vs. disinfectant"***
  [Rutala WA et al: J Hosp Infect 2001; 48 Suppl. A: 66]
- ***1 – 2 hours after floor disinfection identical number of bacteria as prior to disinfection***
  [Ayliffe GAJ et al. BMJ 1966; 2: 442]

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## Surface disinfection:
### Yes and No

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## How may disinfectants harm the environment?

- By causing resistant bacteria (QAV) and affecting sewage treatment performance
- By forming organic halogen compounds (AOX - especially sodium hypochlorite)
- By contaminating surface water

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## Bacterial adaption and resistance to antiseptics, disinfectants and preservatives

*"There are current concerns about the usage of quaternary ammonium compounds, chlorhexidine and triclosan and possible bacterial resistance to them and to antibiotics."*

*"It is thus essential that disinfectants should be employed only when necessary and then only with the full appreciation of the factors influencing their activity and of the mechanisms involved in bacterial insusceptibility."*

**[Russell AD: Bacterial adaption and resistance to antiseptics, disinfectants and preservatives is not a new phenomen. J Hosp Infect 2004, 57: 97-104]**

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## Use of antibacterial consumer products containing quaternary ammonium compounds and drug resistance

- **Exposure of bacteria to antibacterial-containing products (QACs) may exert a selective pressure resulting in the co-selection of genes encoding reduced susceptibility for both biocides and antibiotics**

Aiello AE, Larson EL, Levy SB. Consumer antibacterial soaps: effective or just risky? CID 2007; 45 Suppl 2: S137

Carson RT et al., JAC 2008; Aug. 11

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## Surface disinfection: efficacy and safety issues

- **Peroxygen compounds show good sporicidal properties and will probably replace more problematical substances such as chlorine-releasing agents**
- **Scientific data support the need for proper use of disinfectants, i.e. avoidance of widespread application, especially in low concentrations and in consumer products**
- **There is a need for well-designed studies addressing the role of disinfection in infection control**

Dettenkofer M, Block C. Curr Opin Infect Dis 2005;18:320-5
Dettenkofer M, Spencer RC. JHI 2007;65(S2):55–7

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## Hospital cleaning in the 21st century (I)

- **Cleaning practices should be tailored to clinical risk, given the wide-ranging surfaces, equipment and building design**
- **There is confusion between nursing and domestic personnel over the allocation of cleaning responsibilities (neither may receive sufficient training and/or time to complete their duties)**
- **Fear of infection encourages the use of powerful disinfectants for the elimination of real or imagined pathogens in hospitals**

Dancer S. Eur J Clin Microbiol Infect Dis 2011; 30: 1473–81

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## Hospital cleaning in the 21st century (II)

- **Not only do these agents offer false assurance against contamination, their disinfection potential cannot be achieved without the prior removal of organic soil (=cleaning)**
- **Hospital cleaning deserves further investigation for routine and outbreak practices**

Dancer S. Eur J Clin Microbiol Infect Dis 2011; 30: 1473–81

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## Proper cleaning procedures Targeted surface disinfection

Cleaning and disinfection are established components of hospital infection control, and special situations require special actions (infected or severely immuno-compromised patients; multi-resistant pathogens)

**Do not use surface disinfectants for convenience !**

***Routine* disinfection of frequently touched surfaces is indicated in special settings**

***But: Compliance with hand hygiene is of greater importance***


13 December **Microfibre Cleaning in Healthcare: Is it Really All it's Cracked Up To Be?**
Speaker: Dr. Michelle Alfa, St. Boniface Hospital Research Group, Winnipeg

www.webbertraining.com/schedulep1.php

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