

Role of the Environment & Healthcare-Associated Infection (HCAI)

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Declaration-1

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

I have received recent research funds from Pfizer & Astellas. I have also recently received professional fees from Pfizer.

Outline

- **Background & Introduction**
- **Examples for surfaces**
 - **Bacteria**
 - **Fungi & viruses**
- **Air & water**
- **Conclusions & Reflections**

Background & Introduction

HCAI & the Environment
Surfaces, Air & Water

Immediate area	ward, bed
Instruments	surgical, endoscopes
General	cleanliness building work

Why clean or decontaminate?

- Aesthetically pleasing
- Reassures patients & the public
- Contributes to preventing HCAI

Q. What is the evidence that the environment directly impinges on HCAI rates?

A. There is little incontrovertible evidence. Circumstantial evidence, e.g. outbreaks, observational studies & common sense (biological plausibility) tell us it is important, but it is difficult to quantify

Criteria for Considering if Contaminated Surfaces Cause HCAI

1. Temporal & geographical links
2. Pathogen survives on surfaces
3. Transmission from previous occupant of room
4. Similar clone from patient & surface
5. Enhanced decontamination reduces infections

Survival of Pathogens on Surfaces

Pathogen	Survival
<i>Acinetobacter</i> spp.	3 days to 5 months
<i>Clostridium difficile</i> (spores)	5 months
<i>E. coli</i>	1.5h – 16 months
<i>Enterococcus</i> spp.	5 days to 4 months
<i>S. aureus</i>	7 days – 7 months
<i>C. albicans</i>	1 – 120 days
Adenovirus	7 days – 3 months

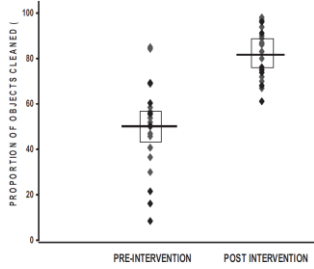
Vary according to pathogen, dry/wet surface, +/- protein

BMC Infect Dis 2006; 6: 130

The Problem & Challenges

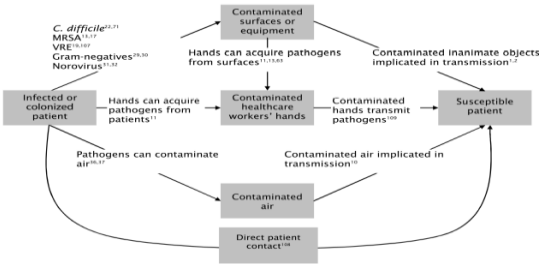
Decontamination, cleaning inadequate even in ICUs

Improved cleaning enhances aesthetics & reduces bioburden, but some pathogens may persist



Crit Care Med 2010; 38: 1054-1059

Hands, Air, Surfaces & Patients



Infect Control Hosp Epidemiol 2011; 32: 687-699

Examples on Surfaces

- Bacteria
- Fungi
- Viruses

What is the overall burden of multi-drug resistant organisms (MDRO)?

- Sponge wipes over > 1,000 cm, high touch non-critical surface
- 9 acute hospitals & 2 long term care facilities

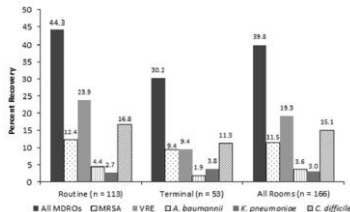
Results

- Door handles > telephone > remote call button for bacteria
- Over bed table > +ve for MDRO on 54% of samples
- Often MDRO discordant with patient in single room

Infect Control Hosp Epidemiol 2016; 37: 1426-1432

What is the overall burden of MDRO?

- Mean microbial burden of 2,700 cfu/100 cm²
- Terminally cleaned rooms with fewer bacteria



Infect Control Hosp Epidemiol 2016; 37: 1426-1432

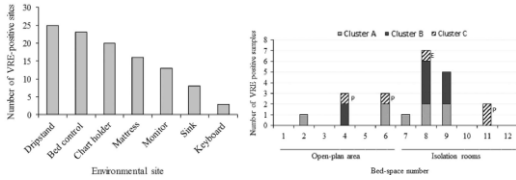
MRSA – Patients & the Environment

- 92/939 (10%) patients +ve for MRSA in extensive screening study
- 65/1,252 (5%) environmental sites positive adjacent to MRSA patients
- MRSA isolated from environment of MRSA-ve patients
- Sites +ve included
 - mattresses, 14%
 - air, 8%

Eur J Clin Microbiol Infect Dis 2012, 31:51-3161

Potential Reservoirs of VRE

- 107 (6.5%) sites +ve; more from single rooms
- 30% +ve from patient & environment at the same time
- 32 distinct types; 3 clusters



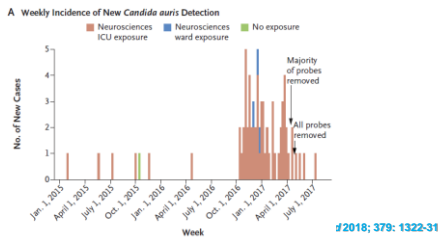
Infect Control Hosp Epidemiol 2018; 39: 40-45

Candida auris

- Emerging fungal pathogen
- May be multi-drug resistant
- Causes invasive infection
- Survives in the environment
- Cross-infection & outbreaks

Oxford ICU Outbreak

- 94% of C. auris in neurosciences ICU
- Re-usable equipment – temperature probe



J2018; 379: 1322-31

Human Parainfluenza & Norovirus in Offices

Table 3 Average concentrations of HPIVs and NoVs RNA copies/100 cm² in positive swab samples (mean values and standard deviations, SD) regarding to object category

Surface	Virus			
	HPIVs (HPIV1, HPIV3)		NoV GII	
	Mean value	SD	Mean value	SD
Keyboard	3.36×10^2	2.37×10^2	N.D.	N.D.
Computer mouse	5.90×10^1	2.20×10^1	N.D.	N.D.
Telephone	1.66×10^3	1.09×10^3	N.D.	N.D.
Desktop	4.85×10^2	4.65×10^2	N.D.	N.D.
Door handle	N.D.	N.D.	5.06×10^1	3.97×10^1
Light switch	N.D.	N.D.	1.40×10^2	8.09×10^1

N.D. not detected

Food Environment Vir 2018; 10: 133-140

C. difficile: A Novel Approach to Detection "It's a Dog's Life"

Train a Springer Spaniel; sensitivity, 92% & specificity, 95%



J Hosp Infect 2017; 97: 140-145

**Air
&
Water**

Air

- Does it matter in normal circumstances
- Isolation room issues
- Operating theatres or rooms

Water

- Aspects of *Pseudomonas aeruginosa*
- Legionella
- Carbapenemase-producing *Enterobacterales* (CPE)

Air-General

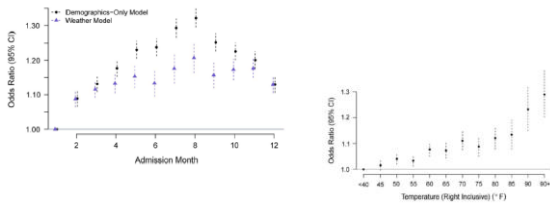
Air, ubiquitous, all around us, essential for life

Q. Does it normally matter in terms of temperature, humidity, airflow, etc.?

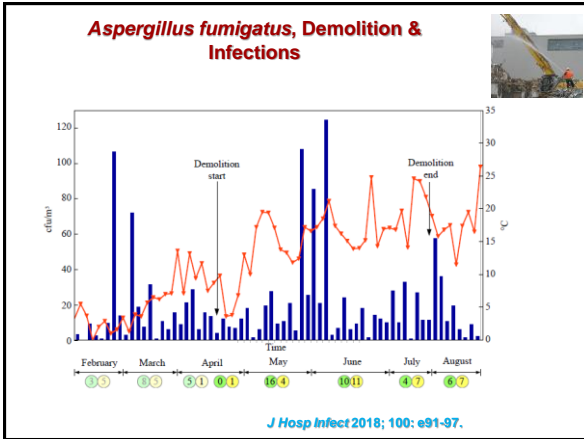
A. Most of the time no, but staff & patients should be comfortable

Seasonal Variability in Surgical Site Infection (SSI)

- 55,655,528 discharges from 2,512 hospitals
- Increase of SSI by 26.5% from January to August
- Seasonality greater for those patients in their 40s, 50s
- Odds of SSI increased by 2.1% per 2.8°C increase



Infect Control Hosp Epidemiol 2017; 38: 809-816



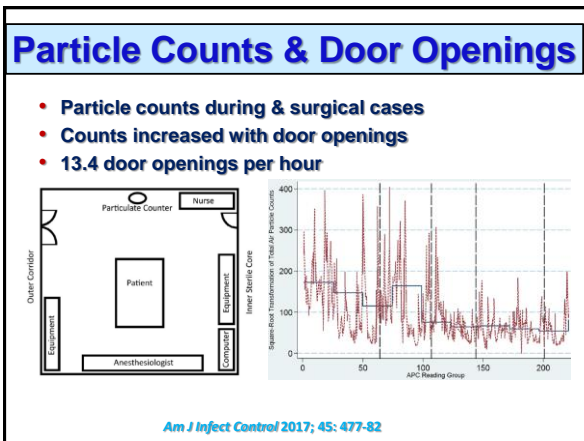
Operating Theatres (Rooms)

Role of Ventilation

- Removal of toxic gases/odours
- Comfort of surgical team
- Patient normothermia
- Prevention of infection

Airborne contamination of surgical wound by:

- Directly on to wound
- Via exposed/contaminated instruments



Isolation Rooms

- A. Standard room air pressures or none, e.g. contact precautions for MRSA**
- B. Positive room air pressure (protects the patient), e.g. neutropenic patient**
- C. Negative room air pressure (protects other patients), e.g. airborne transmission such as for TB**
- D. Negative & additional barriers, e.g. Ebola**

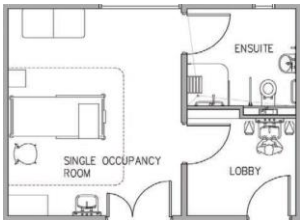
Get the Simple Things Right

- **Solid ceilings**
- **Sealed windows that can't be opened**
- **Appropriately hung door (open-in) with door closure**
- **19 air changes per hour (ACH)**
- **Ensuite negative to patient's room**

Health Building Note 04-01 2013

Airborne Isolation Room - Guidelines





- 1. 1 every 150 acute beds, but every 75 if regional or tertiary care hospital**
- 2. Ante-room should be at least 4m⁴**



Infection Prevention & Control Building Guidelines for Acute Hospitals in Ireland, 2009

What do you check & how?

Beaumont Hospital Infection Prevention & Control Team

No	Visual check item. Record observation	
Don appropriate PPE before entering the AIR if necessary		
1		Outside the ante room: <ol style="list-style-type: none"> Ensure all doors are in the closed position Look at the magnetic pressure sensor which is outside the ante room entrance <ul style="list-style-type: none"> Is the display reading more than 5pa?
2		Inside the anteroom: <ol style="list-style-type: none"> Stand in the ante-room Close all doors <ul style="list-style-type: none"> Is the flap over the patient's bedroom door partially open?
3		En-suite bathroom (if applicable) <ol style="list-style-type: none"> Close the bathroom door behind you <ul style="list-style-type: none"> Is the extract fan working? (Listen)
4		Outside the patient room (if applicable): <ol style="list-style-type: none"> Close the double doors leading into patient room for more than 5 minutes* After the 5 minutes have passed, look at the sensor* located on top of the double doors <ul style="list-style-type: none"> Is the light green?

Waterborne Infections

Abroad

- Typhoid fever
- Cholera

Community

- Cryptosporidiosis

Hospital

- Legionella
- Pseudomonas
- Non-tuberculosis mycobacteria
- CPE (sinks & drains)

Hand Wash Sinks

Clinical hand wash sinks should only be used for the purposes of hand washing

HPSC/HSE Guidelines, 2015

- Signage should be in place to communicate this instruction
- Clinical hand wash sinks must not be used for the disposal of any fluids including body fluids; use the dirty utility area / sluice room for this purpose
- Clinical hand wash sinks must not be used for the disposal of medications or nutritional feeds including breast and formula milk
- Clinical hand wash sinks must not be used for cleaning equipment
- Clinical hand wash sinks must not be used for storing equipment or other unnecessary items



Gridmann Commercial NSF



HTM 64 Counter 21

Potential Risk Areas/ Issues

Decorative Water Features
Ice-making machines
Endoscopy units

Haemodialysis
Dental chair units
Bathing pools & hydrotherapy

Augmented care units (e.g. ICUs)

Guidelines for the Prevention & Control of Infection from Water Systems in Healthcare Facilities



HPSC/HSE, 2015

Legionella species

L. pneumophila sero-group 1, is the most virulent

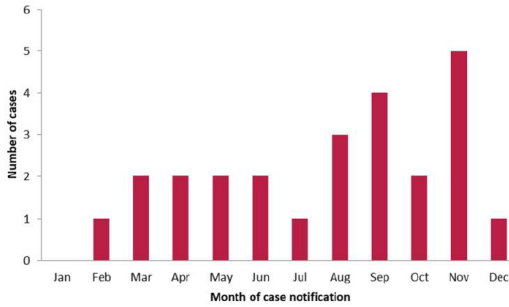
May be present in domestic & hospital water

Spread by aerosols, e.g. when first use an occasionally unused shower

Risk to patients & staff

Legionella Cases in Ireland, 2017

HPSC



Legionella – Risk Factors

Temperature of water, 25°C – 42°C

Water stagnation (dead legs)

Scale & sediment (tanks)

Free-living amoeba

Control of Nosocomial Legionellosis

Management & good systems in place

Estate maintenance of water systems, e.g. removal of 'dead legs' or unused outlets

Water testing

Routine, e.g. flushing

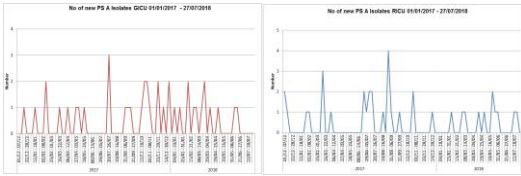
Additional, e.g. chlorine dioxide, copper/silver

Pseudomonas aeruginosa

- **Found in soil, water & gastrointestinal tract**
- **Survives in moist environments, e.g. fluid containers, equipment, sinks, etc.**
- **Causes**
 - Ventilator-associated pneumonia
 - Bloodstream infection
 - Urinary tract infection
- **Present in splashes, e.g. water should not flow directly from tap to drain hole**

Intensive Care Units

- **Good practice & design, such as sinks**
- **Surveillance of pseudomonas infections**



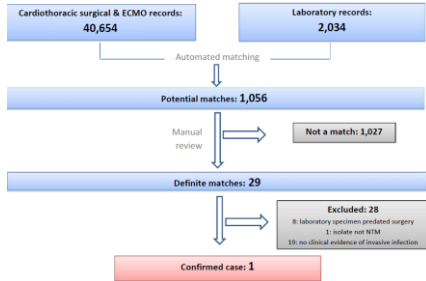
- **Water testing if outbreak & not routine**

Who does what where?

Health Protection Scotland, 2017

	Critical Control Point	Lead Responsibility
1	The hospital water delivery system	Estates
2	Flushing taps to reduce the risk of pipework system contamination	Senior charge nurse
3	Preventing direct water usage colonising/ infecting vulnerable patients	Senior charge nurse
4	Preventing indirect water usage from colonising/infecting patients	Senior charge nurse
5	Preparedness for clinical incidents and earliest possible detection of any clinical incidents	IPCTs
6	Prompt investigation and control measure application for any clinical incidents	IPCTs

Report of Case Finding Investigation to identify *Mycobacterium chimaera* Infections potentially associated with Heater-Cooler Units used during Cardiothoracic Surgery in Ireland HPSC, 2016



Conclusions & Future Directions

Environmental Sampling

- ✓ Not routinely indicated, except for water (e.g. for legionella, endoscope water)
- ✓ Occasionally indicated for outbreak management, e.g. is there a source
- ✓ Research studies ongoing to determine is the environment the 'chicken or the egg'
- ✓ Discuss first with infection prevention & control team & microbiology department
- ✓ Think beforehand what you will do with the results.....especially if unexpected

Conclusions (Surfaces)

- 1. A wide variety of microbes are detectable on surfaces
- 2. Most have adapted but may be antimicrobial resistant
- 3. Cross-transmission under-estimated & outbreaks are the tip of the iceberg
- 4. Routine cleaning is often inadequate

Conclusions (Air & Water)

- 1. Most patients exposed to air & water are not at risk most of the time
- 2. Isolation room design & maintenance are important for all
- 3. Ventilation & physical specifications are more important than sampling
- 4. Good design & effective estates department help prevent waterborne infections

Some Suggested Reading

- 1. Kramer *et al.* How long do nosocomial pathogens persist on inanimate surfaces? A systematic Review. *BMC Infect Dis* 2006; 6:130 doi: 10.1186/1471-2334-6-130
- 2. Otter JA, *et al.* The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Control Hospital Epidemiol* 2011; 32: 687-699
- 3. Dancer SJ. Controlling hospital-acquired infection; focus on the role of the environment and new technologies for decontamination. *Clin Micro Rev* 2014; 27: 665-90
- 4. Carling PC, Wastewater drains: Epidemiology and interventions in 23 carbapenem-resistant organism outbreaks. *Infect Control Hosp Epidemiol* 2018; 39: 972-979

Acknowledgements

- 1. Peter Hoffman, Public Health, England**
- 2. Caoimhe Finn, Infection Prevention & Control Nurse (AODN), Beaumont Hospital**
- 3. Maireád Skally, Surveillance Scientist**
- 4. Peter O'Donovan & Philip Shaw, Estates, Beaumont Hospital**
