The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

The role of water as a vector in the transmission of infections in hospitals

Dr. Jimmy Walker
Scientific Leader for Water and Decontamination, Biosafety
Public Health England

Hosted by Dr. Jean-Yves Maillard
Cardiff University, Wales

Outline

Implications and risks from using water?
Northern Ireland *P. aeruginosa* outbreak
What factors in a water system encourage biofilms?
Guidance and the role of water safety group
Can the risk be controlled?

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

1977, Pharmaceutical microbiology
W.B. Hugo and A.D. Russell


1984, The Revival of injured microbes / edited by M.H.E. Andrew and A.D. Russell

1990, Understanding antibacterial action and resistance.
A. D Russell and I Chopara.

1992, Principles and practice of disinfection, preservation, and sterilization

Drinking water standards

*Clostridium perfringens* is a type of bacterium which produces spores and can be present in the gut of warm blooded animals. Spores are particularly resistant to disinfection using chlorine and their presence in drinking water can be used to indicate a historic contamination.

*Escherichia coli* bacteria are widely distributed in the environment and provide a sensitive measure of the microbiological quality of the water supply.

*Colony counts* are general techniques for detecting a wide range of bacteria. They do not have any direct health significance and are used for trending purposes to assess the microbiological quality of drinking water.

- 2 day at 37°C
- 3 day at 22°C

0 per 100 ml

No abnormal change

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals

Dr. Jimmy Walker, Public Health England

A Webber Training Teleclass

### Table 7.1: Pathogens transmitted through drinking water

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Health significance</th>
<th>Persistence in water supplies</th>
<th>Resistance to chlorine</th>
<th>Relative infectivity</th>
<th>Important animal source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burkholderia pseudomallei</td>
<td>High</td>
<td>May multiply</td>
<td>Low</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>Campylobacter jejuni, C. coli</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>Yes</td>
</tr>
<tr>
<td>Escherichia coli - Pathogenic</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Yes</td>
</tr>
<tr>
<td>E. coli – Enterohaemorrhagic</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>High</td>
<td>Yes</td>
</tr>
<tr>
<td>Francisella tularensis</td>
<td>High</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>Yes</td>
</tr>
<tr>
<td>Legionella spp.</td>
<td>High</td>
<td>May multiply</td>
<td>Low</td>
<td>Moderate</td>
<td>No</td>
</tr>
<tr>
<td>Listeria</td>
<td>High</td>
<td>Long</td>
<td>Low</td>
<td>High</td>
<td>Yes</td>
</tr>
<tr>
<td>Mycobacteria (non-tuberculous)</td>
<td>Low</td>
<td>May multiply</td>
<td>High</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>Salmonella Typhi</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>Other salmonellae</td>
<td>High</td>
<td>May multiply</td>
<td>Low</td>
<td>Low</td>
<td>Yes</td>
</tr>
<tr>
<td>Shigella spp.</td>
<td>High</td>
<td>Short</td>
<td>Low</td>
<td>High</td>
<td>No</td>
</tr>
<tr>
<td>Vibrio cholerae</td>
<td>High</td>
<td>Short to long</td>
<td>Low</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td><strong>Viruses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adenoviruses</td>
<td>Moderate</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>No</td>
</tr>
<tr>
<td>Astroviruses</td>
<td>Moderate</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>No</td>
</tr>
<tr>
<td>Enteroviruses</td>
<td>High</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>No</td>
</tr>
<tr>
<td>Hepatitis A virus</td>
<td>High</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>No</td>
</tr>
<tr>
<td>Hepatitis E virus</td>
<td>High</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>Potentially</td>
</tr>
<tr>
<td>Noroviruses</td>
<td>High</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>Potentially</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>High</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>Potentially</td>
</tr>
<tr>
<td>Sapoviruses</td>
<td>High</td>
<td>Long</td>
<td>Moderate</td>
<td>High</td>
<td>Potentially</td>
</tr>
<tr>
<td><strong>Protozoa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acanthamoeba spp.</td>
<td>High</td>
<td>May multiply</td>
<td>High</td>
<td>High</td>
<td>No</td>
</tr>
<tr>
<td>Cryptosporidium hominis</td>
<td>High</td>
<td>Long</td>
<td>High</td>
<td>High</td>
<td>Yes</td>
</tr>
</tbody>
</table>

According to an assessment commissioned by the United Nations, 4,000 children die each day as a result of diseases caused by ingestion of filthy water

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales

www.webbertraining.com
Opportunistic pathogens (OP) in drinking water distribution systems (DWDS)

<table>
<thead>
<tr>
<th>OP</th>
<th>Detection Frequency in DWDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Legionella</em> spp.</td>
<td>(57% / 85 cell equivalent, CE L⁻¹)</td>
</tr>
<tr>
<td><em>Mycobacterium</em> spp.</td>
<td>(88% / 324 CE L⁻¹)</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>(24% / 2 CE L⁻¹)</td>
</tr>
<tr>
<td><em>Vermamoeba vermiformis</em></td>
<td>(24% / 2 CE L⁻¹)</td>
</tr>
<tr>
<td><em>Acanthamoeba</em> spp.</td>
<td>(42% / 5 cyst equivalent, CE L⁻¹)</td>
</tr>
</tbody>
</table>

*Legionella* spp. - leading cause of drinking water disease burden in the USA (Beer et al 2015)


Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Journal of Hospital Infection
Volume 91, Issue 3, November 2015, Pages 271–274

Short report
Nosocomial outbreak of Pseudomonas aeruginosa associated with a drinking water fountain
D. Costco, A. Bousseau, S. Thévenot, X. Dufour, C. Lalande, C. Burucoa, O. Castel

Summary
Over a four-month period, ten patients were suspected of having acquired nosocomial infection to P. aeruginosa in the ear, nose, and throat department. Environmental and clinical isolates were compared. Only water from a drinking water fountain was contaminated by P. aeruginosa. This isolate and those of three patients had indistinguishable random amplified polymorphic DNA profiles. These patients had serious oncology diseases. The drinking water fountain was used for their alimentation.

Clinical Infectious Diseases Advance Access published April 15, 2015

Prolonged Outbreak of Mycobacterium chimaera Infection After Open-Chest Heart Surgery
Hugo Sax,1,2,3* Guido Bloemberg,1 S. G. Haase,4,5,6 Rami Sommerstein,1 Philipp Kohler,1 Yvonne Achermann,1 Matthias Rösle,1 Volkmar Fehl,6 Stefan P. Kuster,3 Erik C. Büttner,7,8 and Rainer Weber1,8
1Division of Infectious Diseases and Hospital Epidemiology, University Hospital Zurich, 2Institute of Medical Microbiology, National Centre for Mycobacteria, University of Zurich, 3Institute of Surgical Pathology, and 4Division of Cardiovascular Surgery, University Hospital Zurich, Switzerland

Background. Invasive Mycobacterium chimaera infections were diagnosed in 2012 in 2 heart surgery patients on extracorporeal circulation. We launched an outbreak investigation to identify the source and extent of the potential outbreak and to implement preventive measures.

Methods. We collected water samples from operating theaters, intensive care units, and wards, including air samples from operating theaters. Mycobacterium chimaera strains were characterized by randomly amplified polymorphic DNA polymerase chain reaction (RAPD-PCR). Case detection was performed based on archived histopathology samples and M. chimaera isolates since 2006, and the patient population at risk was retrospectively surveyed.

Results. We identified 6 male patients aged between 49 and 64 years with prosthetic valve endocarditis or vascular graft infection due to M. chimaera, which became clinically manifest with a latency of between 1.5 and 3.6 years after surgery. Mycobacterium chimaera was isolated from cardiac tissue specimens, blood cultures, or other biopsy specimens. We were able to culture M. chimaera from water circuits of heater cooler units connected to the

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
HCAI Water borne microorganisms

1400 deaths per year in the USA as a result of waterborne nosocomial pneumonias due to *Pseudomonas aeroginosa*

4000 cases of *P. aeruginosa* bacteraemia in England, Wales and N Ireland per yr

~ 300 cases of Legionnaires disease per year

~ 500 cases of *Stenotrophomonas maltophilia*
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

The overall notification rate was 13.5 per million inhab. in 2014

- Highest notification rate ever
- 6941 cases reported by 29 countries

Figure 1. Eight year trend in Pseudomonas spp., Stenotrophomonas spp. and closely related species bacteraemia reports per 100,000 population (England Wales and Northern Ireland): 2007 to 2014

Pseudomonas spp. accounted for 3.1% of mono-microbial bloodstream infections (BSI; all reported bacteraemia and/or fungaemia) in 2014, making them the eighth most commonly reported mono-microbial BSI causing organisms. In contrast, Stenotrophomonas spp.
Pseudomonas aeruginosa

- Ubiquitous in the environment
- Versatile; survives in a wide range of conditions
- Prefers warm, moist environments
- Able to form biofilms
- Often has resistance to antimicrobials
- Gram-negative rod bacillus
- Fluorescent under UV

The role of water as a vector in the transmission

Pseudomonas aeruginosa

Cause of healthcare-associated infections in the neonatal intensive care unit (NICU) environment.

NICU patients cause sepsis, pneumonia, meningitis, diarrhoea, conjunctivitis and skin infections

Various environmental sources including sinks, respiratory equipment and healthcare workers

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Pathogenicity

- Lower respiratory/pneumonia
- Sepsis/bacteraemia
- Skin and Soft Tissue
- Urinary Tract
- Endocarditis
- CNS e.g. Meningitis
- Gastrointestinal
- Bone and joint
- Eye and ear

Biofilms are ubiquitous

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
Water Outlets are not a new problem.....

Multi-resistant *Pseudomonas aeruginosa* outbreak associated with contaminated tap water in a neurosurgery intensive care unit

F. Bert*, E. Maubec†, B. Brunel*, P. Berry* and N. Lambert-Zechovsky*

*Service de Microbiologie and †Département d’Anesthésie-réanimation, Hôpital Beaujon, Clichy, France

### Summary

From July 1995 to November 1996, multi-resistant *Pseudomonas aeruginosa* O11 was isolated from 36 patients admitted to a neurosurgery intensive care unit. The strain was resistant to ticarcillin, ceftriaxone, imipenem, cefepime, and ciprofloxacin, and susceptible to amikacin. Nine patients were colonized only; the remaining 27 patients had at least one infected site (17 urinary infections, 10 pneumonias and four with sinustitis). *P. aeruginosa* O11 with the same resistance pattern was isolated from tap water. The strain was also cultured from enteral nutrition solutions given to two infected patients. DNA macrorestriction analysis with XbaI established the similarity of the isolates from patients, tap water and solutions. The outbreak was controlled after reinforcement of isolation procedures for infected patients, changing the mode of enteral nutrition and replacing those contaminated with tap water.


Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales

www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Not a new problem.....

The taps were presumably the main source of *P. aeruginosa* during this outbreak, via the hand of nursing staff or nutrition solutions contaminated with tap water.

**Table 1.** Studies comparing genotypes of endemic *P. aeruginosa* (PA) strains isolated from patients and tap water outlets in ICUs and peripheral wards

<table>
<thead>
<tr>
<th>Authors, year (reference)</th>
<th>Study period</th>
<th>Setting</th>
<th>Ward(s)</th>
<th>Genotyping method</th>
<th>No. of positive tap water samples/no. tested (%)</th>
<th>No. of patients harboring a clone previously isolated from water taps/total no. of patients harboring PA</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berthelot et al, 2001(33)</td>
<td>1995-1996</td>
<td>University Hospital, St. Etienne, France</td>
<td>2 Mixed ICUs</td>
<td>AP-PCR, PFGE</td>
<td>34/103 (33.5%)</td>
<td>3/12 (25%)</td>
<td>25</td>
</tr>
<tr>
<td>Trasman et al, 2000(27)</td>
<td>1996-1997</td>
<td>University Hospital, Ulm, Germany</td>
<td>16-Bed surgical ICU</td>
<td>RAPD-PCR</td>
<td>49/72 (68.1%)</td>
<td>5/17</td>
<td>29.4</td>
</tr>
<tr>
<td>Raizer et al, 2002(38)</td>
<td>1998-1999</td>
<td>University Hospital, Ulm, Germany</td>
<td>16-Bed surgical ICU</td>
<td>RAPD-PCR</td>
<td>130/259 (50.6%)</td>
<td>13/31 (42%)</td>
<td>35.7</td>
</tr>
<tr>
<td>Valles et al, 2004(34)</td>
<td>1996-1999</td>
<td>Teaching hospital, Barcelona, Spain</td>
<td>16-Bed mixed ICU</td>
<td>PFGE</td>
<td>93/149 (62.4%)</td>
<td>3/86</td>
<td>37.5</td>
</tr>
<tr>
<td>Blanc et al, 2004(35)</td>
<td>1998</td>
<td>University Hospital, Lausanne, Switzerland</td>
<td>5 ICUs of different specialties</td>
<td>PFGE</td>
<td>21/216 (9.7%)</td>
<td>133/132</td>
<td>27.3</td>
</tr>
<tr>
<td>Trasman et al, 2005*</td>
<td>2001</td>
<td>University Hospital, Ulm, Germany</td>
<td>12-Bed medical ICU</td>
<td>RAPD-PCR</td>
<td>40/143 (28.0%)</td>
<td>8/16</td>
<td>50</td>
</tr>
</tbody>
</table>


Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
A review of prospective studies published between 1998 and 2005 showed that between 9.7% and 68.1% of randomly taken tap water samples on different types of ICUs were positive for *P. aeruginosa*, and between 14.2% and 50% of infection/colonization episodes in patients were due to genotypes found in ICU water.

> 50% of the equipment sampled was highly contaminated.

*P. aeruginosa* repeatedly isolated from sinks, tap biofilm, showers and bedside tables

*P. aeruginosa* contamination was related to the surface humidity, and tap water (biofilm)
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Two babies dead after infection at Belfast hospital

Two babies have died at the Royal Maternity Hospital in Belfast after an outbreak of an infection called pseudomonas.

The Belfast Trust said the deaths, in the neonatal unit, may be linked to the outbreak. Admission to the unit is being restricted.

The bacteria can cause infections in the chest, blood, and urine.

The health minister said identifying the source of the infection was a priority.

Edwin Poots added: "This is a serious incident."

The health trust has asked the Public Health Agency to ensure all necessary steps are swiftly taken to identify the source of the infection so that we contain it and reduce the risk of spreading.

The babies died in the last week to 10 days, but a possible link to the bacteria was only discovered recently.

There are currently 25 babies in the unit, which cares for ill or premature babies.

They are all being tested for the infection and those found to be clear of it will be treated in a different part of the hospital.

Sink taps source of infection that killed three babies

Sink taps were the source of an infection which killed three babies at a Belfast hospital, the Northern Ireland health minister has confirmed.

Edwin Poots told the NI Assembly that the Pseudomonas bacteria had been traced to taps at a neo-natal unit in the Royal Jubilee Maternity Hospital.

The unit was deep cleaned at the weekend after six babies were found to be infected.

The trust is investigating the outbreak at the maternity hospital.

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com

Northern Ireland - statement by Health Minister Edwin Poots - 31st January 2012

“The presence of Pseudomonas aeruginosa has been found in a small number of water outlets in the neonatal intensive care unit of the hospitals”

Taps have been implicated as being a source!

Protect patients in the wards and restore public confidence

Hospital shuts baby unit after infection kills four new-borns

Replace all the taps........
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

PHE Team Approach

- PHE Experts provided advice as the incidents occurred
- Biosafety team organising delivery of components and strategy in place to handle samples and data from a forensic approach
- Food Water and Environmental laboratory (PHE Porton) analysing all the microbiology
- Jane Turton’s laboratory (PHE Colindale) carrying out variable number tandem repeat analysis for isolate identification and strain differentiation
- Howard Tolley carrying out SEM analysis

Inspector Clous “eau”

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Sampling - Issues to consider

- Taps, solenoid valves, thermal mixer units, isolator valves, flexible and metal pipes
- Surprisingly complex, multiple parts, complex shapes, varying materials
- Taps potentially contaminated with Pseudomonas aeruginosa
  - Complete units may contain contaminated water
  - Aerosol risk
  - Safety cabinets and Local exhaust ventilation
  - Need to preserve the integrity of the biofilms and viability of the contamination

Tools for the job....

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Biofilms in lumen of flexible hoses (SEM)
(with kind permission of Dr T Makin and David Harper)

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Biofilms in lumen of flexible hoses (SEM)
(with kind permission of Dr T Makin and David Harper)

Estate & Facilities Alert
Ref. DH (2010) 03
Gateway Ref. 14265
Issued: 05/05/2010
Action underway by: 24/05/2010
Action completed by: 30/11/2010

For: ACTION
IMMEDIATE ACTION
INFORMATION
UPDATE

Water Advisory Regulation Scheme (WRAS) BS 6920,

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
## The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals

**Dr. Jimmy Walker, Public Health England**

**A Webber Training Teleclass**

### Table: Components with P. aeruginosa Positive

<table>
<thead>
<tr>
<th>Tap component location</th>
<th>All components</th>
<th>P. aeruginosa positive Components</th>
<th>Median Pseudomonas CFU (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N  %</td>
<td>N  %</td>
<td>N  %</td>
</tr>
<tr>
<td>Tap body</td>
<td>126  26</td>
<td>18  26</td>
<td>6,340 (22,580)</td>
</tr>
<tr>
<td>Connectors</td>
<td>31  6</td>
<td>0  0</td>
<td>-</td>
</tr>
<tr>
<td>Isolation valve</td>
<td>30  6</td>
<td>0  0</td>
<td>-</td>
</tr>
<tr>
<td>Integrated Mixer and solenoid</td>
<td>38  8</td>
<td>1  1</td>
<td>60 (0)</td>
</tr>
<tr>
<td>Mixer</td>
<td>98  20</td>
<td>2  3</td>
<td>20 (0)</td>
</tr>
<tr>
<td>Flow straightener</td>
<td>97  20</td>
<td>41  60</td>
<td>52,033 (816,820)</td>
</tr>
<tr>
<td>Solenoid</td>
<td>54  11</td>
<td>5  7</td>
<td>520 (23,380)</td>
</tr>
</tbody>
</table>

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales

www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

2.2 x 10^7 cfu *P. aeruginosa*

Analysis (VNTR) identified the same strain in the taps, the water and clinical samples

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Tap Component Analysis

494 components were analysed for aerobic colony count and *P. aeruginosa* (14% of components positive)

Same strain in the taps, the water and clinical samples

Little correlation between ACC and *P. aeruginosa*

Sensor taps were significantly colonised compared to non-sensor

Statistically there were significant differences due to the presence of complex outlet fittings
What does the addendum do?

Develop local water safety groups and plans
Assess the risk to patients if water systems become contaminated with *P. aeruginosa* or other opportunistic pathogens
Actions to take if water systems become contaminated with *P. aeruginosa*
Protocols for sampling, testing and monitoring water for *P. aeruginosa*
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Water Safety Group (WSG):
A multidisciplinary group formed to undertake the commissioning and development of the water safety plan (WSP). It also advises on the remedial action required when water systems or outlets are found to be contaminated and the risk to susceptible patients is increased.

- Director of infection prevention and control (DIPC);
- IPC team;
- Consultant medical microbiologist;
- Estates and Facilities team (including hotel/ cleaning services staff and the Responsible Person (Water));
- Senior nurses from relevant augmented care units

WSP is a risk-management approach to the microbiological safety of water that establishes good practices in local water distribution and supply. It will identify potential microbiological hazards caused by P. aeruginosa and other opportunistic pathogens, consider practical aspects, and detail appropriate control measures.

HTM 04-01 Tap outlets and Flow straighteners

Where practical, consider removal of flow straighteners. However, the removal of flow straighteners may result in splashing and therefore additional remedial action may need to be taken. If they are seen to be needed, periodically remove them and either clean/ disinfect or replace them. Replacement frequency should be verified by sampling/ swabbing.

Check for underused outlets – assess frequency of usage and if necessary remove underused outlet(s).

Assess the water distribution system for non-metallic materials that may be used in items such as inline valves, test points and flexible hoses.

Dead legs and thermostatic mixer valves - stagnation of cold supply
**Frequency of testing**

A systematic schedule based on local risk assessment - water safety plan

Risk assess where your augmented patients are located

All taps do not have to be tested at the same time
Pre flush sample
Potential for highest counts
Biofilm cells will be sought
Indicate contamination in last 2m

Post flush sample
TVC will indicate
contamination further back
in the system

Testing and media
If positive in both, contamination is further back in the system.
Minimum temperature at the most distant taps or outlets should be 55°C.

TMV prevents hot scalding water at hot outlet

TMV prevents thermal purging of the outlet

No lagging after TMV of hot or cold pipes

Post TMV water at ~43°C

Creates a favourable environment for microbial growth
Cold pipe - how often would this cold tap be used?

Forms an immediate dead leg where you could get biofilm growth

Spur from hot water flow and return

TMV

Post TMV water at ~45°C

Unlagged after TMV

Relatively long dead leg

Sensor reduces hand contact

Solenoid

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales

www.webbertraining.com
The role of water as a vector in the transmission of infections in hospitals

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Design and Commissioning?

PHE Porton Test Rig

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The role of water as a vector in the transmission of infections in hospitals

Dr. Jimmy Walker, Public Health England

A Webber Training Teleclass

Pseudomonas aeruginosa recovered from the solenoid components

Microbial Count cfu per cm²

Solenoid Component

Tap 1
Tap 13
Tap 19
Tap 25

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
Effect of removing or replacing the solenoid valve

<table>
<thead>
<tr>
<th>Tap</th>
<th>Feb - Apr 2014 Weekly sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>2</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>3</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>4</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>5</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>6</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>7</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>8</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>9</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>10</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>11</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>12</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>13</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>14</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>15</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>16</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>17</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>18</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>19</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>20</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>21</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>22</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>23</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
<tr>
<td>24</td>
<td>S  S  S  S  S  S  S  S  S  S</td>
</tr>
</tbody>
</table>

The role of water as a vector in the transmission

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Effect of removing or replacing the solenoid valve

<table>
<thead>
<tr>
<th>Week</th>
<th>Feb - Apr 2014 Weekly sampling</th>
<th>Apr - June 2014 Weekly sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solenoid removed</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Effect of removing or replacing the solenoid valve

<table>
<thead>
<tr>
<th>Week</th>
<th>Feb - Apr 2014 Weekly sampling</th>
<th>Apr - June 2014 Weekly sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solenoid removed</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The role of water as a vector in the transmission

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

The role of water as a vector in the transmission

Effect of removing or replacing the solenoid valve

<table>
<thead>
<tr>
<th>Date</th>
<th>Feb - Age 2014</th>
<th>Age - June 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weekly sampling</td>
<td>Weekly sampling</td>
</tr>
<tr>
<td></td>
<td>Solenoid removed</td>
<td>Solenoid replaced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solenoid kept in situ</td>
</tr>
</tbody>
</table>

The role of water as a vector in the transmission

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
Figure 2. Total culturable aerobic bacteria counts on EPDM, stainless steel 316 (SS316), PEX and copper test rig inserts over 84 days. Error bars = SD.

Fig. 2. Heterotrophic plate counts of drinking water biofilms grown on EPDM, PE-X b, PE-X c and copper under constant flow conditions. Heterotrophic plate counts after 14 days were determined in four independent experiments and heterotrophic plate counts after 16, 29 and 43 days were determined in three independent experiments.
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

**Effect of increased flushing on** \( P. \) \textit{aeruginosa} **counts**

- **Sample date:**
  - 03/04/2014
  - 07/05/2014
  - 14/05/2014
  - 21/05/2014
  - 28/05/2014

**Effect of no flushing on** \( P. \) \textit{aeruginosa} **counts**

- **Sample date:**
  - 03/04/2014
  - 07/05/2014
  - 14/05/2014
  - 21/05/2014
  - 28/05/2014

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
Tracking of *Pseudomonas aeruginosa* in QEH burns unit water

**Screening on admission**
- >7% burns
- Wound swabs, stool and urine for microbiology
- Stool for molecular testing

**Environmental sampling of the patients room and shower water**

**Recruited positive patients**
- Wound swabs at each dressing change
- Environmental sampling
- Swabs/tissue for metagenomic analysis
- Environmental sampling on discharge

---

**Results from the QEH Burns Unit**

30 screening patients

5 positive patients

P1, P2, P3, P4, P5

Water isolates
- Positive 52%
- Negative 48%

Environmental isolates
- Wet sites 16%
- Patient contact 4%
- Negative 80%

---

Quick et al., 2014 Seeking the source of *Pseudomonas aeruginosa* infections in a recently opened hospital: an observational study using whole-genome sequencing BMJ Open

Joshua Quick 2014, Beryl Oppenheim, Nick Loman et al., Univ of Birmingham In Press

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales

www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Summary from QEH Burns Unit

Water was the likely cause of infection in 60% patients
Water outlets and wet/moist sites have high levels of contamination
WGS to be used to track isolates from different rooms and even outlets
Could be used as a powerful surveillance method
Can be used to identify antibiotic resistant strains

Joshua Quick 2014, Beryl Oppenheim, Nick Loman et al., Univ of Birmingham In Press

Control Methods

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Identification?
Barcoding?

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
POU filters, where they can be fitted, may be used to provide water free of \textit{P. aeruginosa}. Where fitted, regard filters primarily as a temporary measure until a permanent safe engineering solution is developed, although long-term use of such filters may be required in some cases.

Note that the outer casing of a POU filter and the inner surface can become contaminated.
First line of defence?
Rapid solution to \textit{P. aeruginosa} free water
Can you fit a filter to your tap?
Does it occlude flow?
Is there sufficient space between the filter and basin?
Cleaning?
Contamination of casing?

**Thermal Control?**

The decision whether to install a TMV in areas not normally accessible to patients should be based on a risk assessment
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Areas of biofilm detected (even with thermal flushing and Kemper system on the cold)

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Tolerance to heat due to:
a heat shock protein locus insufficient heat contact time

Chemical Disinfection

Chlorination - cold water storage tank to 20-50 mg/litre free residual chlorine and flow to all parts of the system. This depends on chlorine concentration (at least one hour at 50 mg/l to at least two hours at 20 mg/l). Mains water: 0.1–0.5 mg/l

Chlorine dioxide – may need to shock dose at 5ppm and operate at 0.25-0.5ppm (max DWI). Can take long time to get control.

Copper Silver - The recommended concentrations for Legionella are 0.2 mg/l copper (up to 0.8mg/l) and more than 0.02 mg/l silver (up to 0.08mg/l) are recommended at outlets.

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Are you controlling the biofilm? Where is your biofilm?

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

UV System

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Design and Maintenance

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Changing a tap may help remove the colonisation
Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
Use of water outlets?
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Pragmatic issues - water flows

New fundamental research on presence and control of water borne pathogens

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
Do drains play a role in microbial distribution and recolonisation?

So what do you think is in your drain?
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Image courtesy of Howard Tolley, PHE

Antibiotic resistant bacteria risk from hospital sinks
6 September, 2010 | by Steve Ford, Ben Clever

The Department of Health has issued an alert warning that hospital wash basins have been identified as a source of gram negative bacteria.

The DH has written to directors of nursing and other senior trust managers saying it is aware of reports "emanating from English NHS trusts" and from Wales concerning infection outbreaks stemming from hospital handwash basins.

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

<table>
<thead>
<tr>
<th>Best practice advice for clinical wash-hand basins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use the clinical wash-hand basin only for hand-washing:</td>
</tr>
<tr>
<td>a. Do not dispose of body fluids at the clinical wash-hand basin – use the slophopper or sluice in the dirty utility area.</td>
</tr>
<tr>
<td>b. Do not wash any patient equipment in clinical wash-hand basins.</td>
</tr>
<tr>
<td>c. Do not use clinical wash-hand basins for storing used equipment awaiting decontamination.</td>
</tr>
<tr>
<td>d. Do not touch the spout outlet when washing hands.</td>
</tr>
<tr>
<td>e. Clean taps before the rest of the clinical wash-hand basin. Do not transfer contamination from wash-hand basin to wash-hand basin.</td>
</tr>
<tr>
<td>f. Do not dispose of used environmental cleaning agents at clinical wash-hand basins.</td>
</tr>
</tbody>
</table>

Retrograde contamination

Issue – patient secretions could lead to environmental contamination of HWB and drains(?)

Sluice too far away
- put in additional sluice
- use the toilet for waste
- use gel granules to absorb fluid

If you have to put waste down the hand washing basin – then alert house keeping.
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
Published Reports and Guidance


Addendum for HTM 04-01 P. aeruginosa (March 2013) http://www.dh.gov.uk/health/2013/03/pseudomonas-addendum/
L8 – Legionella control in hot and cold water systems

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Thanks to:

Philip Ashcroft
Carole Fry
Michael Kelsey
Bharat Patel
John Prendergast
Michael Arrowsmith
Peter Hoffman
David Whitely
And everyone that contributed during the consultation phase.............
Sara Atkins and the North London Pseudomonas Working Group

Katy-Anne Thompson
Ginny Moore
David Stevenson
Didier Ngabo

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

November 19 CLOSTRIDIUM DIFFICILE INFECTION IN RURAL HOSPITALS
Dr. Nasir Safdar, University of Wisconsin

December 3 (FREE Teleclass)
HIV TREATMENT AS PREVENTION: THE KEY TO AN AIDS-FREE GENERATION
Prof. Julio S. G. Montaner, BC Centre for Excellence in HIV/AIDS

December 10 RISING TO THE CHALLENGE OF MULTIDRUG-RESISTANT GRAM-NEGATIVE RODS (CRE & FRIENDS)
Dr. Jonathan Otter, King’s College, London

December 17 (FREE Teleclass)
EXAMINING THE “UNMENTIONABLES” = SANITATION AND THE GLOBAL AGENDA
Rose George, Author & Journalist

www.webbertraining.com/schedulept.php

JUST OVER THE HORIZON ...

TELECLASS, EDUCATION 2016

2016 schedule available December 1

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com
The Role of Water as a Vector for Infection in the Transmission of Infections in Hospitals
Dr. Jimmy Walker, Public Health England
A Webber Training Teleclass

Thanks to Teleclass Education

**PATRON SPONSORS**

- [Sealed Air](www.sealedair.com)
- [VIROX](www.virox.com)
- [World Health Organization](www.who.int/gpsc/en)

Hosted by Prof. Jean-Yves Maillard, Cardiff University, Wales
www.webbertraining.com