# What's lurking in your taps and sinks?

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Hosted by Prof. Jean-Yves Maillard
Cardiff University

# Disclosures

- IPC partners – x2 expert panels (money given to UHB charities)
- Cepheid – sponsored talk at IPS 25 (money given to UHB charities)
- GAMA healthcare – x2 talks (not paid only travel and accommodation funded)


## University Hospitals Birmingham NHS Foundation Trust (UHB)

- One of the largest teaching hospital trusts in England
- Includes Birmingham Heartlands Hospital, the Queen Elizabeth Hospital Birmingham (QEHB), Solihull Hospital and Community Services, Good Hope Hospital and Birmingham Chest Clinic
- Treat ~2.2 million people every year

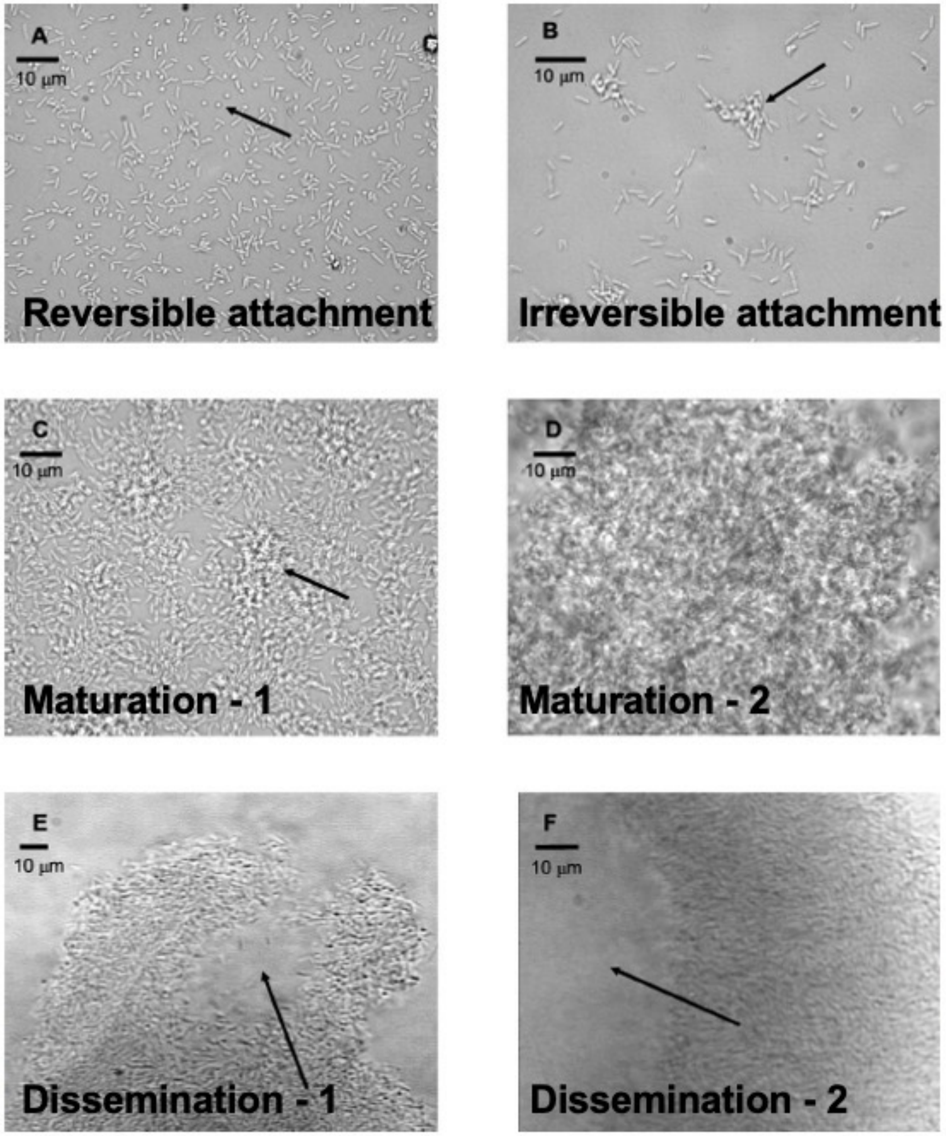
# Overview

- *Pseudomonas aeruginosa*
  - History
  - Transmission at UHB
  - Interventions
- Other water issues
- Other water organisms
- Conclusions

# *Pseudomonas aeruginosa*

- *P. aeruginosa* is widespread in the environment
- Usually colonises hospital and domestic sink traps, taps and drains
- Humans may be colonised at moist sites; highly opportunistic pathogen
- Hospital outbreaks are frequently reported from water sources
- Water transmission is a matter of concern

Garvey MI *et al.*, JHI 2016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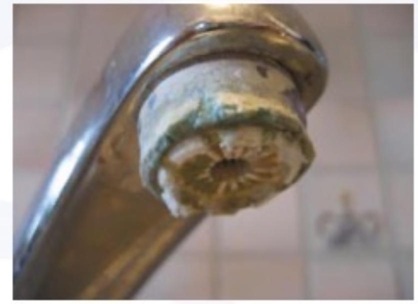

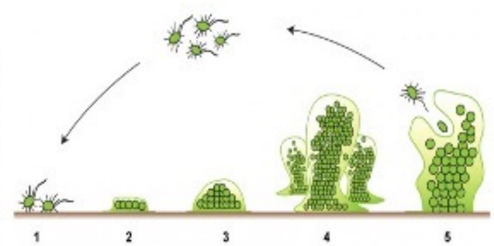
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Garvey *et al.*, J Hosp Infect 2018

# History

APPLIED MICROBIOLOGY, Aug. 1972, p. 219-225 Vol. 24, No. 2
Printed in U.S.A.


## Epidemiology of *Pseudomonas aeruginosa* in a Burns Hospital: Surveillance by a Combined Typing System[1]

PAUL EDMONDS,[2] RAYMOND R. SUSKIND, BRUCE G. MACMILLAN, AND IAN A. HOLDER

*Department of Environmental Health and Shriners Burns Institute, College of Medicine, University of Cincinnati, Cincinnati, Ohio 45219*

Received for publication 3 March 1972

For 3 months, 259 cultures of *Pseudomonas aeruginosa* isolated from nonpatient environmental sources and 262 cultures from 16 infected patients in the Intensive Care Unit (ICU) of Shriners Burns Hospital were typed by a combined system with a high degree of reliability. Sinks were major sources of environmental contamination. Serotypes 1 and 2 were the predominant types found in patients, and they were most prevalent among typable strains from sinks. Strain designations were made on the basis of similarities in data from serological and phage typing. All nontypable strains were typed by pyocin production. Two infected patients carried different strains of *P. aeruginosa* that remained the same type for 45 days, even though their beds in ICU were approximately 6 feet apart. Cross-contamination from patient to patient and spread of infection by nursing personnel were eliminated as major modes of transmission because nasopharyngeal swabs, hair samples, and hands of nursing staff were consistently negative. Splashing of water from contaminated sinks to fomites was suggested as a possible mode of transfer for this infectious agent.

## PSEUDOMONAS IN SINKS, NOT TAPS

SIR,—We reported that sink traps are an important source of contamination with pseudomonas species in our respiratory/surgical intensive-therapy unit.[5] Dr Constable and Dr Thompson (March 31, p. 721) ask whether the water taps were responsible for the reappearance of pseudomonas in the sink traps after decontamination with an immersion heater.

Hospital Practice

## PSEUDOMONAS ÆRUGINOSA IN HOSPITAL SINKS

G. A. J. AYLIFFE J. R. BABB
B. J. COLLINS E. J. L. LOWBURY
S. W. B. NEWSOM

*Hospital Infection Research Laboratory, Summerfield Hospital, Birmingham 18, and Sims Woodhead Memorial Laboratory, Papworth Hospital*

***Summary*** *Pseudomonas æruginosa* was isolated from sink waste-traps in 27 of 116 (23·3%) samples from a large general hospital and from 19 of 47 (40·4%) samples from a burns unit at another hospital. Smaller proportions of samples from sink outlets and surfaces of basins yielded *Ps. æruginosa*. A waste-trap heater ('Econa') used twice daily for fifteen minutes reduced the isolations of *Ps. æruginosa* from waste-traps to a very low level; isolations of other organisms were also reduced, though to a smaller extent. Despite the continuing high frequency of *Ps. æruginosa* in sinks and some other moist hospital sites, *Ps. æruginosa* infections were infrequent in the general hospital and had been greatly reduced by the successful use of various prophylactic measures in the burns unit.

Edmonds *et al.,* Applied Microbiology, 1972; Teres *et al.*, Lancet 1974; Ayliffe *et al.,* Lancet 1974

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NEWS

Sections

## Pseudomonas outbreak review criticises health officials

4 April 2012 | Northern Ireland

**Some of the deaths in the pseudomonas outbreak may possibly have been prevented if the Belfast Health Trust acted sooner, according to the professor leading an independent review.**

Neonatal units in Northern Ireland hospitals have undergone a deep clean

The Regulation and Quality Improvement Authority (RQIA) is investigating the four deaths at hospitals in Belfast and Londonderry in December and January.

It said the Belfast Health Trust should have declared the outbreak sooner and criticised a lack of communication between health officials.

The review team also found there was no common approach across neonatal units for declaring an outbreak.

Top Stories

**EU seeks to close key migrant route**
The EU will seek to close the Balkan route for migrants, as leaders meet for an emergency summit on Europe's worst refugee crisis since World War Two.
7 March 2016

**EDF director quits over Hinkley plan**
7 March 2016

**William and Kate release skiing photos**
7 March 2016

Features

## Pseudomonas outbreak one year on: police begin investigation into babies' deaths

By Niall McCracken, *21 January 2013*


*The Western & Belfast Trust say hygiene standards have improved*

**By Niall McCracken**

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**9 October 2012** Last updated at 20:41

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# Baby dies in Southmead Hospital pseudomonas outbreak

**A premature baby died and 12 others were given treatment after an outbreak of a water-borne bacterium at a Bristol neonatal unit, it has been confirmed.**


Filters have been fitted to the unit's water system

Southmead Hospital said it had found traces of pseudomonas aeruginosa in the water system for its neonatal intensive care unit.

The hospital said the baby died in August after contracting the bacterium.

Four babies died after contracting the bug in hospitals in Northern Ireland in December and January.

It was also found at the Norfolk and Norwich University Hospital in March.

BBC News 2012

Department of Health

## Health Technical Memorandum 04-01: Safe water in healthcare premises

## Part B: Operational management

Safe Water in Healthcare Premises

Authors: Jimmy Walker* and Ginny Moore

Biosafety, Air and Water Microbiology Group, PHE, *National Infection Service,* Porton Down, Salisbury, SP4 0JG

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In the UK, high profile incidents, specifically those in Northern Ireland, highlighted the link between *Pseudomonas aeruginosa,* tap water and clinical infection [1-3]. As a consequence, the Department of Health (England) published new guidance related to the sampling and testing of *P. aeruginosa* in healthcare premises as well as introducing the role of the water safety group [4]. The manuscripts published by Garvey *et al*, Tissot *et al* , and Aspelund *et al,* in this edition of JHI serve as a timely reminder that the risks associated with *P. aeruginosa* and contaminated tap water have not yet been sufficiently controlled or even understood. Coincidentally, the DH (England) has recently updated Health Technical Memorandum (HTM) 04-01 which, as reflected in the title of the new document – *Safe Water in Healthcare Premises*, emphasises the role of water in nosocomial infections [5].

HTM 04-01; Walker *et al.,* JHI 2016

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Short report

# Continued transmission of *Pseudomonas aeruginosa* from a wash hand basin tap in a critical care unit

**M.I. Garvey*, C.W. Bradley, J. Tracey, B. Oppenheim**

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Nosocomial

CrossMark

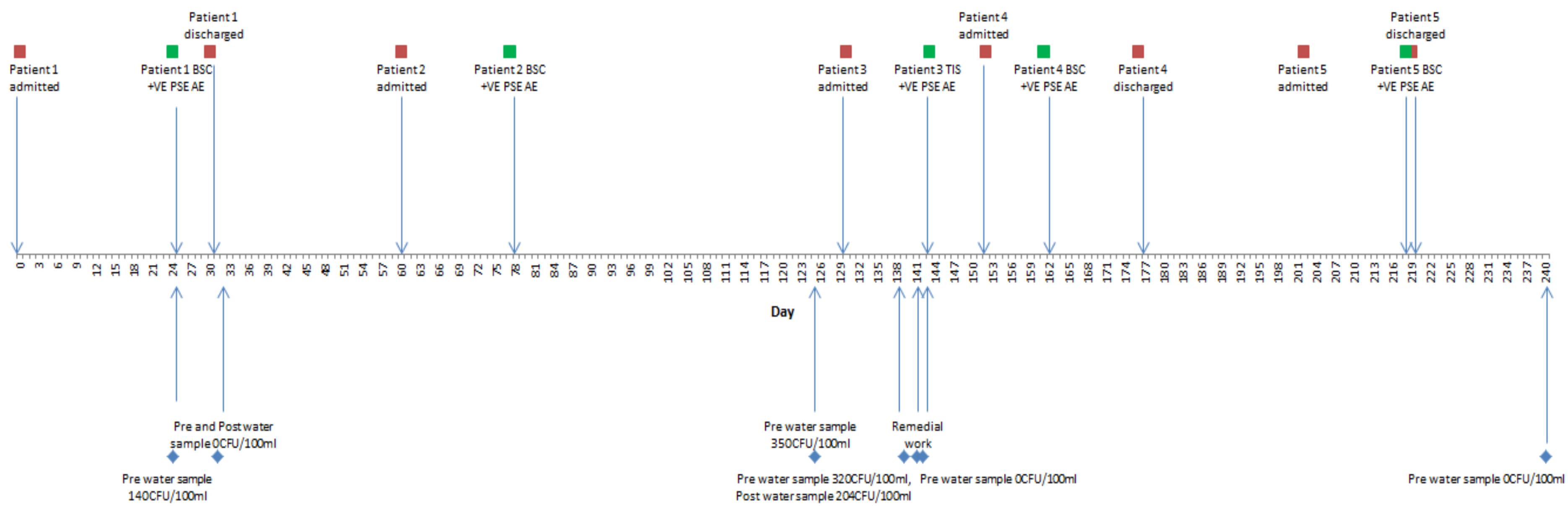
S U M M A R Y

*Pseudomonas aeruginosa* is an important nosocomial pathogen, colonizing hospital water supplies including taps and sinks. We report a cluster of *P. aeruginosa* acquisitions during a period of five months from tap water to patients occupying the same burns single room in a critical care unit. *Pseudomonas aeruginosa* cultured from clinical isolates from four different patients was indistinguishable from water strains by pulsed-field gel electrophoresis. Water outlets in critical care may be a source of *P. aeruginosa* despite following the national guidance, and updated guidance and improved control measures are needed to reduce the risks of transmission to patients.



Garvey MI *et al.*, JHI 2016

- Found some patient water transmission events from routine surveillance




Garvey MI *et al.*, JHI 2016

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# *Pseudomonas aeruginosa* infection in augmented care: the molecular ecology and transmission dynamics in four large UK hospitals

F.D. Halstead[a,b,1], J. Quick[a,c,1], M. Niebel[a,b], M. Garvey[a,b], N. Cumley[a,b], R. Smith[d], T. Neal[e], P. Roberts[e], K. Hardy[f], S. Shabir[f], J.T. Walker[g], P. Hawkey[b,c,*], N.J. Loman[c]

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[b] *Department of Clinical Microbiology, Queen Elizabeth Hospital, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK*
[c] *Institute of Microbiology and Infection, School of Biosciences, University of Birmingham, Birmingham, UK*
[d] *Royal Free London NHS Foundation Trust, Hampstead, London, UK*
[e] *Royal Liverpool University Hospital, Royal Liverpool and Broadgreen University Hospitals NHS Trust, Liverpool, UK*
[f] *Public Health England, Heartlands Hospital, University Hospitals Birmingham, Birmingham, UK*
[g] *Walker On Water, Salisbury, UK*

# UHB water results

- Water sampling in augmented care as per HTM 04-01
- Critical care (231 outlets) results:

**Table 1**
Total number of ICU water outlets positive for *P. aeruginosa* per year between 2013 and 2016.

| ICU | Positive outlets 2013* | Positive outlets 2014* | Positive outlets 2015* | Positive outlets 2016* |
|---|---|---|---|---|
| Area A | (20) 29% | (21) 30% | (28) 40% | (29) 41% |
| Area B | (11) 22% | (14) 29% | (14) 28% | (10) 20% |
| Area C | (8) 15% | (13) 28% | (15) 30% | (12) 24% |
| Area D | (7) 10% | (14) 23% | (17) 28% | (22) 36% |
| Total | (46) 20% | (59) 26% | (54) 24% | (73) 31% |

Key: *Numbers in the brackets refer to number of positive outlets.

**Table 2**
Total number of patient *P. aeruginosa* isolates across ICU per year.

| ICU | *P. aeruginosa* isolates 2014 | *P. aeruginosa* isolates 2015 | *P. aeruginosa* isolates 2016 |
|---|---|---|---|
| Area A | 27 | 27 | 19 |
| Area B | 28 | 31 | 16 |
| Area C | 22 | 23 | 11 |
| Area D | 25 | 21 | 11 |
| Total | 102 | 104 | 57 |

Garvey *et al.*, Int J Hyg Environ Health 2017

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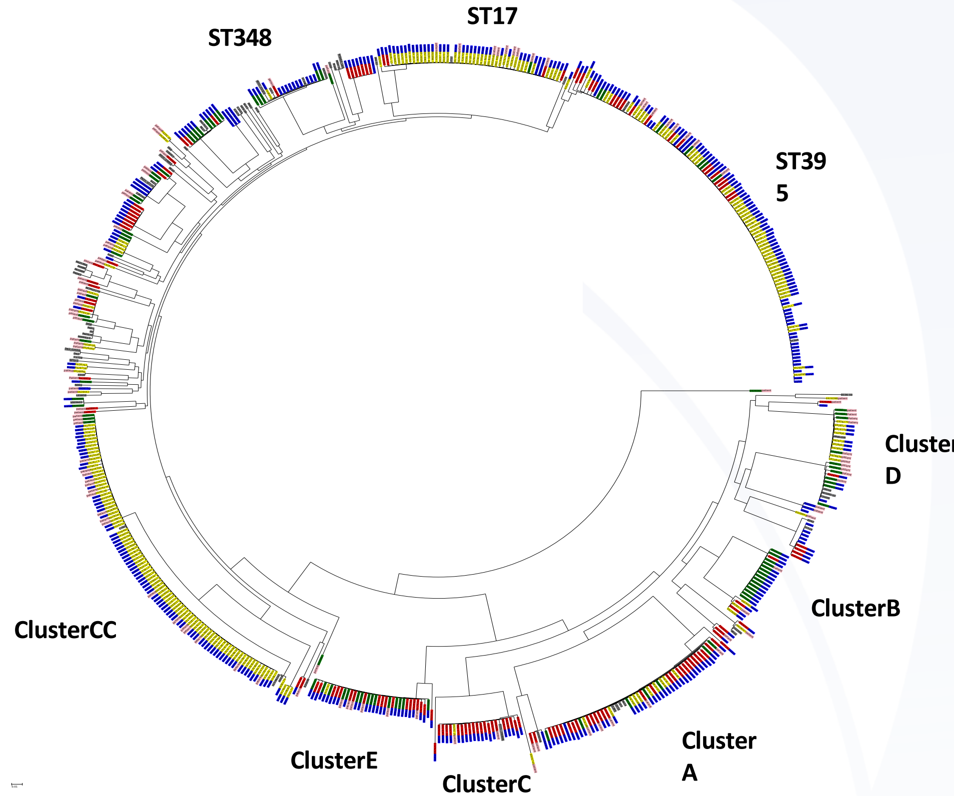
Healthcare Infection Society

***Pseudomonas aeruginosa* infection in augmented care: the molecular ecology and transmission dynamics in four large UK hospitals**

F.D. Halstead[a,b,1], J. Quick[a,c,1], M. Niebel[a,b], M. Garvey[a,b], N. Cumley[a,b], R. Smith[d], T. Neal[e], P. Roberts[e], K. Hardy[f], S. Shabir[f], J.T. Walker[g], P. Hawkey[b,c,*], N.J. Loman[c]

- Diverse strains
- 60% transmission water to patient
- Multiple methods of contamination:
  - Patient waste water
  - Cleaning
  - Contamination of tap at manufacturer's source




Halstead F *et al.*, JHI 2021

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# Engineering waterborne *Pseudomonas aeruginosa* out of a critical care unit

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A B S T R A C T

*Objective:* To describe engineering and holistic interventions on water outlets contaminated with *Pseudomonas aeruginosa* and the observed impact on clinical *P. aeruginosa* patient isolates in a large Intensive Care Unit (ICU).
*Design:* Descriptive study.
*Setting:* Queen Elizabeth Hospital Birmingham (QEHB), part of University Hospitals Birmingham (UHB) NHS Foundation Trust is a tertiary referral teaching hospital in Birmingham, UK and provides clinical services to nearly 1 million patients every year.
*Methods:* Breakpoint models were used to detect any significant changes in the cumulative yearly rates of clinical *P. aeruginosa* patient isolates from August 2013–December 2016 across QEHB.
*Results:* Water sampling undertaken on the ICU indicated 30% of the outlets were positive for *P. aeruginosa* at any one time. Molecular typing of patient and water isolates via Pulsed Field Gel Electrophoresis suggested there was a 30% transmission rate of *P. aeruginosa* from the water to patients on the ICU. From, February 2014, QEHB implemented engineering interventions, consisting of new tap outlets and PALL point-of-use filters; as well as holistic measures, from February 2016 including a revised tap cleaning method and appropriate disposal of patient waste water. Breakpoint models indicated the engineering and holistic interventions resulted in a significant ($p < 0.001$) 50% reduction in the number of *P. aeruginosa* clinical patient isolates over a year.
*Conclusion:* Here we demonstrate that the role of waterborne transmission of *P. aeruginosa* in an ICU cannot be overlooked. We suggest both holistic and environmental factors are important in reducing transmission.



Garvey *et al.,* Int J Hyg Environ Health 2017

# Critical Care Service improvement

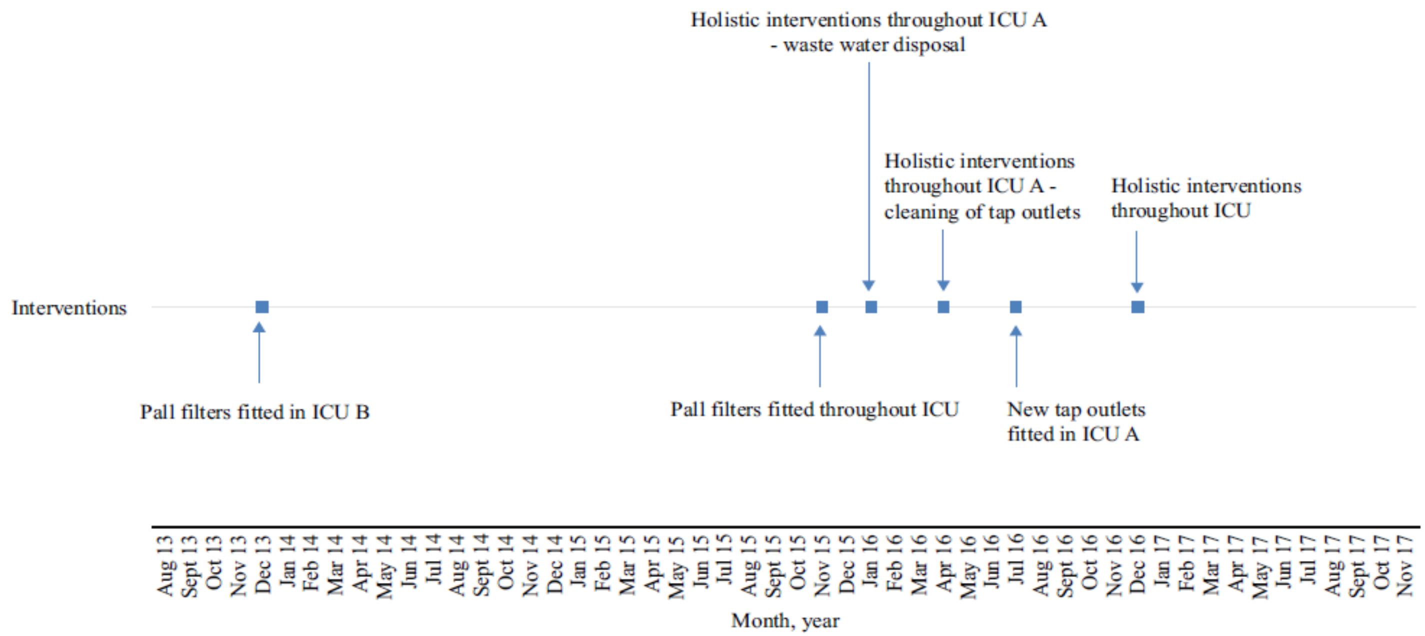


**Figure 2.** Timeline of interventions during the study.

Garvey *et al.*, JHI 2018

# Service improvement

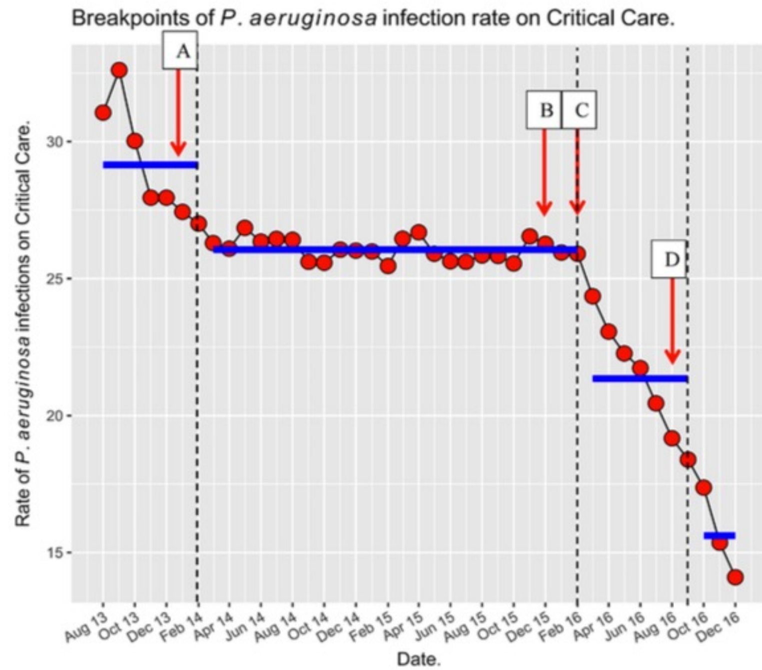


**Fig. 1.** Using breakpoint changes patient *P. aeruginosa* isolate rates per 100,000 bed days were analysed between August 2013–December 2016 across the entire ICU. The breakpoint model identified three probable changes in rate (breakpoint dotted lines), with the fitted means of the segments either side indicated by horizontal blue bars. The first breakpoint was a result of introducing PALL end filters on selected outlets on ICU area B, the second breakpoint was coincident with PALL end filters being fitted on selected outlets across the entire ICU, and the third breakpoint as a response to the holistic infection control interventions and installation of new tap outlets on ICU area A. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
Key: Red arrows, and boxes indicate Infection Control Interventions, dotted line represents breakpoints. Intervention A corresponds to the introduction of PALL filters on selected outlets on ICU area B, intervention B corresponds to the fitting of PALL filters on selected outlets across the entire ICU, intervention C corresponds to holistic infection control interventions, intervention D corresponds to the installation of new tap outlets on ICU area A.

Garvey *et al.*, Int J Hyg Environ Health 2017

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Letter to the Editor

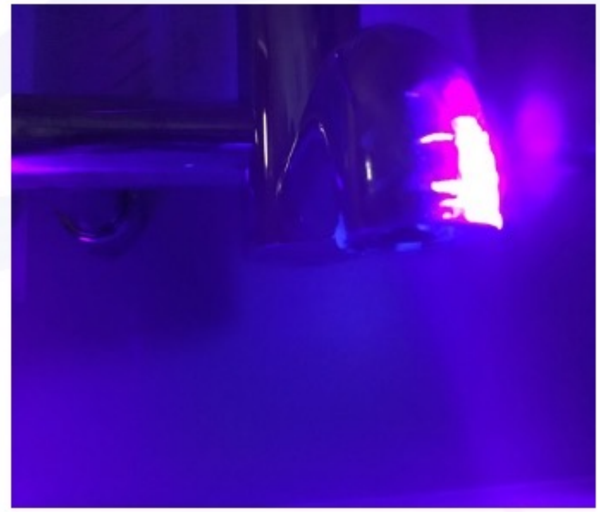
## Evaluating the risks of wash hand basin tap disinfection

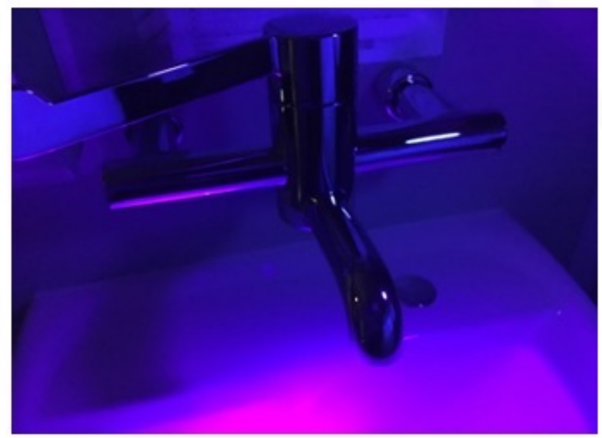
the cleaning solution after they are first dampened, preventing cross-contamination. Cloth 1 was dampened in detergent solution and wrung dry. The cloth was folded in half and half again with the cloth face being turned when moving from surface to surface. Working on the outside of

1. Preparation: Emptying the sink and removing any organic material from the plug, drain and overflow. The tap was then turned on and water was left to run while cleaning the outer areas of the sink.
2. Cloth 1: Cleaning around the tap and sink only, using a J-cloth. It should be noted that cloths are never put back into

mirror, wall tiles, back splash, ledges, pipe work, dispensers, and underside and edges of the sink. The cloth was disposed of when this step was finished or alternatively when all eight sides of the cloth had been used. After this step the taps were turned off, equating to 2 min of flushing.

3. Cloth 2 cleaning the tap outlet: A second cloth was dampened in detergent solution and wrung dry. The cloth was folded in half and half again with the cloth face being turned when moving from surface to surface. Only the tap was cleaned, in the following order working from the outside to the inside: first clean the tap bar, tap lever and tap spout. The tap tip was not touched during the cleaning. The cloth was disposed of when the cleaning stage was finished or alternatively when all eight sides had been used.
4. Cloth 3 cleaning the sink: As above, a new cloth was dampened in detergent solution and wrung dry. The cloth was folded in half and half again with the cloth face being turned when moving from surface to surface. Only the sink was cleaned and in the following order working from the outside to the inside: outside of the sink, inside surface of the sink, overflow, plug, plug chain, and drain. The cloth was disposed of when finished or alternatively when all eight sides had been used.





Garvey *et al.,* JHI 2016

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Letter to the Editor

## The risks of contamination from tap end filters

Sir,

The recent Editorial by Walker and Moore proposes that the risks associated with *Pseudomonas aeruginosa* and contaminated water have not been fully controlled or understood.[1] In addition, the Department of Health has updated the Health Technical Memorandum (HTN) 04-01, emphasizing the role of water in nosocomial infections.[2] Our recent Short report describes an outbreak of *P. aeruginosa* in an intensive care unit.[3] Continued transmission of *P. aeruginosa* was seen from water to patient with the source suspected to be a specific hand wash basin; remedial work was undertaken on the tap outlet including chlorination and disinfection.[3] When the outlet remained intermittently positive for *P. aeruginosa* despite the remedial work, a Pall-Aquasafe™ (AQ31F1S; Pall Medical, Fribourg, Switzerland) disposable tap water end filter was installed. Subsequently *P. aeruginosa* was not detected in the water collected via the end filter and there were no further cases of *P. aeruginosa* transmission.[3]

Tap water end filters, which can be used for a maximum period of 31 days following initial connection to a tap outlet, have a variety of applications including providing water for use in topical applications such as personal hygiene and wound care; for consumption and preparation of cold drinks and food, and for rinsing medical instruments.[4] The double-layer sterilizing grade Supor® membrane (Pall Medical) is rated at 0.2 μm and protects against waterborne particulates and pathogens such as *Legionella* spp. and *Pseudomonas* spp.[4]

Due to the identified risks of *P. aeruginosa* transmission in our patient population, we undertake clinical surveillance of *P. aeruginosa* infection.[3] Since using end filters on tap outlets positive for *P. aeruginosa* in the critical care units we have observed visible contamination of the end filter. Figure 1 shows a tap water end filter with visible contamination on the surface. Further investigation of the surface of the filter identified multidrug-resistant *P. aeruginosa*. Pulsed-field gel electrophoresis typing of the strain from the contamination on the tap water end filter showed that it was indistinguishable from a clinical isolate from the patient adjacent to the sink.

There have been reports detailing how tap outlets may be contaminated with *P. aeruginosa* resulting from the disposal of waste water from a patient into a hand wash basin and also contamination of the tap outlet by inadequate cleaning methods.[5–7] Here we demonstrate that, with the installation of a tap water end filter, contamination of the end filter with *P. aeruginosa* may occur in the same way as contamination of the tap outlet. When the end filters were removed after 31 days, there was visible contamination of the outlet and subsequent testing of the water identified *P. aeruginosa*.

Guidance for the use of end filters means that they must be replaced every month at a cost of around £50 per filter. At our hospital there are 231 tap water outlets, including clinical and non-clinical sinks and showers, in the critical care unit. If tap water end filters were installed on every outlet, the associated costs for the hospital would be £11,550 per month (£138,600 per year). The replacement of tap water end filters also requires ongoing review, which in turn costs time and manpower resources. Given the costs and resources required, tap water end filters are installed on selected outlets in University Hospitals Birmingham where the risk of transmission of *P. aeruginosa* to patients is highest, such as hand wash basins in a patient bedspace. Thus, tap water end filters are installed on 130 of the 231 outlets and this costs the Trust £6,500 per month (£78,000 per year). The use of the end filters has resulted in a reduction of the numbers of *P. aeruginosa* infections in the critical care unit. However, the costs of installing and maintaining the end filters are high.

We have shown that tap water end filters can be contaminated with patient waste water and that contamination of the tap tip can occur probably as a result of the contamination with patient waste water. To reduce the risk of transmission of water borne pathogens such as *P. aeruginosa* in healthcare settings, we suggest that further research is required. A one-off


**Figure 1.** Pall-Aquasafe end filter with visible contamination which yielded multidrug-resistant *Pseudomonas aeruginosa*.

http://dx.doi.org/10.1016/j.jhin.2016.08.006

Garvey *et al.*, J Hosp Infect 2016

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# Tap out: reducing waterborne *Pseudomonas aeruginosa* transmission in an intensive care unit

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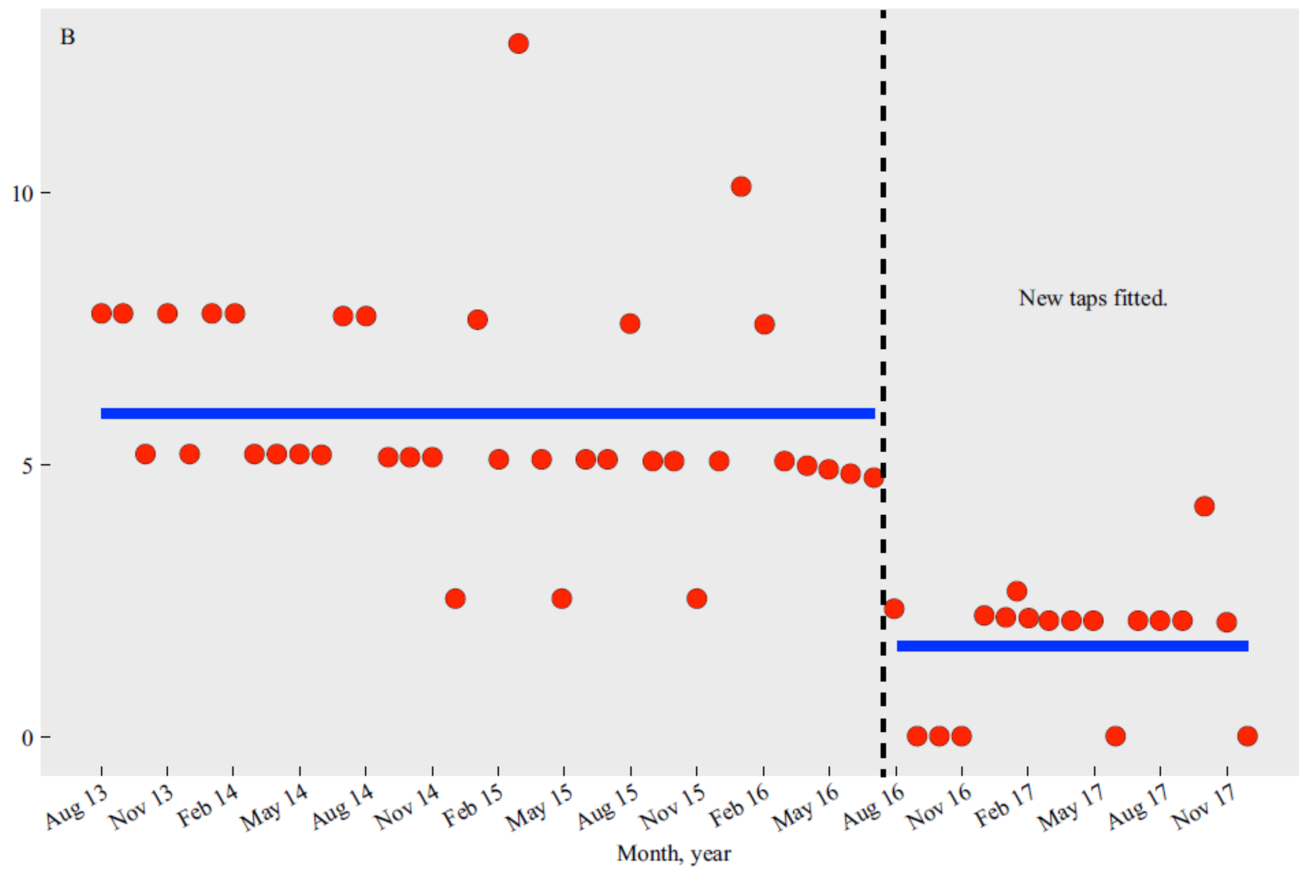
S U M M A R Y

***Background:*** *Pseudomonas aeruginosa* is a ubiquitous and important opportunistic pathogen in immunocompromised or critically ill patients. Nosocomial *P. aeruginosa* outbreaks have been associated with hospital water sources.
***Aim:*** To describe engineering interventions to minimize contamination of water outlets and the subsequent clinical impact.
***Methods:*** New tap outlets were fitted at selected outlets across the intensive care unit (ICU). Laboratory testing demonstrated that, following artificial contamination with *P. aeruginosa*, these taps could be effectively decontaminated using a thermal washer-disinfector. Water samples were collected weekly from new outlets on the ICU over an eight-month period and tested for the enumeration of *P. aeruginosa* via membrane filtration. Surveillance of *P. aeruginosa* from clinical specimens was routinely undertaken.
***Findings:*** Prior to the interventions, water sampling on ICU indicated that 30% of the outlets were positive for *P. aeruginosa* at any one time, and whole genome sequencing data suggested at least 30% transmission from water to patient. Since their installation, weekly sampling of the new tap outlets has been negative for *P. aeruginosa*, and the number of *P. aeruginosa* clinical isolates has fallen by 50%.
***Conclusion:*** Installation and maintenance of tap outlets free of *P. aeruginosa* can substantially reduce the number of *P. aeruginosa* clinical isolates in an ICU.


Garvey *et al.*, J Hosp Infect 2018




Garvey *et al.*, J Hosp Infect 2018.

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Short report

# Where to do water testing for *Pseudomonas aeruginosa* in a healthcare setting

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SUMMARY

*Pseudomonas aeruginosa* is an important nosocomial pathogen widely colonizing hospital water supplies. The Department of Health (England) Health Technical Memorandum (HTM) 04-01 addresses the risk posed by recommending water-testing in augmented care areas including outpatient haemodialysis. We discuss how two teaching hospitals independently reviewed the risk to outpatient haemodialysis patients, drawing the same conclusion. The highest number of infection episodes with *P. aeruginosa* was observed in critical care followed by burns and haematology, with the lowest in haemodialysis. Based on these results, we suggest that water sampling should be undertaken in areas such as critical care, burns, and haematology, but not in outpatient haemodialysis.



Garvey *et al.*, JHI 2017

**Table I**
Percentage of augmented care water outlets positive for *Pseudomonas aeruginosa* per year between 2013 and 2016

| Area | No. of outlets | Positive outlets | | | |
|---|---|---|---|---|---|
| | | 2013 | 2014 | 2015 | 2016 |
| Critical care | 231 | 20% | 26% | 24% | 31% |
| Burns unit | 69 | 29% | 18% | 13% | 12% |
| Haematology unit | 87 | 6% | 8% | 12% | 16% |
| Haemodialysis unit | 149 | 17% | 15% | 24% | 19% |

**Table II**
Total number of patients with *Pseudomonas aeruginosa* infection or colonization across Queen Elizabeth Hospital Birmingham per year in critical care, burns, haematology, and haemodialysis units

| Area | *P. aeruginosa* infections | | | |
|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 |
| Critical care | 93 | 102 | 104 | 57 |
| Burns unit | 19 | 22 | 20 | 18 |
| Haematology unit | 15 | 16 | 12 | 11 |
| Haemodialysis unit | 3 | 4 | 4 | 2 |
| Total | 130 | 144 | 140 | 88 |

American Journal of Infection Control ■■ (2017) ■■-■■

ELSEVIER

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

AJIC American Journal of Infection Control

Major Article

# Waterborne *Pseudomonas aeruginosa* transmission in a hematology unit?

Mark I. Garvey BSc, MSc, DipHIC, PhD *, Craig W. Bradley BSc, Elisabeth Holden FRC path

*University Hospitals Birmingham NHS Foundation Trust, Queen Elizabeth Hospital Birmingham, Edgbaston, Birmingham B15 2WB, UK*

*Key Words:*
Pseudomonas aeruginosa
Water testing
Hematology
Transmission
Outbreak

***Background:*** *Pseudomonas aeruginosa* is an important nosocomial pathogen that commonly colonizes hospital water supplies, including in taps and sinks. We report the transmission of *P. aeruginosa* from water to patients in a clinical hematology setting.
***Methods:*** *P. aeruginosa* from water samples were compared to clinical isolates from hematology ward patients, via molecular typing (pulsed field gel electrophoresis).
***Results:*** *P. aeruginosa* cultured from blood cultures from 3 patients was indistinguishable from water strains, by molecular typing. Based on infection control inspections, the transmission event was surmised to be due to cleaning of equipment, specifically an infusion therapy procedure tray used to transport intravenous drugs to patients, with water from an outlet colonized by *P. aeruginosa*.
***Conclusion:*** We show the importance of holistic factors, such as disposal of patient waste water, cleaning of tap outlets, and cleaning of medical equipment, in the transmission of *P. aeruginosa*, and demonstrate that the role of waterborne transmission of this organism in a hematology setting cannot be overlooked. We suggest that appropriate management of water, including both holistic and engineering interventions, is needed to stop transmission of *P. aeruginosa* from water to patients.


Garvey *et al.*, AJIC 2017

Open Access Research

BMJ Open

# Seeking the source of *Pseudomonas aeruginosa* infections in a recently opened hospital: an observational study using whole-genome sequencing

Joshua Quick,[1,2] Nicola Cumley,[2] Christopher M Wearn,[2,3] Marc Niebel,[2] Chrystala Constantinidou,[4] Chris M Thomas,[1] Mark J Pallen,[4] Naiem S Moiemen,[2,3] Amy Bamford,[2,3] Beryl Oppenheim,[2] Nicholas J Loman[1]

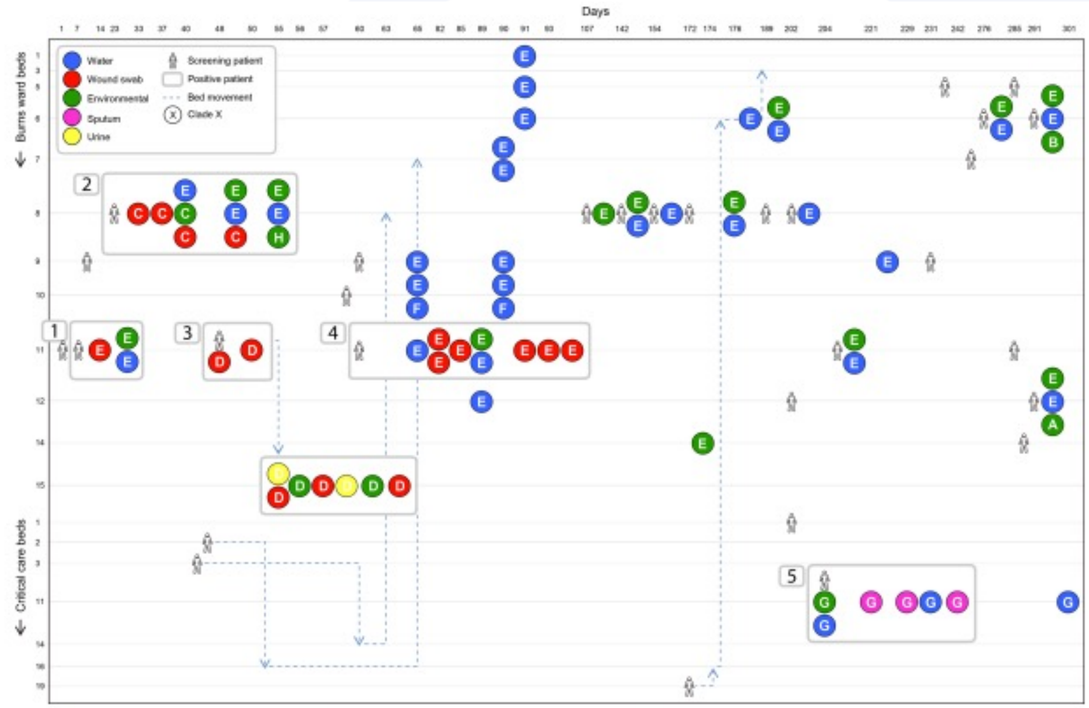
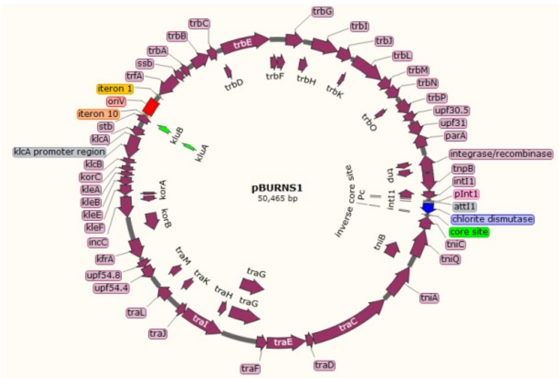
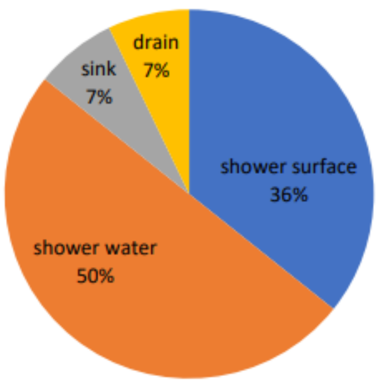


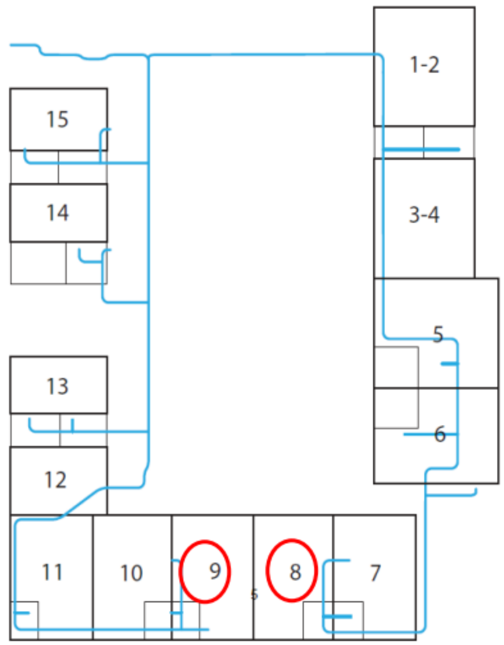

**Figure 2** A schematic view of the 300-day study of *Pseudomonas aeruginosa* in a burns centre and critical care unit. Time in days is shown along the x axis with bed numbers in the critical care unit and burns unit along the y axis. Each circular icon indicates a positive isolate of *P. aeruginosa*. The icon's logotype indicates which environment it originated from (wound, urine/sputum, environment or water). The filled colour of the icon indicates the clade it belongs to. Patient icons represent the enrolment of a screening patient into the study and their location. Patient movements around the hospital are noted by dotted lines. The five patients infected with *P. aeruginosa* are denoted by rounded boxes. Boxes are coloured according to the patient number. In the event two or more isolates of the same source and clade were collected on the same day, these have been collapsed into a single circular icon.

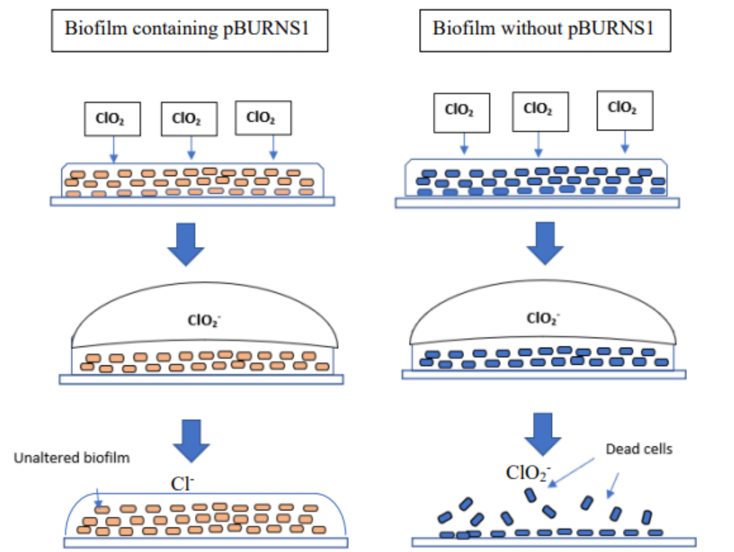
Quick J *et al.,* BMJ 2014

# Chlorine resistant plasmid



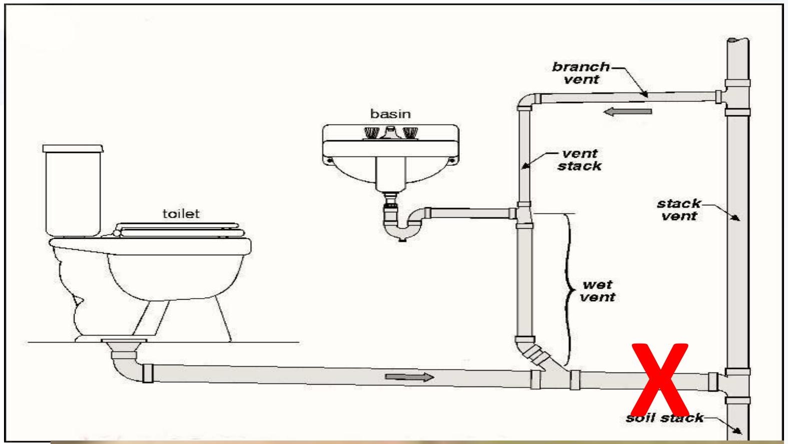

- Transfer to other bacteria in biofilm
- Found chlorine resistant bacteria in clinical specimens

Gambari RO, PhD 2020; Quick J *et al.*, BMJ 2014

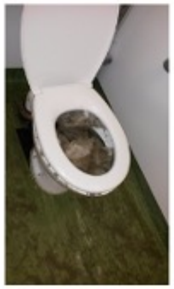
# Other water issues?

# Floods/ Blockages

- Pipes not designed to take waste (big enough)
- Get blocked pipes
- Disposable wipes down toilets; disinfectant wipes disposed of inappropriately
- Macerators – disinfectant wipes = blocked
- ? Outbreaks




UHB internal data analysis


**On The Ward**



**In The Macerator**



**In The Drains / Sewers from Sluices & Toilets**

Vergara-Lopez S *et al.*, CMI 2012

ORIGINAL ARTICLE — EPIDEMIOLOGY

## Wastewater drainage system as an occult reservoir in a protracted clonal outbreak due to metallo-β-lactamase-producing *Klebsiella oxytoca*


S. Vergara-López[1], M. C. Domínguez[2], M. C. Conejo[3], Á. Pascual[3,4] and J. Rodríguez-Baño[4,5]

1) *Internal Medicine Service, Hospital La Merced*, 2) *Laboratory of Microbiology, Hospital La Merced, Osuna, Seville*, 3) *Department of Microbiology, University of Seville*, 4) *Infectious Diseases and Clinical Microbiology Unit, University Hospital Virgen Macarena* and 5) *Department of Medicine, University of Seville, Seville, Spain*


### Abstract


We describe the epidemiology of a protracted nosocomial clonal outbreak due to multidrug-resistant IMP-8 producing *Klebsiella oxytoca* (MDRKO) that was finally eradicated by removing an environmental reservoir. The outbreak occurred in the ICU of a Spanish hospital from March 2009 to November 2011 and evolved over four waves. Forty-two patients were affected. First basic (active surveillance, contact precautions and reinforcement of surface cleaning) and later additional control measures (nurse cohorting and establishment of a minimum patient/nurse ratio) were implemented. Screening of ICU staff was repeatedly negative. Initial environmental cultures, including dry surfaces, were also negative. The above measures temporarily controlled cross-transmission but failed to eradicate the epidemic MDRKO strain that reappeared two weeks after the last colonized patients in waves 2 and 3 had been discharged. Therefore, an occult environmental reservoir was suspected. Samples from the drainpipes and traps of a sink were positive; removal of the sink reduced the rate number but did not stop new cases that clustered in a cubicle whose horizontal drainage system was connected with the eliminated sink. The elimination of the horizontal drainage system finally eradicated the outbreak. In conclusion, damp environmental reservoirs (mainly sink drains, traps and the horizontal drainage system) could explain why standard cross-transmission control measures failed to control the outbreak; such reservoirs should be considered even when environmental cultures of surfaces are negative.



**Keywords:** Carbapenemase, environmental reservoir, IMP-8, *Klebsiella oxytoca*, outbreak

**Original Submission:** 22 December 2012; **Revised Submission:** 17 April 2013; **Accepted:** 27 May 2013

Editor: J.-M. Rolain

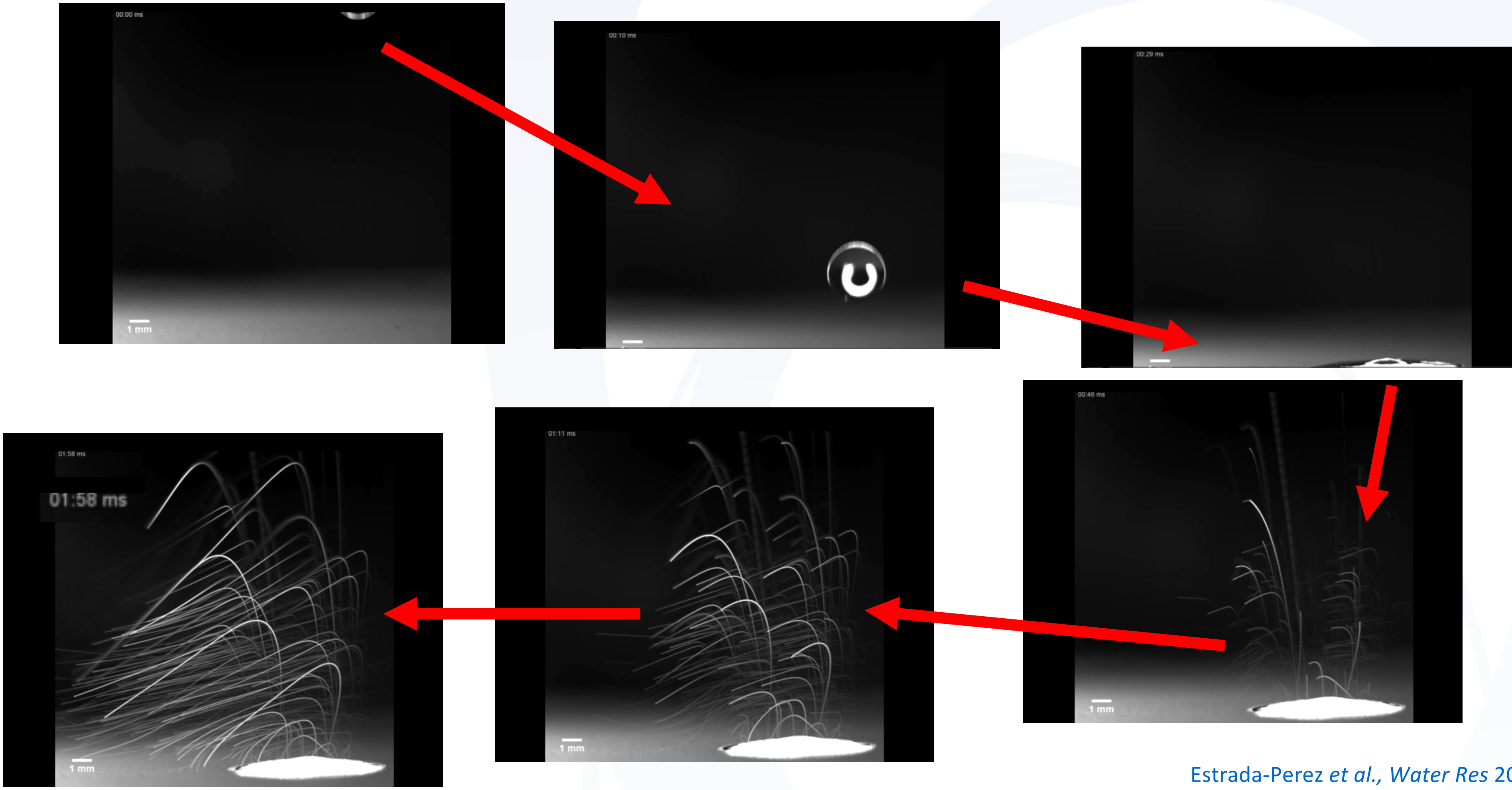
**Article published online:** 31 May 2013

*Clin Microbiol Infect* 2013; **19**: E490–E498

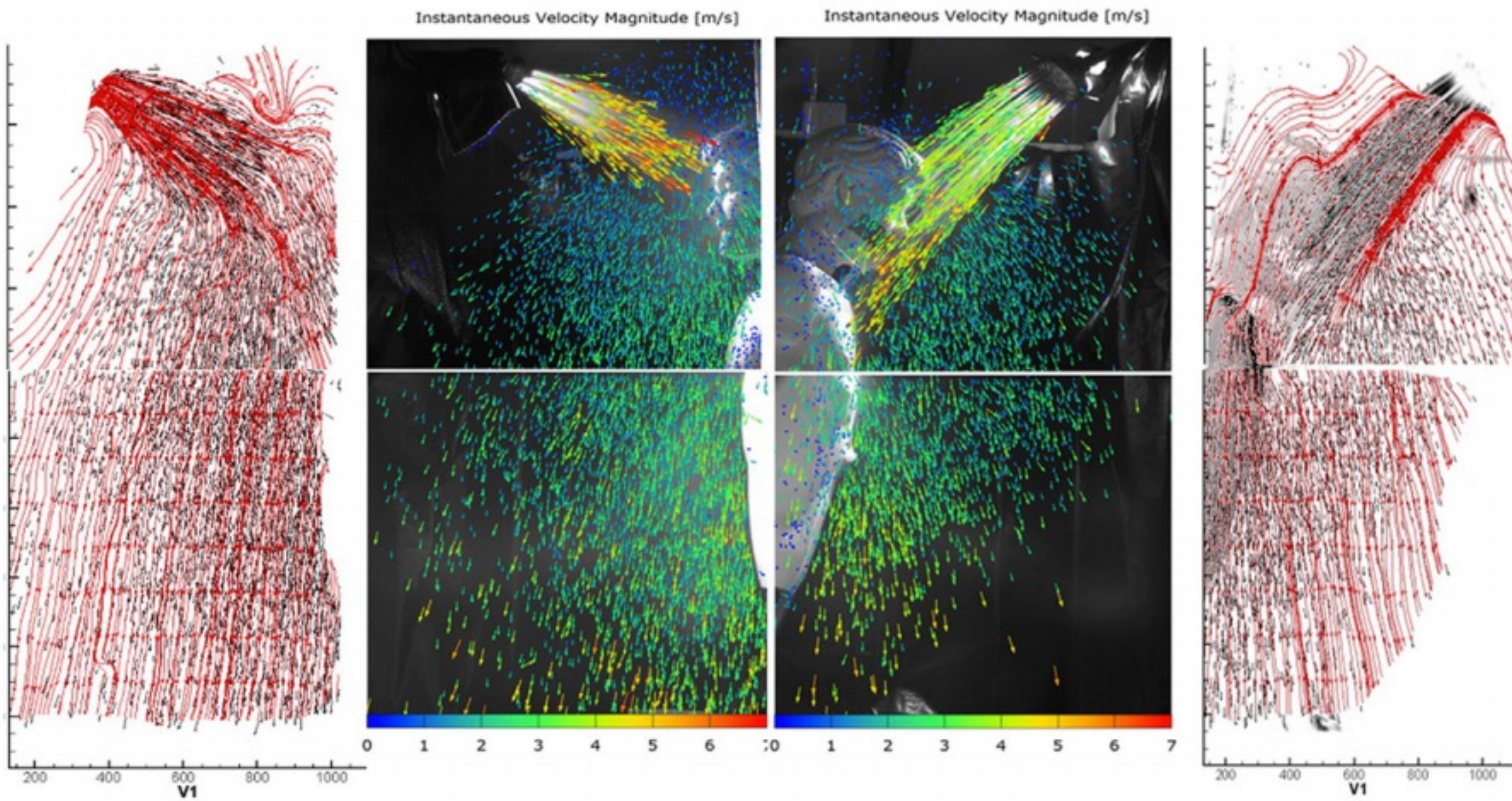
10.1111/1469-0691.12288

UHB internal data analysis

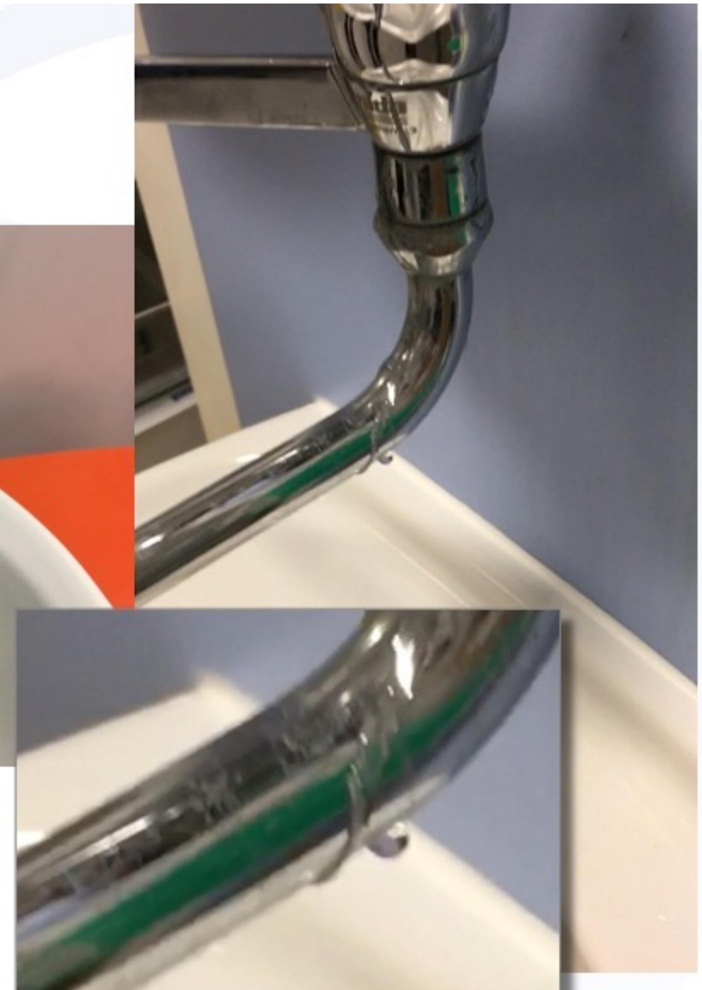
# Water Dispersal




Estrada-Perez *et al.*, *Water Res* 2018




Estrada-Perez *et al., Water Res* 2018



# What is down a sink?

Garvey MI *et al.*, JHI 2017; De Geyter *et al.*, ARIC 2017; UHB internal data analysis

# ‘Sink Splash Zone’

Journal of Hospital Infection 135 (2023) 154–156

Available online at www.sciencedirect.com

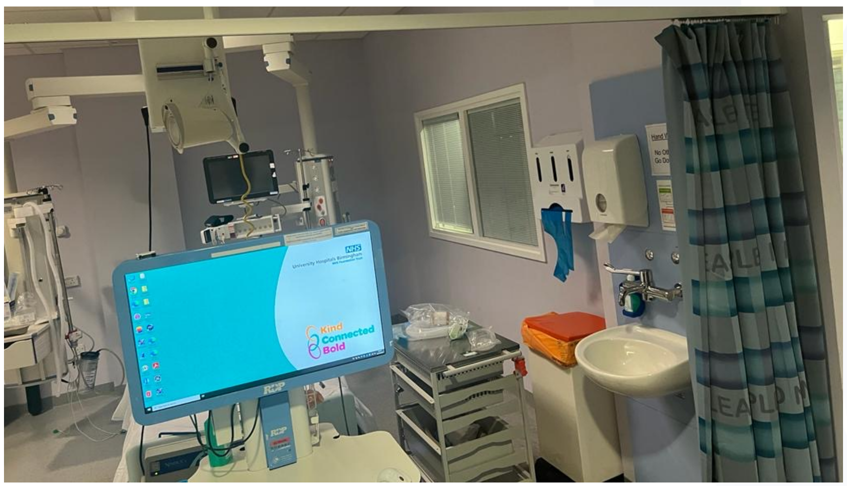
Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

Practice Points

## The sink splash zone

M.I. Garvey[a,b,c,*], N. Williams[a], A. Gardiner[a], C. Ruston[a], M.A.C. Wilkinson[a,b], M. Kiernan[d], J.T. Walker[e], E. Holden[a]




De Geyter *et al. Antimicrobial Resistance and Infection Control* (2017) 6:24
DOI 10.1186/s13756-017-0182-3

Antimicrobial Resistance and Infection Control

RESEARCH **Open Access**

### The sink as a potential source of transmission of carbapenemase-producing *Enterobacteriaceae* in the intensive care unit

Deborah De Geyter[1*], Lieve Blommaert[1], Nicole Verbraeken[1], Mark Sevenois[2], Luc Huyghens[2], Helena Martini[1], Lieve Covens[1], Denis Piérard[1] and Ingrid Wybo[1]

Journal of Hospital Infection 95 (2017) 329–330

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevierhealth.com/journals/jhin

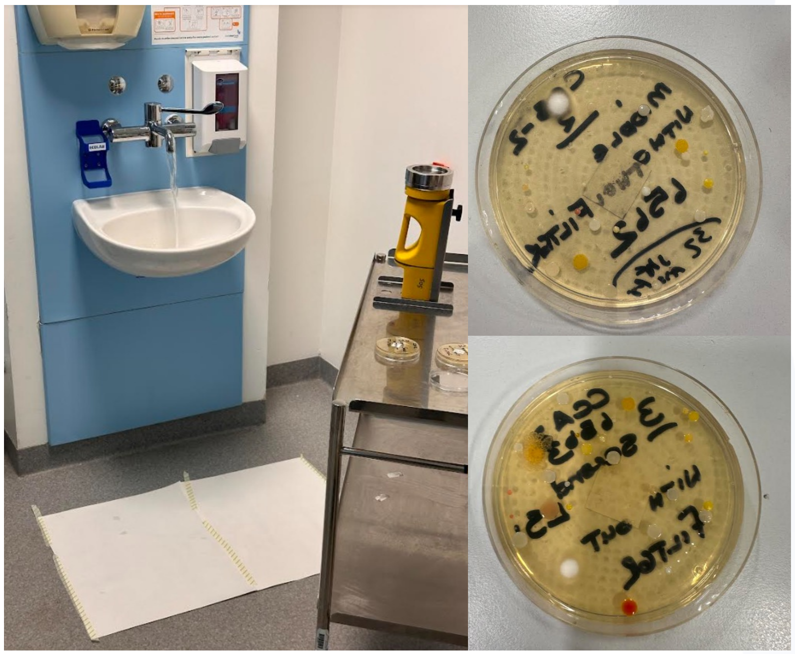
Letter to the Editor

### Using a carbapenemase-producing organism polymerase chain reaction to rapidly determine the efficacy of terminal room disinfection

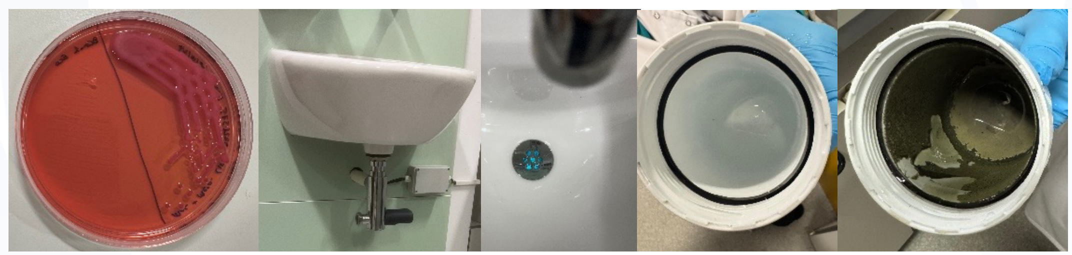
terminal clean (surface area samples with each swab ~30 $cm^2$). The sponges were then placed into tryptone soya broth and incubated overnight, before being subcultured on to solid media. The only difference was that, after overnight incubation, a swab was immersed into each broth and tested using the Cepheid Xpert® Carba-R PCR (Cepheid, Inc., Sunnyvale, CA, USA). The PCR was positive for a *bla*KPC on three of the

Garvey *et al.*, JHI 2023; Garvey MI *et al.*, JHI 2017; De Geyter *et al.*, ARIC 2017

# Further work



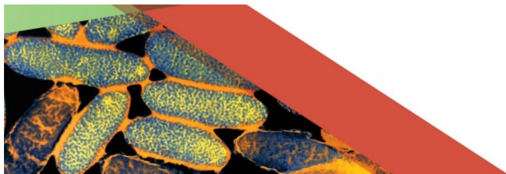
- *Citrobacter freundii, Enterobacter kobei, Enterobacter cloacae, Enterobacter asburiae, Pseudomonas aeruginosa, Sphingobacterium multivorum.*
- pQEB1
- TVCs/ splashing = POU filter > no POU filter > hand hygiene
- CPE outbreak wards find CPEs within sinks



Moran *et al.*, Microbial Genetics 2024

# Other water organisms

- *Legionella pneumophila*
- *Klebsiella pneumoniae*
- *Stenotrophomonas maltophilia*
- *Cupriavidus pauculus*
- *Nontuberculous mycobacteria*



SURVEILLANCE REPORT

# Legionnaires' disease

Annual Epidemiological Report for 2021

## Key facts

- In 2021, the highest annual notification rate of Legionnaires' disease to date in the EU/EEA was observed, at 2.4 cases per 100 000 population.
- The rates are heterogenous across the EU/EEA region, with age-standardised rates varying by country between <1–5 cases per 100 000 population.
- Four countries (Italy, France, Spain, and Germany) accounted for 75% of all the notified cases.
- Males aged 65 years and above were the most affected group (8.9 cases per 100 000 population).
- Only 11% of the cases were reported as culture-confirmed. This is likely leading to an underestimation of cases of Legionnaires' disease caused by *Legionella* species other than *Legionella pneumophila*.
- The majority of the cases were considered to be community-acquired.
- Occurrence of at least one outbreak of Legionnaires' disease was reported by eight of the 27 EU/EEA countries reporting data to the outbreak reporting scheme.
- A total of 19 outbreaks involving 137 confirmed cases were reported.
- The travel-associated Legionnaires' disease (TALD) surveillance scheme observed a 38% increase in cases compared with 2020.
- Similar to previous years, 90% of the TALD cases occurred in individuals aged 45 years and above. A similar age distribution was observed in the annual retrospective data collection of cases of Legionnaires' disease.

Journal of Hospital Infection
Volume 106, Issue 2, October 2020, Pages 232-239

## Toilet drain water as a potential source of hospital room-to-room transmission of carbapenemase-producing *Klebsiella pneumoniae*

L. Heireman [a], H. Hamerlinck [a], S. Vandendriessche [a], J. Boelens [a b], L. Coorevits [a], E. De Brabandere [b], P. De Waegemaeker [b], S. Verhofstede [a], K. Claus [a], M.A. Chlebowicz-Flissikowska [c], J.W.A. Rossen [c d], B. Verhasselt [a], I. Leroux-Roels [a b]

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https://doi.org/10.1016/j.jhin.2020.07.017

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Summary

Background

Carbapenemase-producing Enterobacterales (CPE) have rapidly emerged in Europe, being responsible for nosocomial outbreaks.

Current Opinion in
Infectious Diseases

Articles & Issues For Authors Journal Info

NOSOCOMIAL AND HEALTHCARE RELATED INFECTIONS: EDITED BY TRISH M. PERL

## Mitigation of nontuberculous mycobacteria in hospital water: challenges for infection prevention

Kaul, Christina M.[a]; Chan, Justin[a,b]; Phillips, Michael S.[a,c]

Author Information

*Current Opinion in Infectious Diseases* 35(4):p 330-338, August 2022. | *DOI:* 10.1097/QCO.0000000000000844

BUY Metrics

### Abstract

**Purpose of review**

The purpose of this review is to summarize recent literature on nontuberculous mycobacteria in water of healthcare systems. Despite improvement in identification techniques and emergence of infection prevention and control programs, nontuberculous mycobacteria remain present in hospital water systems, causing outbreaks and pseudo-outbreaks in healthcare settings.

Available online at www.sciencedirect.com
Journal of Hospital Infection
journal homepage: www.elsevierhealth.com/journals/jhin

## Outbreak of *Stenotrophomonas maltophilia* on an intensive care unit

A. Guyot [a,*], J.F. Turton [b], D. Garner [a]

[a] Department of Microbiology, Frimley Park Hospital, Camberley, UK
[b] Microbiology Services — Colindale, Public Health England, London, UK

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*Keywords:*
Drinking water
Environmental typing
Epidemiology
Intensive care unit
Molecular typing
*Stenotrophomonas maltophilia*
Water supplies

SUMMARY

***Background:*** *Stenotrophomonas maltophilia* causes opportunistic infections and remains a problem pathogen on intensive care unit (ICU) due to its multidrug resistance.
***Aim:*** An outbreak of *S. maltophilia* on ICU is described in order to highlight the risk from contaminated devices for supply of drinking water.
***Methods:*** The outbreak was investigated by a combination of epidemiology, environmental sampling and molecular typing.
***Findings:*** From 2009 to 2011 isolates of *S. maltophilia* from 23 patients were found to belong to only two genotypes by contrast with isolates from 52 other patients during this period, which represented distinct strains. The monthly incidence for all *S. maltophilia* strains ranged from 0 to 11% and for the two outbreak strains from 0 to 9%. Admission and weekly pharyngeal screening on ICU showed that the outbreak strains were acquired on ICU (range: 3—90 days). The majority of isolates (74%) were from the respiratory tract. Only two of 12 (17%) colonized intubated patients developed pneumonia. Environmental sampling found the two outbreak strains in two sinks and in the drinking water of the cooling unit in the ICU kitchen. *S. maltophilia* had formed a biofilm in the flexible tube from the carbon filter to the chiller and from the latter to the tap at the kitchen sink. This cooled water was used for providing drinking water and mouth care to ICU patients. The outbreak strains disappeared after removal of the water-cooler and the monthly incidence fell to <2% of ICU admissions.
***Conclusion:*** This outbreak report highlights the risk from biofilms in devices that supply drinking water for ICU patients.


Journal of Hospital Infection
Volume 111, May 2021, Pages 53-64

## Investigation and control of an outbreak due to a contaminated hospital water system, identified following a rare case of *Cupriavidus pauculus* bacteraemia

T. Inkster [a], C. Peters [a], T. Wafer [b], D. Holloway [c], T. Makin [d]

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https://doi.org/10.1016/j.jhin.2021.02.001

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Summary

Background

*Cupriavidus pauculus* is rare cause of clinical infection. We describe an outbreak of *C.pauculus* and other Gram-negative bacteraemias in a paediatric haemato-oncology unit secondary to a contaminated water supply and drainage system.

ECDC 2021; Heireman *et al.,* JHI 2020; Kaul *et al.,* Curr. Op. Infect. Dis. 2022; Inkster *et al.,* JHI 2021; Guyot *et al.,* JHI 2013

Hopman *et al. Antimicrobial Resistance and Infection Control* (2017) 6:59
DOI 10.1186/s13756-017-0213-0

Antimicrobial Resistance
and Infection Control

RESEARCH Open Access

# Reduced rate of intensive care unit acquired gram-negative bacilli after removal of sinks and introduction of 'water-free' patient care

Joost Hopman[1*†], Alma Tostmann[1†], Heiman Wertheim[1], Maria Bos[1], Eva Kolwijck[1], Reinier Akkermans[3], Patrick Sturm[1,4], Andreas Voss[1,2], Peter Pickkers[5] and Hans vd Hoeven[5]

**Table 1** 'Water-free' patient care activities

| Patient care-related action | New method with 'water-free' working |
|---|---|
| Gloves and gowns | Universal gloving and gowning (pre- and post-intervention period) |
| Hand washing after visual contamination | 'Quick & Clean', (Alpheios B.V., Heerlen, The Netherlands) wipes to remove extensive contamination from hands. Followed by disinfection with alcohol-based hand rub |
| Medication preparation | Dissolving of medication in bottled water (SPA reine, Spa, Belgium) |
| Drinks | Bottled water (SPA reine, Spa, Belgium) |
| Canula care | Disposable materials |
| Hair washing | Rinse-free shampoo cap (Comfort Personal cleansing products, USA) |
| Washing | Moistened disposable wash gloves, (D-care,Houten, The Netherlands) |
| Dental care | Bottled (SPA reine, Spa, Belgium) |
| Shaving | Electric shaving, or with warm bottled water (SPA reine, Spa, Belgium) |

Hopman J *et al.,* Antimicrob Resist Infect Control. 2017

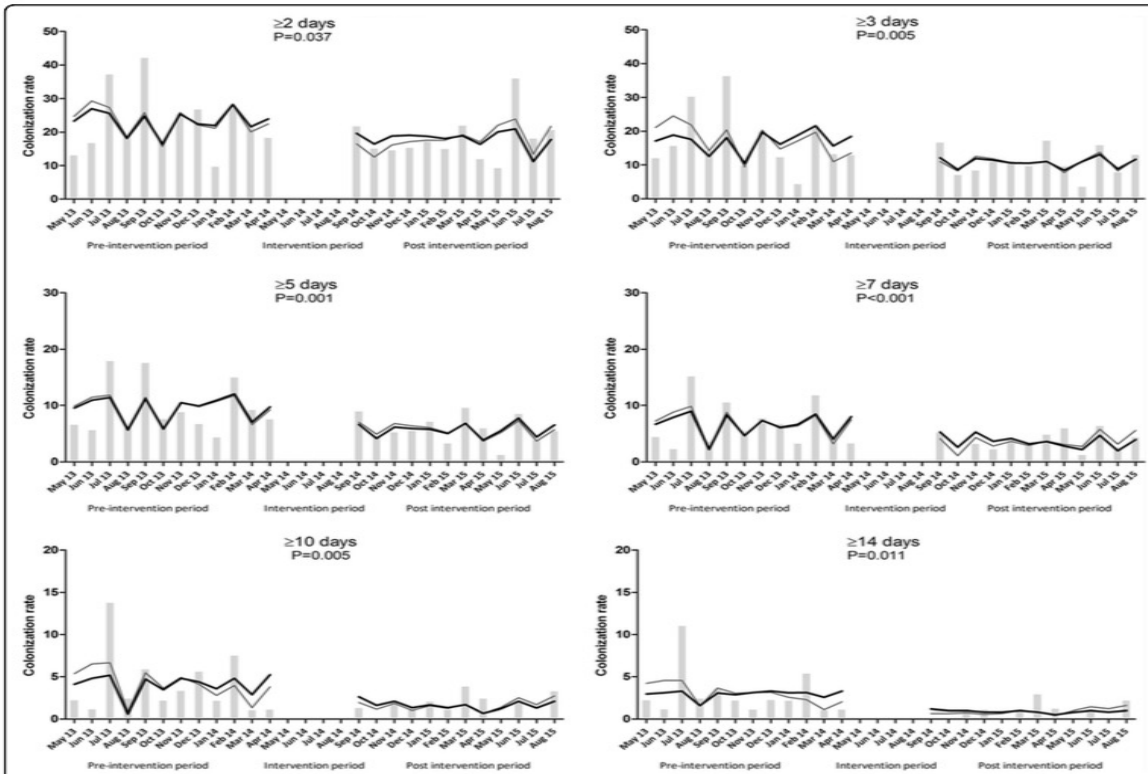


**Fig. 2** Monthly gram-negative bacilli (GNB) colonization rates. Legend: Monthly GNB colonization rates (bars), the predicated rate based on the full model (*grey line*) and the predicted rate based on the parsimonious model (*black line*). β2 level change *p*-values are shown in 2A to 2F, where β2 stands for the level change in the monthly colonization rate immediately after the intervention. Section A to F refer to GNB identified in ICU patients with a length of stay of ≥2, ≥3, ≥5, ≥7, ≥10 or ≥14 days after ICU admission

Hopman J *et al.,* Antimicrob Resist Infect Control. 2017

# Sinks in patient rooms in ICUs are associated with higher rates of hospital-acquired infection: a retrospective analysis of 552 ICUs

G-B. Fucini [a,b,*], C. Geffers [a,b], F. Schwab [a,b], M. Behnke [a,b], W. Sunder [c], J. Moellmann [c], P. Gastmeier [a,b]

[a] *Charité—Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Institute of Hygiene and Environmental Medicine, Berlin, Germany*
[b] *National Reference Centre for Surveillance of Nosocomial Infections, Berlin, Germany*
[c] *Institute of Construction Design, Industrial and Health Care Building, Technische Universität Carolo Wilhelmina zu Braunschweig, Braunschweig, Germany*

ARTICLE INFO

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Sinks
Water
*Pseudomonas aeruginosa*
Intensive care unit
Infection control

SUMMARY

***Background:*** Sinks in hospitals are a possible reservoir for healthcare-related pathogens. They have been identified as a source of nosocomial outbreaks in intensive care units (ICU); however, their role in non-outbreak settings remains unclear.
***Aim:*** To investigate whether sinks in ICU patient rooms are associated with a higher incidence of hospital-acquired infection (HAI).
***Methods:*** This analysis used surveillance data from the ICU component of the German nosocomial infection surveillance system (KISS) from 2017 to 2020. Between September and October 2021, all participating ICUs were surveyed about the presence of sinks in their patient rooms. The ICUs were then divided into two groups: the no-sink group (NSG) and the sink group (SG). Primary and secondary outcomes were total HAIs and HAIs associated with *Pseudomonas aeruginosa* (HAI-PA).
***Findings:*** In total, 552 ICUs (NSG $N$=80, SG $N$=472) provided data about sinks, total HAIs and HAI-PA. The incidence density per 1000 patient-days of total HAIs was higher in ICUs in the SG (3.97 vs 3.2). The incidence density of HAI-PA was also higher in the SG (0.43 vs 0.34). The risk of HAIs associated with all pathogens [incidence rate ratio (IRR)=1.24, 95% confidence interval (CI) 1.03–1.50] and the risk of lower respiratory tract infections associated with *P. aeruginosa* (IRR=1.44, 95% CI 1.10–1.90) were higher in ICUs with sinks in patient rooms. After adjusting for confounders, sinks were found to be an independent risk factor for HAI (adjusted IRR 1.21, 95% CI 1.01–1.45).
***Conclusions:*** Sinks in patient rooms are associated with a higher number of HAIs per patient-day in the ICU. This should be considered when planning new ICUs or renovating existing ones.

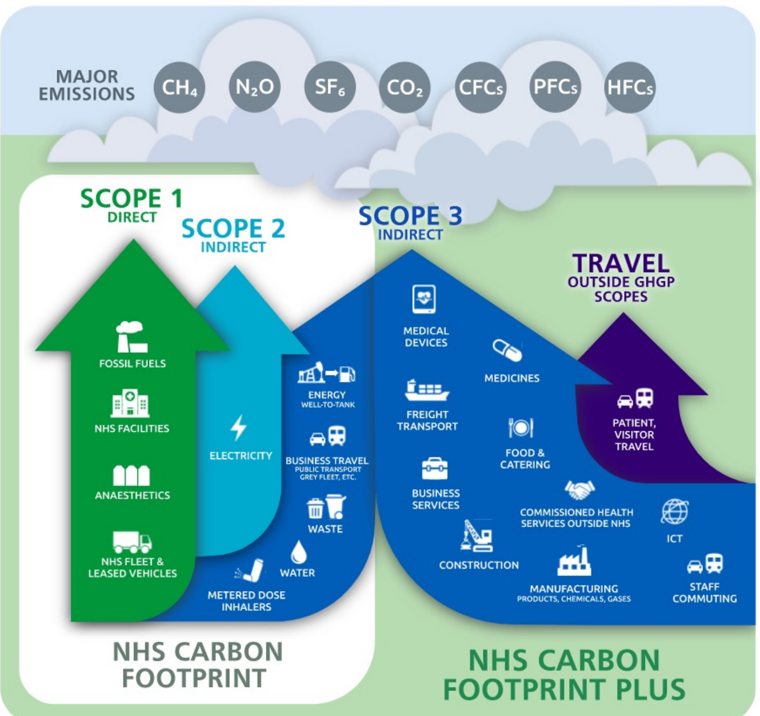

**Table IV**
Adjusted incidence rate ratios (aIRR) for all hospital-acquired infections on intensive care units (ICU) according to the presence of a sink in patient room and further risk factors or confounders

| Parameter | Category | aIRR | 95% CI | *P*-value (type III) |
|---|---|---|---|---|
| Presence of sink in patient room | Sink group | 1.21 | (1.01–1.45) | 0.039 |
| | No-sink group | 1=reference | | |
| Type of ICU | Interdisciplinary in hospital <400 beds | 1.001 | (0.83–1.21) | 0.004 |
| | Interdisciplinary in hospital ≥400 beds | 1.278 | (1.04–1.57) | |
| | General surgical | 1.255 | (1.00–1.59) | |
| | Special surgical (neurosurgical, cardiovascular) | 1.335 | (1.00–1.78) | |
| | Paediatric | 2.133 | (1.14–4.01) | |
| | Weaning | 0.952 | (0.60–1.53) | |
| | Others | 2.11 | (1.44–3.10) | |
| | Medical/neurological | 1=reference | | |
| Length of stay (days) | Risk increase per day | 1.01 | (1.00–1.02) | 0.016 |
| Invasive ventilation use | Risk increase per 1% | 1.009 | (1.00–1.01) | 0.001 |
| Urinary tract catheter use | Risk increase per 1% | 1.014 | (1.01–1.02) | <0.001 |

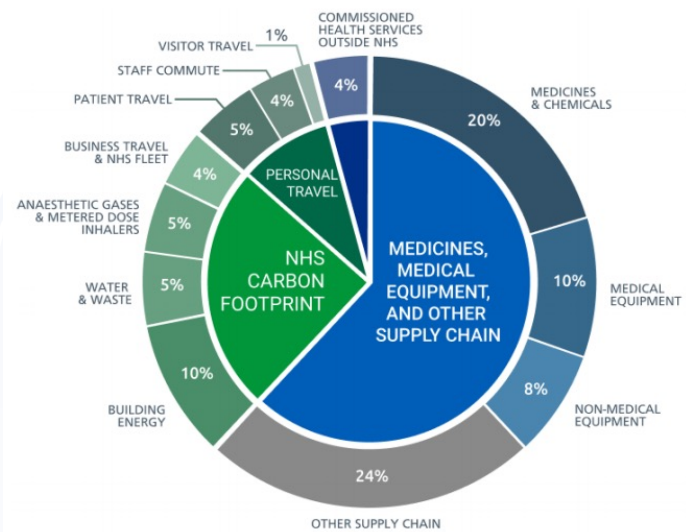
CI, confidence interval.

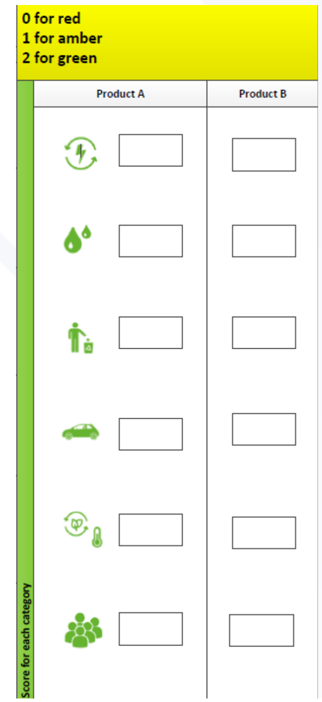
Fucini *et al.*, JHI 2023.

# The English NHS Carbon Footprint




Delivering a net zero NHS, NHSE 2022




| | | | | | | |
|---|---|---|---|---|---|---|
| Increase in water use | Similar water use | Reduction in water use | Increase in foul sewerage | Reduction in foul sewerage | Increase in use of toxic chemicals/ drugs | Reduction in use of toxic chemicals/ drugs |

# Final thoughts

- Contamination of taps with *Pseudomonas* leads to transmission
- Holistic factors as well as engineering to reduce transmission
- Sinks are a source of transmission
- Other water issues – splashing, blockages, practice etc.
- Remember other micro-organisms *Legionella spp.*
- Waterless ICU?

# Acknowledgments



# Thank you

## Questions?

## APRIL

3 ... Assessment of Mould Remediation in a Healthcare Setting Following Extensive Flooding
With Manjula Meda, UK

10 ... Use of Artificial Intelligence for Healthcare-Associated Infection Surveillance
With Prof. Ruth Carrico, US

22 ... Cost Analysis of a Hand Hygiene Improvement Strategy in Long-Term Care Facilities
**Afro-European Teleclass**
With Dr. Anja Haenen, Netherlands

24 ... What's Lurking in Your Sinks? Past Problems, Present Challenges, and Future Technologies
With Dr. Mark Garvey, UK

30 ... The Impact of Sink Removal and Other Water-Free Interventions in Intensive Care Units on Water-Borne Healthcare-Associated Infections
**Australasian Teleclass**
With Jia Ming Low, Singapore

## MAY

5 ... Special Lecture for World Hand Hygiene Day
With

15 ... Non-Ventilator Hospital Acquired Pneumonia
With Prof. Michael Klompas, US

22 ... COVID-19 Preparedness – What Went Wrong? What Are the Next Steps? The Point of View of a Biomedical Engineer
With Prof. Davide Piaggio, UK

## JUNE

2 ... IPAC Considerations in Global Emergencies
With Dr. Bois Marufov, Canada

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