# Looking deeper

THE JOURNAL OF THE WATER SAFETY FORUM

Issue 7 | **March 2020**

## Inside this issue

# The antibiotic resistance 'time bomb'

Looking Deeper Editor, **Susan Pearson**

In last year's BBC dystopian drama 'Years and Years', starring Emma Thompson, depicting how the near future in the UK might pan out from 2019 to 2029, someone is reported dead from an infected cut that turns into sepsis for which no antibiotic treatment is available. Of the various fanciful scenarios depicted for the next decade, deaths from infections with highly drug-resistant 'superbugs' is the one that is entirely plausible.

The threat from antibiotic resistance has increasingly cropped up in the news in recent years — but then tends to drop into the background again. Yet should we be more frightened? In 2013 the outgoing Chief Medical Officer, Dame Sally Davies, described antibiotic resistance as a "ticking time bomb"; by last summer, as we reported in Looking Deeper (Issue 5), she stressed the dangers should now be treated as seriously as extreme weather events.

And now, the World Health Organisation (WHO) has warned that despite numerous initiatives underway to reduce resistance, few products in development target the most critical resistant bacteria. Publishing two new reports in January on clinical and pre-clinical development of new drugs, they revealed that the more innovative options are likely to take years before they reach patients.

*"Never has the threat of antimicrobial resistance been more immediate and the need for solutions more urgent."*

*Dr Tedros Adhanom Ghebreyesus, WHO Director-General*

For the water safety/infection control community, the issue is a growing concern, mentioned with increased regularity at pretty much every conference and seminar in the last few years. In this issue of Looking Deeper, our interview with Infection Control Nurse Specialist Alyson Prince outlines how more investigation and understanding of the interface between the healthcare environment itself and patients and clinical staff is needed to minimise both the impact and the spread of multi-drug resistant organisms.

Some of these conclusions are echoed in our report from last autumn's second Water Safety Forum, which discussed how bacteria colonise water drainage systems in healthcare facilities and in particular references the highly antibiotic-resistant carbapenemase producing *Enterobacteriaceae* (CPE), also highlighted by Alyson.

Looking ahead, Armitage Shanks will be running a Healthcare seminar in April in London, with themes including healthcare design and hand washing, as well as sponsoring a Water Hygiene Masterclass alongside Pall Medical in Birmingham in June (see: idealspec.co.uk/events).

We will also be publishing further supplements in our popular 'Back to Basics' series. The next one, available alongside our Summer issue, will cover correct installation of sanitaryware to minimise bacterial contamination.

## Contents









# Editorial Contributions

Susan is an independent journalist and communications specialist with a background in biology, medical research and publishing. She has been writing on medical issues for over 25 years and on waterborne infection and water management since 2010. She has been a frequent contributor to IHEEM's Health Estate Journal and WMSoc's Waterline.

**Susan Pearson**

Elise is an independent consultant to the water and medical devices industries and a former Chair of the Water Management Society (WMSoc). She is a state-registered microbiologist and a Fellow of WMSoc, IHEEM, RSPH and IBMS. She chairs and presents at numerous international conferences.

**Elise Maynard**

Geraldine is the Research Lead for Health Facilities Scotland (HFS), working on development of an evidence base to underpin the guidance produced by HFS. Geraldine also leads on the development of HFS's Infection Control in the Built Environment guidance, which provides NHS Boards with a framework and information to identify, discuss and manage infection control risks collaboratively, and on the development, implementation and management of HFS's Statutory Compliance Audit and Risk Tool (SCART).

**Dr Geraldine O'Brien**

Catherine is Director of Research and Innovation in the School of Civil Engineering at the University of Leeds, Co-Director of the Leeds Institute for Fluid Dynamics and Co-Director EPSRC Fluid Dynamics CDT. She is a chartered mechanical engineer, with a background in fluid dynamics, with teaching and research expertise in building physics and environmental engineering, ventilation, indoor air quality and infection control in the built environment. She received the University of Leeds Women of Achievement Award in 2016 and the IMechE Construction and Building Services Division Prize in 2014.

**Professor Catherine Noakes**

Alyson is an Infection Control Nurse Specialist at University College Hospitals London (UCLH). Alongside water hygiene management in the healthcare setting, she is a Specialist in the built environment, working to ensure infection control standards are adhered to during building works, from pre-construction design through the duration of the planning process, working with both hard and soft FM contractors. She is also involved in overseeing the commissioning and decommissioning of healthcare buildings.

**Alyson Prince**

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# In the news...

## A cup of green tea could help fight 'superbugs'

Green tea is already thought of as a 'healthy' alternative to a regular cuppa, full of antioxidants along with the ability to provide revival against afternoon yawning. But now it looks as if it also comes with some added perks — one of the antioxidants it commonly contains can help eliminate antibiotic resistance.

Scientists at the University of Surrey have discovered that epigallocatechin (EGCG) can restore the activity of aztreonam, an antibiotic commonly used to treat infections caused by pathogenic *Pseudomonas aeruginosa* bacteria.

The study, published in the Journal of Medical Microbiology, conducted *in vitro* tests to analyse the synergy of EGCG and astreonam, looking at how they interacted individually and in combination. The researchers found the combination of aztreonam and EGCG was significantly more effective at reducing *P. aeruginosa* numbers than either agent on its own.

Researchers believe that in *P. aeruginosa*, which is becoming increasingly difficult to treat, EGCG may

facilitate increased uptake of aztreonam by increasing permeability in the bacteria. Another potential mechanism is EGCG's interference with a biochemical pathway linked to antibiotic susceptibility.

Lead study author Dr Jonathan Betts said: "We urgently need to develop novel antibiotics in the fight against anti-microbial resistance. Natural products such as EGCG, used in combination with currently licensed antibiotics, may be a way of improving their effectiveness and clinically useful lifespan."

The research was carried out in partnership with Public Health England, the German Centre for Infection Research and the University of Cologne.

## Good games promote good hand hygiene

An innovative approach to combating drug-resistant superbugs using interactive games was set up at Southampton General Hospital during the recent World Antibiotics Awareness Week as a way of promoting good hand hygiene.

Aimed at both children and adults, a series of interactive consoles were used to demonstrate how quickly bacteria can spread when hands are not washed properly and to educate on how over-use of antibiotics leads to bacterial mutation and drug resistance, and therefore fewer treatment options.

For example, the computers highlighted that after going to the toilet there may be some 'poo germs' left on hands and that if you don't wash your hands properly these bacteria can be spread over light switches and door handles.

One of the lessons for young children stresses that washing your hands properly takes as long as singing 'Happy Birthday' twice.

The Southampton General team hope the games helped people understand the issue and potentially reduce the number of antibiotics prescribed. The consoles were developed by Prof Tim Leighton and his NAMRIP team at the University of Southampton in partnership with the Winchester Science Centre, from which they can be loaned.


*Credit: Cameron Bowen*

## How bacteria 'unite' to evade antibiotics

A 'smart' survival mechanism used by bacteria to evade antibiotic treatment, which may help explain why some bacterial infections cannot be treated with antibiotics, has been revealed by a team of researchers headed by Jean-Louis Bru at the University of California, Irvine, USA.

Bacteria that have flagellae have the ability to move collectively in 'swarms'. However, the research, published in the Journal of Bacteriology, reveals the ability of opportunistic *Pseudomonas aeruginosa* bacteria to send signals that isolate any bacteria challenged by antibiotics or bacteriophage treatment from the primary bacterial swarms.

The researchers showed that both 'phage' infection of the bacteria abolishes swarming motility in the infected sub-population and stimulates the release of the *Pseudomonas* quinolone signaling molecule PQS. This forces back the uninfected subpopulations from approaching the infected area, limiting the infection to a sub-population, therefore promoting the survival of the overall population. The same response is generated against antibiotic treatment, with swarms totally repelled from the zone of antibiotic-treated *P. aeruginosa*.

The team demonstrated, for the first time, that PQS acts as a stress warning signal that causes the main population of bacteria to physically avoid cell stress, effectively a collective stress response that promotes the survival of bacterial populations.

The study was carried out by examining the growth and spread of bacteria in petri dishes in response to the antibiotic gentamicin.

Study co-author Nina Molin Høyland-Kroghsbo, from the University of Copenhagen in Denmark, commented: "It is a smart survival mechanism for the bacteria. If it turns out that the bacteria use the same evasive manoeuvre when infecting humans, it may help explain why some bacterial infections cannot be effectively treated with antibiotics."

## Dates for diaries...

**Water Management Society: The Good, The Bug and the Deadly**
25/03/2020 Manchester, UK
wmsoc.org.uk/conferences.php

**Armitage Shanks Pall Medical Water Hygiene Master Class**
June 2020 Birmingham, UK
idealspec.co.uk/events.html

**IHEEM Dublin 2020**
6-7/05/2020 Dublin, Ireland
iheem.org.uk/Dublin-2020

**Water Management Society AGM and Conference**
3/06/2020 Tamworth, UK
wmsoc.org.uk/conferences.php

**European Healthcare Design 2020**
8-10/06/2020 London, UK
europeanhealthcaredesign.salus.global/conference-show/european-healthcare-design-2020

**Health Infection Society 40th Anniversary celebration**
10-11/06/2020 London, UK
his.org.uk/training-events/40th-anniversary

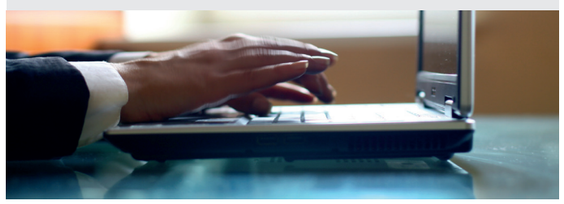
**Legionella Conference 2020**
19-21/08/2020 Chicago, USA
legionellaconference.org

**Healthcare Estates (IHEEM) conference**
6-7/10/2020 Manchester, UK
iheem.org.uk/Healthcare-Estates-2020

**Infection Prevention 2020**
28-30/10/2020 Bournemouth, UK
ips.uk.net/conference

## Share your thoughts with us in the next issue

We would really value your reactions to this latest issue of Looking Deeper. We'd like to hear from you about what you liked, what you feel could be improved on and what topics you want to see discussed. You can contact us at **editorial@lookingdeeper.co.uk**




# Water Safety Forum — hidden dangers from wastes

A flavour of the discussions from the second Water Safety Forum (WSF) held at Ideal Standard's London Design and Specification Centre in September 2019. The expert panel at this event comprised consultant clinical microbiologists, independent microbiology specialists for the healthcare industry and representatives from Health Facilities Scotland and Public Health England's water microbiology research team, alongside sanitaryware design engineers.

Until recently, much of the research and discussion on how to break transmission pathways for waterborne healthcare-acquired infections (HCAIs) has focused on contamination of taps and basins — how to prevent contamination in the first place and how to prevent any that might be present from reaching vulnerable patients. But reports are currently appearing in the literature — some of which have been discussed in previous issues of Looking Deeper — of the role of contaminated waste and drain traps in spreading HCAIs.

There is now a consensus that says we need to think about what happens further down plumbing systems where water disappears out of sight: How do bacteria colonise drainage systems? How does this colonisation impact HCAIs? What solutions might be found for these problems?

This was the main focus of the latest WSF brainstorming session to gain insight into the current concerns of users in relation to sanitaryware and fittings in the healthcare environment. Several key issues were identified, including: blockage and design of waste traps and the role of mis-usage of wash hand basins (WHBs) and taps in facilitating contamination.

The conversation ranged over possible solutions and considered the role of innovative design from sanitaryware manufacturers.

## What are the problems?

### *Bacterial contamination*

A range of organisms of clinical significance have been found within waste traps and drains. Of increasing concern are antibiotic-resistant organisms such as carbapenemase producing *Enterobacteriaceae* (CPE), which appear to be easily spread throughout hospital drainage systems.

Plumbing that has any connection to a hospital's waste or sewer system provides the potential for dissemination of these bugs, which may then take hold in any biofilms present within U-traps, basins and toilets.

Current research by Public Health England (PHE)'s water microbiology team at Porton Down suggests that back flow of water is likely to push this contamination back up into WHBs, especially if there is a residue of water that is slow to drain or doesn't drain away fully — whether as a result of drainage pipes placed at the wrong angle, other design issues and/or blockages.

Once a hospital has had a major CPE outbreak, it seems to be impossible to eliminate the organism, which then becomes an effective vector for antibiotic-resistance.[1,2]

### *Human factors*

The cause of contamination of WHBs and drainage systems often comes down to the way they are being used — something the panel discussed at length, and which we have covered previously in Looking Deeper.[3,4,5]

While the guidance (HTM 04-01 Part C: 3.3) makes it clear that clinical WHBs should be used only for hand washing, a paper describing results of filming users' behaviour at a hand wash station showed that only one in 25 were used solely for the correct purpose.[6]





WHBs are often used, wrongly, for the disposal of a range of substances, the biggest problem being potentially infected patient fluids that can introduce pathogenic bacteria onto basin surfaces and tap ends. While respiratory secretions from respiratory kit or patient wash water should be disposed of in the appropriate sluices, ICU nurses may not be able to leave their patient or healthcare workers might not have time to walk all the way to a distant facility.

Another common problem is the disposal of tea and other drinks, foodstuffs, toothpaste and toiletries, which provide nutrients for bacterial growth. There have also been reports of disposal of antibiotics in basins, encouraging antibiotic resistance within biofilms.

Many problems in waste traps and further down the drainage system have been caused by blockages created by collections of debris that have been flushed into the system via basins and sinks that then impair drainage as well as facilitating biofilm growth.

Detritus found in drainage systems includes: wipes (a major cause of blockages), bits of paper towels, parts of syringes and other plastics and significant amounts of hair in oncology shower drains[7].

The panel noted that sometimes, due to pressure on staffing levels and resources, these issues may not be highlighted until there is an outbreak of a waterborne infection.

### *Design of drains*

Design of drain and waste traps can contribute to contamination problems. For example, gaskets/spigots at the back of sinks may be incorrectly tightened in such a way as to slow/prevent drainage by creating a small 'weir' that encourages biofilm growth in the U-bend.

In showers, drains are often designed in such a way that patients will be standing on top of them as they shower, even when the drains may be flooding due to unsavoury and potentially contaminated blockages.

### *Cleaning drains*

While contaminated drains need to be cleaned or decontaminated, the process of doing so can itself cause hazards. For example, the use of bottle brushes is no longer allowed because this spreads contamination around basins and beyond.

In augmented care in particular, it is crucial that there is no aerosolisation from drains that might come into contact with patients or surfaces adjacent to patients.

The panel posed the question: is it important to clean the drain or find means to 'control' the drain so that bacteria cannot migrate back into the basin? They also considered where the boundary of a drain from 'dirty' to 'clean' should be defined, for example, beyond the U-bend into the sewer — and how to maintain that barrier. They mooted that perhaps drains should only be cleaned when problems arise rather than be cleaned routinely.

### *Incorrect installation*

Incorrect installation of taps, basins and showers is a frequent contributor to contamination problems. Taps that are installed to flush directly over a drain will cause splashback, spreading potentially contaminated aerosols.

WHBs and hand wash stations are often not set up correctly: for example, elbow-operated handles for taps are too close to back panels, so that people re-contaminate their hands, and soap and towel dispensers are set directly above basins.


The panel noted that the competency of contractors installing plumbing in healthcare is a significant issue that needs to be addressed. Many may be competent for low-risk buildings such as schools and office blocks, but are not assessed for healthcare and infection control requirements.

## Solutions

### *Human behaviour*

Alongside increased education and training to highlight the risks of certain behaviours, suggestions from the panel included:

- Making it more physically awkward to use hand wash zones inappropriately, for example, by introducing shielding to prevent splashing on nearby surfaces.
- Using psychological methods and product design that supports education about hazards. For example, making clinical WHBs look less like classic tap and basin/sink arrangements so that users will develop different associations around usage: e.g. dental staff should use a separate WHB that they identify as being for hand washing only and a separate, very different, sink for dirty equipment.

  One suggestion was to keep WHBs white (to represent 'cleanliness'), while giving 'dirty' sinks, equipment and areas a colour, such as 'biohazard' yellow. It would also be possible to incorporate text or a graphic into a basin's ceramic under the glaze to communicate instructions such as 'clean' or 'for hand washing only'.
- Using clinical considerations for prevention of 'wrong behaviours', e.g. creating different clinical methodologies to eliminate reasons for disposal of biological fluids in WHBs, such as development of a new medical wipe to be disposed of in the clinical waste bin.
- Using human factors to eliminate use errors so that patients are provided with washing facilities that helps to protect them from exposure.

Clinical WHBs should be placed at a safe distance away from patients, with a separate general use basin and a waste station further away — which might change staff behaviour provided they do not have to walk too far to dispose of 'dirty' substances.

Conversely, a new hazard might be introduced in the form of a seldom-used outlet, as stagnation encourages biofilm formation.

*Waste traps*

The panel put forward a number of suggestions for design solutions, including:

- Heated waste traps
  There was a discussion around the efficacy of heated waste traps. Two types were discussed: larger block-like units and heated U-traps. With the latter type, the reservoir of water that collects allows sampling both above and below the U-bend. Sampling by PHE has demonstrated significantly less bacterial contamination above the heated trap.

  There was also a suggestion that the rising steam from heated water retained in a heated U-bend could be effective as a steriliser that disinfects the system right up into the basin.

  The downside of these devices is that they are liable to breakage and are often very expensive to fix.
- Chemical solutions
  Several options were discussed: sodium hypochlorite or peracetic acid has been used in some locations to clean U-bends on a weekly basis. Although biofilm will generally grow back, the panel noted that this method could be used to manage the problem and to restrict biofilm to lower levels of a drain to move the hazard further away from patients. Biofilms may spread up the pipes from waste traps, at a potential spread rate of 1 mm per day.

  However, contact time is needed in the pipes leading into sinks in order to attack any biofilm that might be present, and foaming substances are now being developed to address this.

*Design of hand wash stations*

The layout of hand wash stations is not consistent, differing from one hospital to another. They need to be configured so that hand wash and alcohol gels do not drip into the basin or onto the tap outlet. Paper towel dispensers should not be placed directly above a basin because small fragments of towel are known to fall into the basin when towels are pulled from the dispenser, which can contribute to blockages. However, paper towels need to be easy to reach to prevent hands dripping over adjacent surfaces.

*Commissioning: design stage*

In new builds and refurbishments, some problems could be prevented at the design stage — yet contracts are often set up without input from Water Safety Groups (WSGs) or infection control teams. There is also a disconnect from those who are specifying and designing the 'kit' in the first place. However, conversely, if WSG members have not had specific training on water issues, they may not have clear design requirements at the commissioning stage.

## Conclusions

There was a consensus from the panel over the importance of generating more understanding about bacterial movement and growth within waste pipes and traps and how this could influence the design of new interventions. It is also crucial to improve understanding





of potential transmission pathways, i.e. how these pathogens reach patients.

It was noted that whatever method of mitigation or eradication are put in, biofilm will often find its way back from that situation. The literature shows that it is often the weaker organisms that are destroyed by interventions, leaving behind the strongest, thus creating multi-treatment resistant organisms in addition to multi-drug resistant organisms.

The panel emphasised that because it can be difficult to isolate a problem without creating a new point of failure, new interventions should not be over-engineered, but need to be kept simple and intuitive to prevent unintended consequences from over complex designs.

The panel concluded that there cannot be a 'one size fits all' approach to solving contamination problems because each situation is unique. In addition, guidance cannot be too "hard and fast" — it needs to provide sufficient flexibility and allow some degree of interpretation to suit individual circumstances. While most previous thinking has largely been focused on individual taps, basins and wastes — a more holistic systematic approach, incorporating behavioural changes, may be the key to finding solutions.

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7. Breathnach, A.S. *et al* "Multidrug-resistant *Pseudomonas aeruginosa* outbreaks in two hospitals: association with contaminated hospital waste-water systems", *J Hosp Infect* **82**:19-24, 2012.


# Water Safety Forum Panel

**Elise Maynard — Chair**

Independent consultant to the water and medical devices industries — a state-registered microbiologist and former Chair of the Water Management Society.

**Professor Peter Wilson**

Consultant Medical Microbiologist and Professor of Microbiology at University College London Hospital, and Chair of the Speciality Training Committee for Microbiology for London.

**Dr Mike Weinbren**

Consultant Clinical Microbiologist and Director of Infection Control, Kings Mill Hospital, Sherwood Forest Hospitals NHS Foundation Trust, and Chair of the Hospital Infection Society Working Party on water.

**Ian Storrar**

Head of Engineering (Principal Engineer) for Health Facilities Scotland.

**Dr Geraldine O'Brien**

Research Manager for Health Facilities Scotland and Lead on development of compliance and infection control training tools.

**Dr Ginny Moore**

Public Health England, Porton Down, project team leader for water microbiology and healthcare-acquired infections (HCAIs).

**Dr Paul McDermott**

Independent advisor in biological risk management and former Health and Safety Executive specialist inspector on *Legionella* risk control. Involved in development of HSE guidance and strategies on *Legionella* control.

# Joined up thinking needed to fight antibiotic resistance

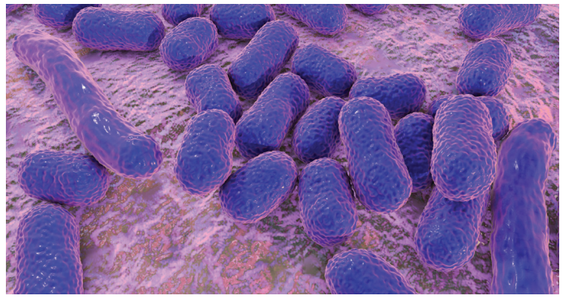
Antibiotic resistance is now recognised as a serious threat to human health. Susan Pearson talks to Infection Control Nurse Specialist Alyson Prince about the implications for water safety in healthcare.

Alyson Prince is an Infection Control Nurse at University College Hospitals London (UCLH) with specialist knowledge of the built environment.

Here Alyson gives a summary of her thoughts on the importance of understanding the interactions between the built environment and clinical practice — including water systems as a reservoir for multi-drug resistant organisms (MDRs) — in order to inform safe practice to prevent transmission of MDR hospital-acquired infections (HAIs).

### *What are the dangers from antibiotic resistance in relation to infection control and water safety?*

The World Health Organisation (WHO) has highlighted the threat from antibiotic resistance, identifying the key driver for drug resistance as over-use of antibiotics, and has included emerging HAI pathogens such as *Pseudomonas aeruginosa* in its list of antibiotic-resistant "priority pathogens". MDR organisms in the hospital environment are now increasingly of concern as there are fewer antibiotics available to treat patients who acquire an infection.



In the UK, the link between water and HAIs other than *Legionella* was established following the 2012 neonatal *P. aeruginosa* outbreak in Belfast. Investigations revealed the link between contaminated water from outlets and the infections arising in neonatal infants, which was thought to have contributed to infant deaths. While the initial focus for mitigation rested on tap components, pipes and also cleaning and changing equipment, increasingly, the causative organisms in a number of *P. aeruginosa* outbreaks have also been found in the sinks and drains of water outlets connected with the affected patients.[1]

Currently, carbapenemase producing *Enterobacteriaceae* (CPEs), most commonly found in the gut have developed resistance to carbapenems, one of the most powerful types of antibiotics used only in serious infections. Some of these organisms can survive well in water, making them of particular concern as they can be spread widely within the hospital environment via hands, feet and equipment.

But where do these organisms originate? While they have many sources, CPEs are most commonly found in the gut of humans and animals who are likely to have been exposed to multiple antibiotics. Some patients acquire these as part of their contact with other infected patients or contaminated environments.

The presence of CPE organisms in water systems is a mounting problem, but as yet there is no definitive picture of their origins when found in drains; they could be coming from the water supply itself, which has become contaminated, could be generated as a result of contamination due to disposal of inappropriate items into wash hand basins (WHBs) or could be transferred from the patients themselves.

However, this concept of the 'patient as the source', is relatively recent — many public buildings have been found to have their own micro-biomes, which tend to be colonised by the people who occupy them.[2] It is now understood that intensive care units (ICUs) are vulnerable to becoming 'colonised' by MDR organisms, due partly to the high throughput of the sickest patients, whose condition means that they are often exposed to large amounts of antibiotics.

The problem is then exacerbated as inter-hospital transfer of patients can allow these organisms to move between healthcare facilities, with new groups of patients potentially being exposed to 'colonised' patients that have not yet been identified as such.

It is therefore important to ensure a thorough risk assessment of patients on admission, including screening, although the criteria for screening is now changing as new information emerges. Currently, rectal isolates are cultured, but results are not always definitive and colonisation in a patient doesn't necessarily manifest any obvious clinical symptoms prior to the patient developing an infection.

### *How should practice be altered to reduce risks?*

Clinical practice has to change to reduce risks, but that can only happen with further understanding of how water systems work and how their contamination occurs, which requires further investigation.

In some ways, we are in a 'Catch-22' situation — until we understand all the risks, we can't change our practice. Even with *Legionella*, which we largely know how to manage, there still isn't a standardised approach across all NHS Trusts. With *P. aeruginosa* there's still considerably more research needed into what facilitates its growth and transmission between patient and environment.

There have been numerous thorough investigations showing that some components of taps, thermostatic mixing valves (TMVs) and EPDM rubbers in hoses can be a source of nutrients for these organisms. However we also need to look into what may be found in drains and the mechanisms of aerosolisation in close proximity to vulnerable patients. There are a number of factors in buildings that can contribute to that risk, i.e. the combined effect of water flow, softness or hardness of water, numbers of tap and shower outlets, how they are maintained, how water is utilised by all occupants of the clinical environment and what biocides are being used.

When a positive outlet is identified, the current position is often to remove outlets and pipe work that is perceived to be contaminated. This has been shown to reduce contamination of the environment — but that doesn't necessarily solve the problem. Biofilm can harbour MDR organisms and further interrogation of the system as a whole may be useful.

In the meantime, water should be considered as a reservoir for these organisms and infection control measures and effective cleaning of both hands and near patient equipment can reduce environmental contamination and reduce the risk of transmission.

### *What's the solution?*

Risk assessment (RA) of the outlets is key, including analysis of how they are used and an understanding of the clinical practice in the area and how that could be contributing to contamination of the system. However, WHBs and showers need continual RAs, including routine testing and increased frequency of testing of positive outlets, as is recommended in the current guidance.

Testing for *P. aeruginosa* requires a genuine 'first catch' water sample after a period of non-use. In busy units where staff are continually utilising the outlet this can be difficult to achieve and close collaboration between clinical and estates teams is essential to achieve thorough RAs.

In order to provide confidence that the clinical environment is safe for vulnerable patients, it is often prudent to adopt a belt and braces approach. This could include point of use filters for 'positive' outlets and further decontamination of hands with alcohol gel following hand washing.

### Education

There needs to be more education to promote understanding for staff about their own impact on the environment they work in.

For example, in ICUs patient wash water may be tipped down WHBs because the outlet is perceived as a 'sink' or because poor building design has left the location of facilities and outlets poorly placed, impeding clinical practice. Clinical staff will often find resourceful solutions, such as disposing of waste water in a WHB sink because the sluice may be located too far away for safe disposal.

It is also important to understand that staff are under time constraints and will find ways to save time in order to provide better quality care for their patients. In particular, ICU nurses cannot leave their patient if there is no available cover for their absence, maybe leaving no choice but to use the WHB for disposal of fluids.

In the meantime, we have mitigations that we can implement if we identify a risk to patient safety from a water source. Where a patient has been identified as colonised with these organisms we implement strict contact precautions which include isolation of the patient, enhanced cleaning around the patient and communication and collaboration with the teams throughout the patient's journey.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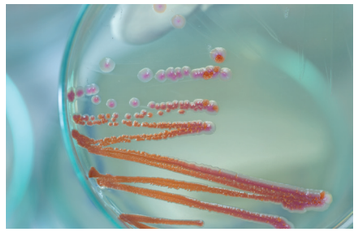


# A question of risk

**How tools based on question sets to inform the early commissioning stages for NHS buildings are being used in Scotland to help minimise infection control risks from water.**

There is an increasing consensus that poor design in healthcare facilities can result in compromised water safety yet conversely, well thought-out design can deliver buildings that minimise risks — a focus on the importance of correctly identifying risks at the briefing stage of the procurement process is crucial.

At a recent Water Hygiene Masterclass in Glasgow, sponsored by Armitage Shanks and Pall Medical,* Health Facilities Scotland (HFS) Assistant Director Eddie McLaughlan stressed "if we don't get the briefing right, then we don't get the right product at the end of the day". He emphasised that one of the biggest lessons learnt in delivering health facilities that minimise risk is the need to network with industry to ensure that everyone involved in commissioning is "on the same page" with the issues.

McLaughlan's colleague Dr Geraldine O'Brien, HFS's Research Lead, went on to describe how the ongoing development of two tools allows Scottish NHS Boards to target limited resources to the highest risk areas. These tools, SCART and HAI-SCRIBE, are key components in driving forward the process of making sure that early stages in commissioning of NHS buildings are accurately informed.

SCART is HFS's Statutory Compliance Audit and Risk Tool, providing NHS Boards with a common way to measure and report on statutory compliance to stay consistent with Health and Safety Executive (HSE) approaches and interpretations.

*Eddie McLaughlan and Dr Geraldine O'Brien in Glasgow.*

HAI-SCRIBE (Healthcare Associated Infection System Controlling Risk in the Built Environment) allows identification of infection control risks associated with each stage of the development of a healthcare facility, from the design/planning stage right through to the ongoing monitoring of that healthcare facility. Both tools are built around question sets to identify and manage risks and pull the right people on board to deliver effective decision making.

## Question sets and dialogue

Why have question sets? The impetus behind the development of HAI-SCRIBE, the first of these tools to be put together, followed the Watt report on the December 2001-January 2002 salmonella outbreak at Glasgow's Victoria infirmary, which claimed three lives. This highlighted that infection prevention and control risks were not being identified and led to the set-up of a multidisciplinary group to consider how to improve this situation. Feedback revealed a clear communication gap between different teams, working in silos without any dialogue. Estates teams saw infection control teams as blocking their job, while infection control staff complained that estates personnel would come along and "just start taking down tiles and do whatever they like".

The best strategy to get people to talk was to start asking questions. A series of questions were formatted that were associated with each stage of the development of the healthcare facility to allow staff to identify and manage the infection control risks.

It was considered that asking questions should not be left down to one individual and the question sets are designed to aid communication and collaboration, with compromise thrown into the mix to cover the many situations where "one size doesn't fit all".

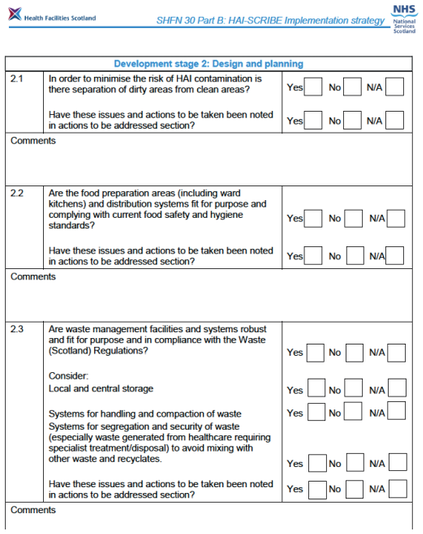
## SCART

SCART is used by all Scottish Boards. It is based around 39 estates and facilities topics, with the question sets for each designed to help Boards identify risks. These identified risks are then amalgamated into action plans so that Boards can take forward action to allow mitigation of risk and in turn monitor and manage their position.

Each of the SCART question sets have been developed through expert advisory groups who trawl through the guidance and compare question sets against the risk associated with non-compliance with each question.

This gives Boards a common way to measure and report on statutory compliance and allows Boards to target limited resources towards the areas of highest risk. The tool covers a wide range of topics — from ventilation, water systems, medical gasses, electrical systems — and allows Boards to demonstrate that they are proactive in trying to mitigate risks.

However, Dr O'Brien noted that there is need for continuous improvement. For example there can be gaps in action plan development: "Going forward we're continuing to support the Boards and help them to a point where they can tell what's working effectively and know what the current position is with regards ...[to the] risks they have identified and put a mechanism in place that helps them to escalate [the focus on] those risks."



Health Facilities Scotland — *SHFN 30 Part B: HAI-SCRIBE Implementation strategy* — NHS National Services Scotland

**Development stage 2: Design and planning**

| | | |
|---|---|---|
| 2.1 | In order to minimise the risk of HAI contamination is there separation of dirty areas from clean areas? | Yes ☐ No ☐ N/A ☐ |
| | Have these issues and actions to be taken been noted in actions to be addressed section? | Yes ☐ No ☐ N/A ☐ |
| Comments | | |
| 2.2 | Are the food preparation areas (including ward kitchens) and distribution systems fit for purpose and complying with current food safety and hygiene standards? | Yes ☐ No ☐ N/A ☐ |
| | Have these issues and actions to be taken been noted in actions to be addressed section? | Yes ☐ No ☐ N/A ☐ |
| Comments | | |
| 2.3 | Are waste management facilities and systems robust and fit for purpose and in compliance with the Waste (Scotland) Regulations? | Yes ☐ No ☐ N/A ☐ |
| | Consider: Local and central storage | Yes ☐ No ☐ N/A ☐ |
| | Systems for handling and compaction of waste | Yes ☐ No ☐ N/A ☐ |
| | Systems for segregation and security of waste (especially waste generated from healthcare requiring specialist treatment/disposal) to avoid mixing with other waste and recyclates. | Yes ☐ No ☐ N/A ☐ |
| | Have these issues and actions to be taken been noted in actions to be addressed section? | Yes ☐ No ☐ N/A ☐ |
| Comments | | |

*Example of NHS Health Facilites Scotland HAI-SCRIBE question set.*

## HAI-SCRIBE

HAI-SCRIBE, which has been around since 2002, poses questions that allows a team to identify, manage infection prevention and control risks associated with each stage of the development of the healthcare facility. The set is broken down into sections looking at key stages: proposed site for a development, design and planning, construction and refurbishment, and the ongoing maintenance of the healthcare facility.

Question sets are assigned to systems and procedures, for example, the ventilation system, the water system, how easy it is to clean surfaces. It is currently a paper based document, but is in the process of being converted into a web based tool.

Dr O'Brien stressed that to come to a successful decision on how to manage risks, it is crucial to get the 'right people' around a table to discuss what solutions will work. "We had already seen friction between estates and infection control teams....[and] we were seeing that collaboration was pivotal to ...success....[We had to ask] 'how can the guidance help you to move forward?'"

She noted that HAI-SCRIBE would not be used for every maintenance task as "healthcare systems" would grind to a halt — but at the same time removal of ceiling tiles and light fittings, for example, should not happen without engagement with infection control staff.

"It's about having a happy medium. Everyone has to be aware of what's going on and invariably that involves group communication."

## Goals

HFS are proactive in engaging with Boards, carry out implementation sessions and have a statutory compliance SCART manager to support use of this tool and to see where it could be improved. Ultimately, the aim is to move to Boards driving development of the tool forward themselves.

Implementation sessions for HAI-SCRIBE are also carried out across the Boards. "We give them... scenarios to work through so that [they] are all working in the same way.... so we ...continuously reinforce the message."

**The Glasgow meeting was one of a series of free events organised by Armitage Shanks and Pall Medical. The meeting was chaired by Dr. Martin Connor, Consultant Microbiologist, Infection Control Doctor and Clinical Director for Diagnostic Services at NHS Dumfries and Galloway.*

*The next Water Hygiene Masterclass will take place in Birmingham in June. For further information, visit: www.idealspec.co.uk/events*

# Latest Research



**BMC Microbiol.**
2019 Dec 23;19(1):303. doi: 10.1186/s12866-019-1687-0.

**Exploring the antimicrobial resistance profiles of WHO critical priority list bacterial strains.** Havenga, B *et al.*

The aim was to determine the antimicrobial resistance of clinical, environmental and control strains of the WHO "Priority 1: Critical group" organisms, *Acinetobacter baumannii, Escherichia coli, Klebsiella pneumoniae* and *Pseudomonas aeruginosa* to various classes of antibiotics, colistin and surfactin (biosurfactant). *A. baumannii* was isolated from environmental samples and antibiotic resistance profiling was performed to classify the test organisms [*A. baumannii* (n =6), *P. aeruginosa* (n =5), *E. coli* (n =7) and *K. pneumoniae* (n =7)] as multidrug resistant (MDR) or extreme drug resistant (XDR). All the bacterial isolates (n =25) were screened for colistin resistance and the mobilised colistin resistance (mcr) genes. Biosurfactants produced by *Bacillus amyloliquefaciens* ST34 were solvent extracted and characterised using ultra-performance liquid chromatography (UPLC) coupled to electrospray ionisation mass spectrometry (ESI-MS). The susceptibility of strains, exhibiting antibiotic and colistin resistance, to the crude surfactin extract (cell-free supernatant) was then determined. Antibiotic resistance profiling classified four *A. baumannii* (67%), one *K. pneumoniae* (15%) and one *P. aeruginosa* (20%) isolate as XDR, with one *E. coli* (15%) and three *K. pneumoniae* (43%) strains classified as MDR. Many of the isolates [*A. baumannii* (25%), *E. coli* (80%), *K. pneumoniae* (100%) and *P. aeruginosa* (100%)] exhibited colistin resistance [minimum inhibitory concentrations (MICs)≥4mg/L]; however, only one *E. coli* strain isolated from a clinical environment harboured the mcr-1 gene. UPLC-MS analysis then indicated that the *B. amyloliquefaciens* ST34 produced C13-16 surfactin analogues, which were identified as Srf1 to Srf5. The crude surfactin extract (10.00mg/mL) retained antimicrobial activity (100%) against the MDR, XDR and colistin resistant *A. baumannii, P. aeruginosa, E. coli* and *K. pneumoniae* strains. Conclusion: Clinical, environmental and control strains of *A. baumannii, P. aeruginosa, E. coli* and *K. pneumoniae* exhibiting MDR and XDR profiles and colistin resistance, were susceptible to surfactin analogues, confirming that this lipopeptide shows promise for application in clinical settings.

**J Hosp Infect.**
2019 Nov 27. pii: S0195-6701(19)30485-2. doi: 10.1016/j.jhin.2019.11.015. [Epub ahead of print]

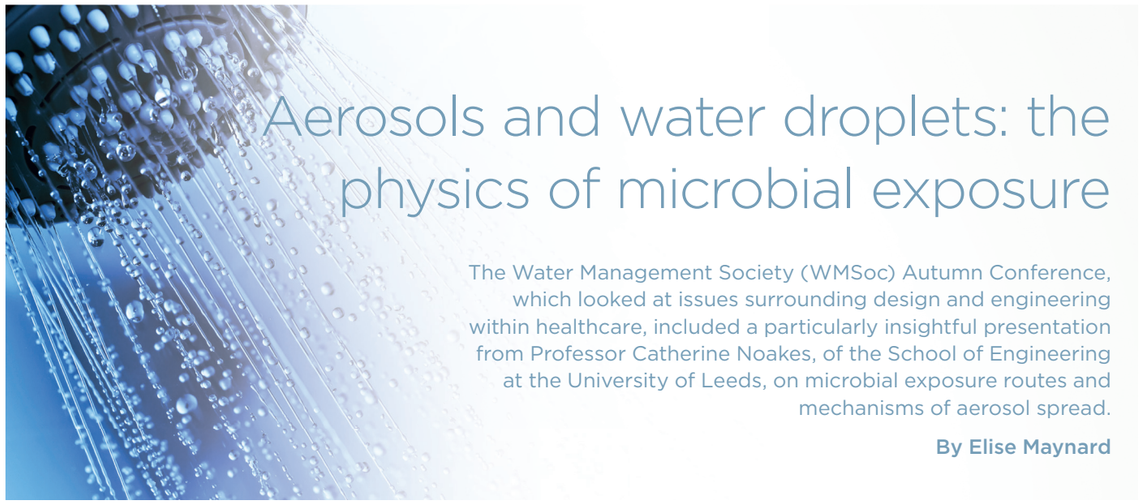
**Outbreak of carbapenemase-producing *Enterobacteriaceae* associated with contaminated water dispenser and sink drain in cardiology units in a Korean hospital.** Jung J *et al.*

We report a large outbreak in the cardiology units involving intensive care units (ICU) and wards at a tertiary care hospital. Contact tracing, a case-control study to find the risk factors for acquisition of CPE and environmental sampling were performed during a CPE outbreak between July and December 2018. A total of 87 patients with CPE infection or colonisation were identified at cardiology units. Diverse organisms were identified containing blaKPC, blaNDM-1, blaVIM or blaIMP, blaOXA-48 and co-producing organisms. Case-control study indicated that using the sinks in the ward patient room bathroom for teeth brushing was associated with CPE acquisition (83% vs. 30%; P = 0.03). We cultured the environment and isolated KPC-producing *Escherichia coli* from a water dispenser and NDM-1-producing *Citrobacter freundii* and *Enterobacter cloacae* from sinks in patient rooms. Pulsed-field gel electrophoresis (PFGE) analysis of KPC-producing *E. coli* from patients and the water dispenser in ICU and NDM-1-producing *E. cloacae* from patient and sink drain showed the same pulsotypes. The water dispenser and sink drain were suspected as possible reservoirs of CPE in this outbreak. Close contacts with contaminated water such as tooth brushing were identified as risk factors of CPE acquisition.

**Chemosphere.**
2019 Nov;235:354-364. doi: 10.1016/j.chemosphere.2019.06.157. Epub 2019 Jun 22.

**Effect of hydraulic conditions on the prevalence of antibiotic resistance in water supply systems.** Zhang J *et al.*

The incidence of antibiotic resistance genes (ARGs) in tap water leads to potential risks to human health and draws more and more attention from the public. However, ARGs harbored in drinking water remain largely unexplored. In this study, a simulated water supply system was designed to study the effects of different pipe flow rates on the transmission of antibiotic resistance in water supply systems. We observed that the biofilm in low flow rate pipeline (0.1 m/s, 0.3 m/s) had a higher concentration of both antibiotic resistant bacteria (ARB) and ARGs, while high flow rate (0.5 m/s and 0.7 m/s) resulted in low relative abundance of ARB and high relative abundance of ARGs in biofilms. The results showed that the high flow rate led to an abundance in non-culturable bacteria and a scarcity of nutrients in the biofilm, giving rise to its antibiotic resistance. High-throughput sequencing pointed out that the high content of *Caulobacteraceae* and *Paenibacillus* were determined in biofilms of high flow rate pipelines. Similarity analysis of microbial community composition of inlet water (IW), biofilms and outlet water (OW) showed that the composition of microbial community in OW was more similar to that in biofilms than in IW. Genera of bacteria in biofilms and OW (*Brevundimonas*, *Brevibacillus* and *Pseudomonas*) which had relationship with sul I, sul II in biofilms (P < 0.05) had higher relative abundance than that in IW. Different flow rate conditions had an impact on the biomass, microbial community, ARB and ARGs composition of biofilms. Thus, the detachment of biofilms can increase the antibiotic resistance of the water.



# Aerosols and water droplets: the physics of microbial exposure

The Water Management Society (WMSoc) Autumn Conference, which looked at issues surrounding design and engineering within healthcare, included a particularly insightful presentation from Professor Catherine Noakes, of the School of Engineering at the University of Leeds, on microbial exposure routes and mechanisms of aerosol spread.

**By Elise Maynard**

A study looking at toilet plume[1] noted that after flushing, microbes were found on all bathroom surfaces. Many other studies since, have also found microbes in the air as well as surfaces. Studies on showers, sinks, taps and drains have all found potential for aerosol release and demonstrated the presence of microorganisms in biofilm on fittings and in water, as well as the aerosolisation of *Legionella*, fungi and non-tuberculous mycobacteria. These particles may be as small as 1 µm and can reach the lower lung, with some showing a clear association with disease risk.

Professor Noakes discussed the underlying mechanisms of microbe dispersal by aerosol — a combination of physics and biology. The physics of flow characteristics is crucial and mostly occurs as turbulent flow within domestic hot and cold-water systems. The differences between droplet and aerosol were explained — typically infection control refers to <5 µm as "airborne" and >5 µm as "droplet."

She advised that the human eye can't see less than 40 µm so if you can see it, then it is a droplet! However, up to a 100 µm is inhalable and surface contamination can be any size. She provided evidence that smaller[2] and hydrophobic[3] bacteria are more likely to aerosolise as the latter prefer the water-air interface.

Professor Noakes showed images of types of water flow such as jet-flow (see image above), which is generally seen in showers and taps.[4,5] Exposure by splash is more often by toilet-flushing or caused by the design of certain taps and basins. Other influences of importance are evaporation and ventilation.

While human behaviour effects can be hard to control, the implications for design are as follows:

Showers:

- Larger slower jets are less likely to directly aerosolise
- Splashing on shower surfaces can't be controlled.

Sinks and drains:

- Splashing can be reduced by design — but must be of the tap and sink combination
- Good drainage design and management can reduce sink trap transmission.

Microbial control:

- Source control may be more effective than reducing droplet/aerosol production
- Important in both potable water and drainage systems.

In conclusion, aerosolisation is a very complex area of science and is still a particularly active area of research — but understanding the interaction with microorganisms is even more challenging. There are no clear rules as to when something will splash or aerosolise, yet there are times when it is more or less likely.

## References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2. Wang, H.X. *et al* "Effect of Fluid Type and Microbial Properties on the Aerosolization of Microorganisms from Metalworking Fluids", *Aerosol Sci & Tech* **12**: 1139-1148, 2004.
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4. Estrada-Perez, C.E. *et al* "Droplet distribution and airborne bacteria in an experimental shower unit", *Water Res* **130**: 47-57, 2018.
5. Zhou Y. *et al* "Particle Size Distribution and Inhalation Dose of Shower Water Under Selected Operating Conditions", *Inhalation Toxicology* **19**: 333—342, 2007.


WMSoc's 'Designing Out 3' took place last November at the Society of Chemical Industries in London. The expert speakers included Mike Ralph (Principal Engineer and Senior Policy/Strategy Lead (Hard FM), NHS England), Eddie McLaughlan (Assistant Director, Health Facilities Scotland), Jonathan Gaunt (Chair of the Society of Public Health Engineers), Graham Thomson (Oculus Consulting) and Mary Henderson (Rainbow Water Services Ltd). The day was chaired by Dr Jimmy Walker (Walker on Water).