Research Q&A: The role of air pressure transients on the spread of bacteria from water trap seals in clinical settings: A laboratory based pilot study

Professor Michael Gormley



# NHS Scotland Assure Research Service

NHS Scotland Assure is adding to the knowledge base available to built environment projects. Building on this existing knowledge will reduce risks, increase quality and promote sharing research with key stakeholders.

Through working with external stakeholders and other NHS Scotland Assure services the research service will ensure information is based not only on best practice but best evidence and will benefit those who need it. The service will seek to ensure that the most up to date and robust research is translated into practice as new and emerging evidence become available.

Throughout 2020 and 2021 the NHS Scotland Assure Research service commissioned a number of research projects which address gaps in current evidence. These research topics relate to previous issues and lessons learned within previous NHS Scotland projects and are in line with the key themes identified by NHS Scotland Assure stakeholders.

# Research Q&As

Our research Q&As are designed to talk about these research projects – why the research is needed, what it set out to achieve, what impact it will have on existing guidance and more.

Full research reports are also available by contacting Professor Michael Gormley at m.gormley@hw.ac.uk

## Research Q&A with Professor Michael Gormley

### 1. What is the research that was carried out?

In this research, we used a full-scale physical model of a wash-hand basin and drain installation which is common in single occupancy room en-suite bathrooms in hospitals. The research explored how disease-causing bacteria might spread from drains back into a wash-hand basin when air pressure surges happen in the drainage system. Air pressure surges (or waves) happen all the time within drainage systems. These surges can push contaminated water, air, and aerosols into the room. This possible way for disease to spread hasn't been clearly identified before. Along with identifying this risk, we also used our understanding of the drainage system to suggest a solution using devices that reduce air pressure surges and thus stop bacteria coming into the wash-hand basin from the drain and reduce the potential for disease spread in hospitals.

### 2. Why is this research needed?

It has been long been established that bacteria grow in the water trap seals (U-bends and bottle traps) connected to basins used for handwashing and other activities. The prevailing wisdom until now has been that these bacteria do not come back into the basin when certain precautions are taken – for example, ensuring there is no direct flow from a water tap into the plug hole. This research set out to show that there are other ways in which bacteria can come back into a wash-hand basin and pose a risk to patients and staff. The consequences of this are especially important in healthcare settings, where there is a risk of outbreaks caused by antibiotic resistant bacteria, which are hard to treat.

While water trap seals (U-bends and bottle traps) are designed to block bad odours coming from the plumbing system, the warm water inside them creates a perfect environment for harmful bacteria to grow and thrive. Naturally occurring air pressure changes in the drainage system can disturb the water in the trap seal, causing droplets and aerosols to rise into the basin, contaminating the air and nearby surfaces, which can cause diseases to spread on contact.

Understanding how this happens is the first step in finding ways to reduce the risk, and this research aimed to do just that.

### 3. Who were the team behind the research?

The Chief Investigator was Professor Michael Gormley- Professor of Public Health and Environmental Engineering at Heriot-Watt University.

Co- investigators were:

* Dr. David Kelly – Heriot-Watt University
* Dr. David Campbell – Heriot Watt University
* Dr. Thomas Aspray – Microbiologist – SolidSense Ltd
* Dr. Thomas Dight – Heriot-Watt University

### 4. What did the research set out to achieve?

The research sought to show that air pressure surges in the drainage system can cause contaminated water and contaminated aerosols to enter wash-hand basins from water trap seals (specifically bottle traps in this case) even when there is no activity from the wash-hand basin itself. We set out to show that it was possible for bacteria, contained in tiny invisible water droplets and aerosols could be detected in the wash-hand basin following an event in the drain some distance away. We also set out to show that these air pressure surges could be reduced or eliminated which would in turn reduce or eliminate the contaminants coming back into the wash-hand basins. The focus of the research was the type of appliances and drainage systems found in single occupancy hospital rooms with en-suite facilities.

### 5. How was the research carried out?

The research was laboratory based and was therefore a pilot study of real-world scenarios. The team at Heriot-Watt have a long history of working with building drainage systems, including the mitigation of air pressure surges in general (at best these cause smells in buildings, however, there is a growing recognition that there is a public health aspect to the occurrences). We constructed a model building drainage network consisting of 50m of pipework connected to a mock-up of an en-suite bathroom using appliances and fittings specified by NHSScotland Assure. We manipulated the air pressure inside the system to simulate what would happen in the event of a pressure surge typical in a real system. We measured air pressures, aerosol levels and also bacteria numbers (we used *Pseudomonas alloputida* KT2440 as a model bacterium for the study because it is safe to use and representative of other bacteria).

### 6. What challenges did you encounter?

Simulating full-scale system operation in a laboratory is challenging and only made possible because of the 30 years’ experience we have in simulating other drainage system scenarios. Controlling contaminants – for environmental sampling and aerosol measurements was also very challenging. We have developed methodologies for working in these contaminated environments over the years which helped make this work possible.

### 7. What were your main findings?

Our main findings were:

1. Positive pressure waves cause ingress of contaminated water into a sink during an event.
2. When the sink trap is contaminated with bacteria, this can be detected on the surface of sink, at the strainer, and on the tap –Colony forming units (CFUs) - a measure of the number of viable bacteria present, were reported at all these locations.
3. The strainer was contaminated even when there was no visible ingress of water to the sink (contamination under the strainer).
4. Positive pressures occur naturally in plumbing systems and can be exacerbated by other activities such as jetting of horizontal lines for blockage clearance.
5. Positive pressure surges generate aerosols which were detected at various locations above the sink strainer.
6. Aerosols were detected even when no visible sign of ingress occurred (agitation below the strainer level).
7. Pressure alleviation in the wastewater system reduces the pressure experienced by the sink trap, reduces the generation of aerosols, and reduces the ingress of contaminated water into the sink.

### 8. How will the research be used?

The research has already been used to apply for additional funding from NHSScotland Assure research fund to carry out the research on an extended basis in a real hospital setting. This, in conjunction with additional laboratory-based investigations could help explain the spread of infectious diseases, particular those with an Antimicrobial Resistant (AMR) component, and to propose new ways to mitigating some aspects of their spread.

### 9. What are the next steps for study in this field?

The next steps are to carry out the research in a real-world setting and to evaluate the potential impact of air pressure transients on the spread of disease in hospitals.

### 10. Will this research have an impact on current guidance?

There is potential for this research to inform NHS Scotland ‘Scottish Health Technical Memorandum 04-01: Water safety for healthcare premises Part A: Design, installation and testing’. The current version makes very little reference to above ground drainage systems.