Scottish Hospitals Inquiry
Witness Statement of
Dr Susanne Surman-Lee

This statement was produced by the process of sending the witness a questionnaire with an introduction followed by a series of questions and spaces for answers. The introduction, questions and answers are produced within the statement.

Personal Details

1. Name, qualifications, chronological professional history, specialism etc – please provide an up-to-date CV to assist with answering this question.

A Dr Susanne Surman-Lee is my professional name, (my married name is Dr Susanne Lee). I am a Consultant Clinical Scientist (Public Health Microbiologist) registered with the UK Health Professions Council (Reg. No. CS02982) and Director of Legionellae Ltd).

I am also a Chartered Biologist, an Honorary Fellow of the Royal Society for Public Health, a Fellow of the Royal Society of Biology, a Fellow of the Institute of Healthcare Engineering and Estate Management, a Fellow and member of the Technical Committee of the Water Management Society and a Fellow and Council Member of the Pool Water Advisory Group
My specialism is public health microbiology especially water hygiene and infection control in the built environment.
See also attached CV for chronology

Summary of Involvement

2. Can you provide a brief summary of your involvement with the QEUH and RHC? **Ref Bundle 8 – Page 134**

A I was initially contacted via an email from Phil Ashcroft the former, Department of Health Principal Buildings & Facilities Management Services Engineer, on the 16th of March 2018, asking for help on behalf of Ian Storrar, Health facilities Scotland. Following this I exchanged telephone conversations and emails with Dr Teresa Inkster to get an update and background information on the situation and to see if I could be of help. I then made a site visit on the 25th of April 2018 primarily to visit the problem areas.

I attended an initial meeting with Dr Inkster, Annette Rankin, Health Protection Scotland, Nurse Consultant, Prof Brenda Gibson, Consultant Haematologist, at the Royal Hospital for Children and Susie Dodd, the Lead IPCN at RHC and in the afternoon with Dr Teresa Inkster, Annette Rankin, Maryanne Kane – the Interim Director of facilities, Ian Powrie, the Estates manager Colin Purdon, estates and Ian Storrar -.

Because of the limited time the discussions focused on the children's hospital only and included a visit to ward 2A. I gave some feedback on the day and prepared a report for Dr Inkster with some observations and recommendations following the visit.

After that I exchanged a number of emails and telephone calls with Dr Inkster to answer queries on the ongoing situation.
I was later contacted by the Lisa Summers from BBC Scotland in January 2020 to ask if I would be willing to give them independent expert advice on the water issues at QEUH. I subsequently was asked to take part in a BBC documentary which was filmed in March 2020. **Ref Bundle 8 – Page 134**

Limitations

3. Considering the limitations described – only discussing the children's hospital and your visit to ward 2A – did/have these limitations restricted your ability to give an opinion or advice in relation to the water situation at the QEUH/RHC in any way? If so, please explain how and why you were so restricted.

A The intention of the meeting was what I understood to be a preliminary visit to visit Ward 2a following the isolation of *Cupriavidus paulculus* and *Stenotrophomonas* spp. This was suggested during discussions with Dr Inkster to better understand the water related risks in the RCH as it is always difficult to envisage areas just from verbal descriptions and wanted to see for myself the physical layout to avoid making assumptions based on verbal information only. The reason the visit was shorter than I would have liked was that I had an upcoming planned hospital procedure which required some recovery time and limited time available between existing work including a series of teaching commitments in the USA. I was also under the impression this was a preliminary visit, and I would have time for more in-depth visits at a later date.

Summary:

4. Did you have contact with Dr Inkster in advance of your visit? If so, when did you have contact with Dr Inkster? What was the nature and details of any such contact?

A Yes, see above, both emails and telephone conversations to give me the background to the water hygiene issues current at that time and make arrangements for the visit.

5. Can you explain what Cupriavidus Pauculus and Stenotrophomonas are? What is your knowledge/experience of these? Are you aware of the circumstances surrounding the discovery of these hospital acquired infections (HAIs)? Can you explain what you mean by 'clinically significant'?

A Both *Cupriavidus paulculus* (previously known as *Ralstonia paucula*) and *Stenotrophomonas* species belong to a group of Gram negative* bacteria which have been previously shown to cause hospital acquired infections associated with exposure to water. Whilst naturally occurring opportunistic pathogens

present in water supplies, including *Stenotrophomonas* and *Cupriavidus* species, rarely cause infection in those with competent immune systems they can cause serious illness and sometimes death in those who are at high risk of infection because they are immunocompromised as a result of their illness or treatment.

a) What is your knowledge/experience of these?

A I had not had personal experience of this particular opportunistic pathogen, but I have many years' experience working in both clinical and public health microbiology and investigating adverse results, cases and outbreaks associated with the range of microbial waterborne pathogens including from healthcare premises.

The ecology and routes of transmission of *Cupriavidus* and *Stenotrophomonas* species have many similarities to those of *Pseudomonas aeruginosa,* a common Gram-negative opportunistic pathogen associated with causing waterborne infections and outbreaks particularly in immunocompromised patients. The range of recognized waterborne pathogens associated with causing infection is growing and we are seeing many species of bacteria, previously unrecognized as causative agents of infections from water and the environment being reported. This increase is partly because the methods for identifying environmental pathogens correctly was previously difficult, time consuming and costly and limited by the available techniques, as most identification kits for identifying pathogens were aimed at the common pathogens associated with causing human infections so environmental [1]isolates of concern, obtained during investigations, had to be sent to specialist reference laboratories for identification. Developments in technology over the last few years have drastically improved the ability to identify environmental isolates as this technology has become more available, simplified, and able to give rapid results at reasonable costs.

My understanding from conversations with Dr Inkster at that time was that there was an epidemiological relationship which suggested the hospital water in 2a

[1] *Gram staining is used in the laboratory to differentiate between different groups of bacteria based on the properties of the cell wall which affect their ability to take up coloured dyes (stains). Gram positive bacteria retain the stain and look dark purple under the microscope whereas Gram negative bacteria are not able to retain the stain and look pale pink.

could be a source of infections that had caused harm to two patients. Sampling had also identified environmental sites positive for *C. paulculus.*

b) Can you explain what you mean by 'clinically significant'?

A Both *C. paulculus* and *Stenotrophomonas* spp. have previously been linked to causing infections in highly susceptible patients. If present in healthcare wards / units where patients at higher risk of infection can be exposed to water, sprays or aerosols derived from water or wastewater, either directly or indirectly, they potentially pose a significant risk of harm to patients. Indirect transmission can occur from cross contamination from splashes containing pathogens from water and / or associated drains, landing on surfaces. For example, on water system fittings, equipment and personal effects within the splash zone from a sink (this can be up to 2m), as well as clothing, drinking water, staff or other persons etc. which can then be transferred either directly i.e. via direct patient contact or indirectly, via contact with a person or object previously splashed).

6. Do you recall how you were received at the meetings? Did those with whom you met engage with you and actively seek your advice? Did anyone not engage with you? If so, can you recall who and in what way they didn't engage?

A I have had many meetings like this during previous investigations into hospital acquired cases. It is such a long time ago now so cannot be sure, but I can't remember it felt any different to similar situations I had been in previously.

7. You briefly described the water supply/system to both the QEUH/RHC. In your opinion, and based on your experience, is the water supply and system what you would expect for a new build hospital? If not, what would you typically expect in this regard? Why would you expect the water supply and system to be set up in that way? What is the risk of the water supply and system not being set up as you would expect?

A I was surprised that such a large hospital, particularly one intended for use by high-risk patients with compromised immune systems was not designed to protect patients at high risk of waterborne infections with good design and engineering and a multiple barrier approach to prevent waterborne infections Supply water, even when meeting all the regulatory standards is not sterile and will contain a range of microorganisms which rarely do harm to the general population however it is recognized that they may cause serious harm and sometimes death to patients highly susceptible to infection. When water is supplied into the building, bacterial pathogens at cold water supply temperatures are usually present in low numbers and with a low capability to cause infection.

As temperatures rise, their ability to colonise and grow within water systems increases, as does their ability to cause infection. In large and complex systems such as in hospitals, the risk of microbial colonisation within system pipework and fittings increases from the point of supply entry as it travels through the complex water systems within buildings, particularly where there are many floors and loops, and sub loops of water system pipework within the system.

It is predictable that the traditional primary control within building water systems to manage the risk of microbial growth i.e. temperature will not be achieved consistently throughout the entire systems, including up to all outlets, particularly when there are areas which are intermittently used such as OPDs etc and ensuite facilities for patients who are too ill to use the facilities e.g. showers etc.

I would have hoped for a risk assessment for water safety at the design stage, to ensure the systems were designed to maintain water quality targets which would ensure safety for all intended users who may be exposed to water and wastewater as well as sprays and aerosols derived from water sources. This risk

assessment should include all potential modes of transmission taking account of those who are most susceptible to infection. Because of the complexity of large hospital systems and the susceptibility of the intended user groups, I would also have expected a multibarrier approach e.g. temperature as the primary control backed up by a water treatment system such as chemical disinfection (the type of biocide should be determined based on risk assessment) together with a flushing regime to ensure the controls (temperature and biocide) were pulled through to all the outlets. Hot water maintained at 55°C will control bacteria released from biofilms whilst maintaining water at ≤ 20°C minimises the risk of growth and transmission of waterborne pathogens. Even when there are controls in place there is the potential for contamination of the outlet and retrograde colonisation (growth backwards from the outlet) through the system particularly for *P.aeruginosa* and other similar Gram-negative organisms which typically grow in higher oxygenated areas of the system.

All outlets should therefore have been designed to minimise risk of biofilm formation without any inserts to increase the risk of microbial colonisation as they increase the surface area for biofilm formation especially as these were identified as a risk factor for *P. aeruginosa* infections in the Belfast outbreak which resulted in the deaths of neonates.

8. As an interim measure, point of use filters had been put in place in the children's hospital whilst a longer-term measure was sought. What was your view on the use of point of use filters? Was this an appropriate solution? What, if any, is the risk in using point of use filters? In your experience, how can any such risk be mitigated? Were any such mitigation measures in place in the RHC?

A In my opinion this was a sensible and a commonly used option to protect patients whilst the root cause of water hygiene problems is being investigated, especially for patients at increased risk of waterborne infections (*see HSE HSG 274-part 2 para. 2.117*). For high-risk patients, the point of use filters (POUF) should be of an absolute sterilising grade (0.2 micron) to give the highest level of protection and prevent exposure to all waterborne pathogens.

As with all control measures there are several factors that need to be considered in the decision-making process. For example: -

1. When filters are fitted it reduces the activity space (the space between the outlet and the basin / basin drain) for handwashing and increases the risk of touching and contaminating the filter or the drain below if the distance from the filter outlet and basin have not been designed to take POUF. Depending on the design of the basin and tap, the fittings may need to be changed to ensure the risk of POUF contamination during handwashing activities is minimised.
2. There is also a risk of breaching the water fittings regulations if the air gap between the water level and outlet is breached so the filter comes in contact with water in the basin (which because plugs are not used in wash hand basins in clinical settings, will be in contact with the drain contents increasing the potential for contamination of the sink surfaces and for backflow into the distributed water supply.
3. Particularly in water systems with hard water and / or particulates the flow through the filter may become reduced to the extent that users have been known to remove the filter to get a suitable flow for washing/ showering etc. particulates can be a problem even in soft water.
4. Where there is a drain directly below the filter outlet splash back from the drain may contaminate the filter outlet, so it becomes colonised with potential pathogens.
5. If the fitting of the filter is not carried out by someone trained and competent then there may be leakage around the filter which results in the water delivered through the outlet of the filter becoming contaminated.
6. Poor cleaning techniques can also result in filter outlet contamination.
7. Those taking samples may remove and refit filters resulting in cross contamination.
8. The casings are more fragile in some filters and so may get damaged if badly handled or dropped, for example.

These risk can be mitigated if:

- there is a due diligence approach to the selection and procurement of filters,
- they are fitted by trained personnel, preferably trained by the manufacturer.
- ward, cleaning staff and users have awareness training, so they understand.
  - why the filters have been fitted,
  - how to avoid contamination
  - how to clean basins with filters present.
- Those taking samples and directing sampling should ensure it is understood that filters should not be reinstalled.
- new filters must be fitted by those trained to do so after filter removal.
- All relevant personnel e.g. those installing filters, ward staff, IPC teams risk assessors and cleaners should also know to report any signs of leakage around the joint between the tap and the filter so immediate action can be taken.

I was not party to the decision-making process for using POU filters so cannot comment on the last part of the question.

Discussion Points Included:

9. Reason for growth of waterborne opportunistic pathogens:

a) You stated that the presence of these pathogens in the water supply, particularly the hot water supply, suggested that temperature control had not always been achieved. Can you expand on this and explain your reasoning behind this conclusion? What is the importance of maintaining temperature control?

A See also answer above, repeated adverse results suggests that there has been a failure in water management.

At low temperatures, background bacteria which occur naturally in supply waters are typically in low numbers in the incoming water, and may be dormant, in a viable but not culturable state (VBNC) or growing slowly and have a low capacity to cause infection. There was evidence of ongoing issues with poor temperature management in the draft Review of Issues Relating to Hospital Water Systems' Risk Assessment A43941023 which had been sent to me prior to my visit.

The presence of these opportunistic pathogens such as *Cupriavidus paulculus* and *Stenotrophomonas* spp. etc. suggests that there had not been adequate management of the water systems since the systems were filled. Water borne pathogens can be controlled in the flowing hot and cold water to the outlet if kept at the HSE ACOP L8 and Guidance HSG 274 / SHTM/HTM target temperatures right up to the outlet. This requires a design that ensures good flow, and minimises the distance from the supply pipework to the outlet or inlet to thermostatic mixing valves (TMVs) where fitted.

Effective biocide dosing acts as a secondary barrier to keep patients safe when target temperatures are not maintained, whilst it does not remove biofilms, it mops up the microorganisms released from the biofilm in the planktonic (water phase).

Temperature control is the traditional method advocated in national codes of practice and guidance for controlling the risk of *Legionella* and if applied consistently would also have helped to control and minimise the risk from other waterborne pathogens in the distributed water too.
An additional biocide would also have helped to prevent intermittent contamination events during remedial works or maintenance, for example, when replacing outlets and retrograde growth from outlets contaminated by staff and / or patients which can track backwards up through up the pipework (called retrograde contamination).

10 Do you have a view on whether the pipework was contaminated before installation? If so, what is your view and what is it based on?

A The Draft Review of Issues Relating to Hospital Water Systems' Risk Assessment A43941023 identified that there was documented evidence that there were open ended pipes on site. This is bad practice and means that nutrients, dust debris, contamination from insect and rodents which can support the growth for microorganisms could have entered the pipes before fitting. Tap fittings, TMV s etc. maybe contaminated before they are fitted into the system if they had been pre wetted during the manufacturers testing process and can contain several mls of water; visible biofilm has also previously been seen in

new off the shelf fittings. Without a validated disinfection step before installing into an existing water system new components such as TMvs, outlets etc. these can then introduce potential opportunistic pathogens into the system.

a) Do you have a view on whether there was mismanagement of the water system following pressure testing which then led to contamination? If so, what is your view and what is it based on? **Ref Bundle 8, Page 150 (and again on pages 11,12,13,15,)**

A I don't personally have the evidence of when ingress occurred except for the potential for contamination by poor management of pipework on site (see answer above), for example it could have been at multiple occasions from when items were wet tested by the manufacturer, then transported and stored on site or during construction with retained water or damp areas within, but also there could have been contamination during installation, filling or commissioning by poor hygiene and / or using equipment that had been previously used or wet tested at manufacture. The Review of Issues Relating to Hospital Water Systems' Risk Assessment A43941023 indicated that there were many issues which could have led to ingress into the systems during construction including; the incoming mains pipe which was identified as being contaminated with soil and debris, the water tanks were not clean at the time of handover and hot and cold water system pipe work at both QEUH and RCH were contaminated during the installation process with documented evidence of open ended pipes and that flushing took place without the Point of Entry Filters (POEF) in place which were intended to prevent organisms entering the hospital water system.

11 You stated that there was at least a 12-month lag in filling the system and occupation of the building. Where did you get this information from? Were you advised of this? If so, by whom? Were you provided with documentation or other information regarding this? If so, what were you provided with and who provided it to you? In your opinion, what is the significance of a 12-month lag between filling a water system and occupation of a building?

A This recommendation was based on information in Review of Issues Relating to Hospital Water Systems' Risk Assessment A43941023 mentioned above hat Scottish Water had tested the supply of both QEUH and RCH in 2012,

- there was water in at least some of the pipework in August 2014 and

- commissioning of the systems did not take place until November 2014.

I cannot remember exactly where the 12-month period came from (probably verbally during my site visit). The evidence that there was at least several months between filling and handover means the system was put at significant risk. Even a short period of time following filling with water when the system is not safely managed poses a risk of systemic colonization and growth of biofilms especially if the filling process bypassed the point of entry filtration system and there was no ongoing flushing with disinfected water of the entire filled system.

a) You stated that biofilm was developing in the water system. Were you provided with evidence relating to this? Did you view biofilm on your visit to Ward 2A? You state that biofilm is more resistant to biocide than others. Can you explain and expand on this point please?

A The isolation of several opportunistic pathogens from water samples is consistent with the presence of biofilms on the surfaces of water system pipework and components. Microorganisms within water preferentially grow on surfaces and not usually within the water phase. It is usually not possible without taking systems apart and culturing and / or visualising them under a microscope to prove that biofilms are present except when there is gross colonisation of visible components.

Biofilm within pipework etc. is not usually visible to the naked eye. There are many peer reviewed publications, over several decades, that have shown colonization and growth of biofilms rapidly occurs when conditions allow within water systems and components, and that biofilm associated bacteria are inherently resistant to the levels of biocide commonly used in water treatment when compared to the same species in the planktonic phase (i.e. unattached to biofilms).

12 Recommendation 1 related to what should have been done in advance of the building handover. Were you provided with details of what happened pre-handover and how the water system was managed? If so, what information were you provided with? What was this recommendation based on? Was this specific to the QEUH/RHC based on your visit, or general advice that would be given to all hospitals?

A General advice for all new systems is that they should be filled with water as close to handover as possible to minimize the risk of colonization and growth of microorganisms during the period between filling, commissioning and handover which, for a hospital can be for some months. For this reason, national guidance states that initial pressure testing should be with air or an inert gas via a filter to prevent the ingress of airborne microorganisms. Once filled, systems and any attached equipment should be disinfected and flushed to remove nutrients present from manufacture and installation etc. and then kept flowing and disinfected as if the building was in full operational use.

Records should be kept of when the system is filled; commissioned; handed over; and occupied together with all disinfection monitoring and flushing and any remedial works that need to be carried out.

Fungal Contamination including Aspergillus:

13 Can you explain what you meant by ‘damping down’ being used as a control measure to reduce fungi being released into the air?

A Damping down is using water (usually as water sprays) to minimise the risk of airborne contamination during demolition, including from fungal spores.

a. What were you advised of regarding cleaners’ observations on the amount of dust in the hospital? If so, what were you advised in this regard? What did you consider the significance of any such observations?

A I cannot recall whether this was discussed at the time of my visit.

b. You stated that Aspergillus had been cultured from numerous hospital sources, including food and water. Who advised you of this? Did you see documentation to support this? What is the significance of this observation?

A This was not specific to RCH or QUEH, I am aware of this from previous incidents I had been involved in and from peer several publications to this effect. *Aspergillus* spp. and other fungal pathogens have previously been identified as a cause of hospital acquired infections, particularly in immunocompromised patients. There are various recognized potential routes of transmission including water, food and airborne transmission. Because it is recognized that immunocompromised patients are at higher risk of both water and airborne transmission of a range of opportunistic pathogens, mitigations should be in place to prevent exposure from the concept stage of the building for example units for high- risk patients designed with appropriate ventilation and HEPA filters in place to minimise the risk of ingress of airborne particles including airborne pathogens and fungal spores.

c. You stated that fungal contamination is likely a result of the ongoing demolition works in the hospital. Can you expand on this please? Were any alternatives to the demolition works being the source of the contamination considered? If so, what sources were considered? What, if anything, was your view on the most likely source of contamination?

A Dust and debris released during demolition is recognized as a source of fungal spores. Please see answer above for alternative sources. In my opinion it is possible that the contamination came from demolition works.

Training:

14 What were your specific concerns regarding staff training at the QEUH/RHC? What were these concerns based on? Did you consider staff training to have been adequate? If not, why not?

A This follows on from the answers from previous questions where it was identified in the Review of Issues Relating to Hospital Water Systems' Risk Assessment A43941023 that there were failures during installation, with pipework being uncapped, point of entry filtration bypassed for example which suggests there was a lack of understanding of the importance of maintaining water hygiene and the effect on patient safety. This is especially important where there are patients at high risk of infection and the need for everyone involved in the construction of new healthcare premises, including those involved in designing, constructing, procurement, installing, filling systems, commissioning and normal operation and maintenance to have at the very least a basic understanding of water hygiene requirements and the implications if care is not taken to avoid contamination.

a. You mentioned the HSE Guidance and HTM Series HTM 04-01 and changes to this guidance. Can you explain what this guidance is? What is its importance? Who would you expect to have received this training? Who should be complying with the aforementioned guidance?

A The HSE is responsible for ensuring that risks health and safety in the workplace are appropriately managed to comply with the Health and Safety at Work Act and associated legislation including the Control of Substances Hazardous to Health Regulations (COSHH). This includes the management of risks from biological

agents for example *Legionella*. The HSE Approved Code Of Practice (ACOP L8) is intended to help to explain the requirements necessary to comply with legislation and explain the duties for those with responsibility for health and safety under the law, the associated guidance HSG 274 part 2 gives examples of good practice of how water systems can be managed safely. Whilst it is not essential that the ACOP and guidance have to be followed, the onus is on those responsible for health and safety usually in a large organisation the Duty Holder supported by the Board, to show that if they do deviate from the ACOP and guidance the outcome should be as good or better than if they had fully followed the ACOP and guidance. The HSE ACOP and guidance are applicable to all organisations with five or more employees.

The HTM's are Department of Health guidance documents (and SHTMs in Scotland) which provide additional guidance over and above that published by the HSE to give advice relating to governance, the design, operation and management of hospital premises and facilities including the provision of water for the purposes outlined in the drinking water regulations as well for specialist uses in the diagnosis and treatment of patients. Whilst there are different versions in England and Scotland, the SHTMs are generally based on or similar to the HTMs and reflect Scottish local requirements. Contracts for capital projects that I have seen, all stipulate that standards and guidance documents should be followed and complied with.

Training: -All those who have an effect on water quality, specially architects, design engineers, procurement teams, contractors such as plumbers / installers should receive training on water hygiene and the contents of the guidance within the HSE ACOP and associated guidance and that from the SHTMs, HTMs, HBNs as appropriate and how to maintain water hygiene.

Compliance; whilst contracts I have seen tend to list compliance with all standards and guidance including that from professional bodies these are often out of date and may not reflect current best practice since the guidance was published, Those writing tender specifications and contracts should be aware of the limitations of what they are asking for and the need to specify and derogate

where guidance no longer ensures the safety of the intended patients.

b. Recommendation 2 highlights the importance of internal maintenance staff training and training not being restricted to Legionella. Was Legionella training the limitations of the training in place for staff at the QEUH/RHC? What was your understanding of the staff training programme at the hospital at the time of your visit and what was this understanding based on? Did you have any concerns relating to the training programme?

A See previous answers also due to time limitations, I did not go into training during my visit, I was under the impression this was a preliminary visit to give immediate advice on the ongoing problem, this is a recommendation I would give to any premises with water hygiene problems, particularly where there are immunocompromised patients at high risk of infection and indications of poor system management. It is important to underline that it is not just the estates team needing to be informed on water hygiene issues but all who can have an impact on water hygiene including: - clinical and IPC teams, ward staff, ancillary and specialist service groups, patient support services, contractors as well as the patients themselves and visitors too, in high-risk areas. etc.

c. Recommendation 3 refers to plumbers and contractors requiring to have completed an approved training programme before being engaged. Is this recommendation based on those engaged by the QEUH/RHC not having appropriate training or experience? If so, who advised you of this? If not, what was your understanding of the training of those engaged to carry out the work on the hospital?

A This is a common finding that plumbers, installers, commissioning teams etc. do not have sufficient training. The SHTM 0:01 part B identifies training as a key component of competence. The leaving of debris in water tanks and failure to achieve target temperatures indicates poor understanding, lack of supervision and training was a likely scenario. See also previous answers.

Water Safety Group:

15 You mentioned the 'scheme of control', can you explain what this is and who advised you of this/where your knowledge of this comes from? In what way does it not comply with best practice guidelines?

A The scheme of control is a legal requirement Health & Safety Executive Approved Code of Practice and guidance (ACOP L8) "Legionnaires' disease The control of legionella bacteria in water systems".to describe and document the measures to prevent or control the risk from exposure to legionella bacteria" The written scheme should specify measures to take to ensure that control measures minimize risk as far as reasonably practical and remain effective." It is in effect the water management plan which includes the barriers put in place to minimise the risk of ingress and colonisation of microorganisms into water systems and the ongoing controls and monitoring to ensure water hygiene is maintained. In healthcare where *Legionella* is not the only hazard it should be based on a risk assessment which identifies all potential hazards (agents which can do harm) and hazardous events (events that can lead to ingress or an increase in the levels of hazard such that they can cause harm. Water hygiene targets for each use should be specified for each patient group depending on their susceptibility and taking account of all the potential sources and modes of exposure etc. to keep patients, staff and visitors safe. This includes not just water in distribution, but also water used for patient diagnosis and treatment. The risk assessment should evaluate the effectiveness of the scheme of control and make recommendations for improvement.

A copy of the written scheme (SHTM 04-01: Water Safety Written Schemes, NHS GG&C Generic Written Scheme) was sent to me by Dr Inkster on the 17/4/2018.

Greater Glasgow and Clyde Written Scheme Hierarchy Diagram on page 4 of this document shows the WSG which includes much representation from Estates and Engineering including the legionella risk assessor but not those assessing for other waterborne pathogens including for *P. aeruginosa* or input from the IPC team or other specialist users of water e.g. dialysis, , with the consultant microbiologist in an advisory capacity. The notes on page 6 of the written scheme refer to a *Legionella* role but no mention of responsibility for

other pathogens. Similarly, the table on page 8 refers to what is need for L8 (*Legionella* compliance), the only reference to *P. aeruginosa* is in a cross reference to *"All outlets advised to be flushed daily in NHS GG&C Standard Operating Procedure (SOP) For Minimising The Risk Of Pseudomonas Aeruginosa Infection From Water"* and whilst augmented care is mentioned on page 9 it is only in the context of *Legionella* risk. There is no mention of precautions to be taken to protect immunocompromised patients at increased risk of infection from other waterborne pathogens.

a. In what way was it 'geared towards legionella'? Can you provide more information on this? What risks are associated with focusing on legionella? In what way can it be improved to focus on other pathogens?

A See also above answers. The risk assessments carried out by DMA are entitled as L8 Risk Assessments. L8 is the shortened term used for the HSE Approved Code of Practice and Guidance Legionnaires' disease – The control of legionella bacteria in water systems and also quotes BS 8580:2010 Water quality – Risk assessments for Legionella control – Code of practice and refers to it being a Legionella risk assessment.

For high-risk patients such as those in the children's haematology oncology, whilst it is important to effectively control the risks from *Legionella,* this is not the greatest risk to these patients. Because of their immunocompromised state they are at risk from a whole range waterborne pathogens particularly *Pseudomonas aeruginosa* and other gram-negative bacteria as well as from non- tuberculous mycobacteria, and fungal infections. There is much evidence from a range of peer reviewed journal publications highlighting the risks to immunocompromised patients from such a wide range of waterborne pathogens and that preventing exposure to tap water for those at greatest risk, significantly reduces the risk. The World Health Organisation (WHO) published a helpful table identifying the quality of water for patients at high risk of infection in their 2003 publication "Heterotrophic Plate Counts and Drinking-water Safety, *The Significance of HPCs for Water Quality and Human Health.* This is referred to in the latest WHO guidelines for drinking water quality 2022. The 2018 DMA risk assessment whilst still focused on *Legionella* does make some recommendations which would

improve the management and monitoring the risk from *P. aeruginosa* e.g. that the use of hand gels would discourage water use, and that as there had been positive samples for *Legionella* sampling, they advised IPC have input into the sampling plan for *Pseudomonas*.

b. Recommendation 4 concerns changing the composition of the Water Safety Group. What was the composition of the group at the time of your visit? Why did you recommend changing the group structure? You recommended a more holistic/multi-disciplinary approach to the group composition. What in your opinion would this look like and who would participate? Why did you recommend a more holistic/multi-disciplinary approach?

A See also answer above. Prior to the issues ongoing at the time of my visit, the focus of the scheme of control is focused on the risks from *Legionella*. A Water Safety Group (WSG), especially where there are patients at high risk of infections, including those from exposure to water and wastewater, needs to be multidisciplinary with the skills and competencies required to deliver safe water for all users and types of use within healthcare to be able to consider all potential hazards relevant to the susceptibilities of the population who are likely to be exposed. The British standard for developing water safety plans (BS 8680:2020) advises that a gap analysis should be carried out on existing risk assessments to identify what is missing to ensure that water is safe the intended population. This would include a risk assessment for *P.aeruginosa* and other waterborne pathogens for this group of patients and appropriate barriers put in place to protect them from harm. (BS 8580-2) recommends a multidisciplinary approach is needed for risk assessment for *P. aeruginosa* and other waterborne pathogens which would include those involved in the patient day-to-day care as well as infection prevention and control specialists and others as required, should carry out these risk assessments. They should identify all potential hazards and hazardous events that is, events that could lead to the ingress or an increase in levels of hazards which could cause harm to the population likely to be exposed. (a hazard is an agent which can do harm, these may be biological (including bacteria such as *Legionella, Pseudomonas aeruginosa*, *Stenotrophomonas* spp., *Cupriavidus paulculus* etc., chemical such as biocides

and their breakdown products, physical e.g. water which could cause scalds, spilt water resulting in falls, or radiological e.g. in areas where radioisotopes are used in treatment and / or research) plan (scheme of control) should then put in place to minimise these risks from water in an individual healthcare environment (ward/ unit etc). A multidisciplinary approach (and therefore a multidisciplinary group of personal with different and necessary skills to identify all hazards, potential sources of exposure to water, sprays and aerosols derived from water as well as the modes of transmission applicable to each particular patient group. They also need to understand the harm they can cause, and the measures required to prevent that harm. This needs input from medical microbiologists, clinical teams, IPC teams with experience in the built environment, and estates teams and those responsible for all uses of water to which patients may be exposed including where water is used for patient diagnosis and treatment such as aquatic therapy, dialysis, decontamination teams etc. In addition, representation is needed from those responsible for housekeeping including the application of correct cleaning techniques of water fittings and components, water used for food preparation and drinking water and how systems and equipment are maintained are all important for maintaining safe water hygiene.

c. In recommendation 5, you advised to include water from diagnosis and treatment to be included in the WSP. What is the WSP? Please explain the rationale behind this recommendation.

A See above: The water safety plan is a holistic management plan for drinking water safety based on risk assessment using Hazard Analysis of Critical Control Points (HACCP) principles as advocated by the World Health Organization. HACCP was originally developed for the space program to prevent food and waterborne infections whilst astronauts were in space and then adopted by the WHO in 2003 to reduce the risk from contamination of water supplies, moving away from a reactive scheme of control based on sampling results to a proactive and preventive water safety plan approach which looks at the points where contamination could enter water systems or equipment and identifying barriers to prevent such contamination.. Once the risk assessment has been completed then a scheme of control should be developed based on the risk assessment findings to prioritize and mitigate identified risks as well as a program of monitoring to ensure the plan remains effective. This is backed up by supporting programmes such as training, surveillance, audits and ongoing review. The

WSP includes the processes by which an organization ensures water will be safe for all uses and all users at the point of exposure. Exposure to waterborne pathogens can be by:

- **direct contact** for example: bathing in water,
- **indirect contact** e.g., touching surfaces which have been wetted including by being sprayed with water droplets.
- **direct consumption** – e.g. drinking water
- **indirect consumption** -e.g. eating food irrigated or washed by contaminated water
- **inhalation** e.g. inhalation of aerosols (formed from when water is aerosolized for example through turning on a shower or when a tap is turned on and water hits a hard surface or when a toilet is flushed. Aerosols which cause infection in humans have to be less than 0.5 microns, (1 Micron = one millionth of a meter, a human hair is about 50 microns wide).
- **aspiration** e.g. when water is drunk but instead of going into the gastrointestinal tract enters the respiratory tract instead (commonly referred to “as going down the wrong way”

The WSP approach is advocated for the management of *Legionella* risks in the 2007 publication Legionella and the prevention of legionellosis and more holistically for all waterborne pathogens in the WHO Water safety in Buildings (i.e. those based on the results of sampling water and then only reacting when results are available Reactive water management plans which rely on sampling results are not effective as by the time the results are returned the water has already been consumed / used)

published in 2011. there is also a British Standard BS 8680:2020 previously mentioned for the development of WSPs

d. What was the current role of Infection Prevention Control within the water safety group at the time of your visit and report? Who at that time had oversight of water use? Did you consider the oversight regime to be appropriate?

A See earlier answer; - the WSG was very much legionella focused. As far as I can recall Dr Inkster was the lead infection control doctor and was an advisor to the WSG. However as previously identified the scheme of control available at the time did not include membership of the IPC team. In Scotland the SHTM part B (2014) advises that WSGs were led by the Responsible person, whereas in England the DH HTM 04:01 and under the Health and Social Care Act it is the Director for Infection Prevention and Control (DIPC).

e. You referred to special user groups. Can you explain what a special user group is? Would special user groups not normally be included? What is the importance of including them?

A Specialist user groups are for example, those providing diagnosis and/ or treatment which requires the use of water, which usually has special water quality requirements (with water quality targets different to and often over and above those needed to comply with tap water quality requirements as distributed to outlets in general wards etc.). The types of specialist user groups in hospitals depends on the types of patient groups using the facilities, for example, those responsible for haemodialysis, decontamination, aquatic therapy, pharmacy preparations, laundry, food preparation, patient support services including cleaning and water treatment providers. These specialist services usually either require water of a defined water quality for their intended purpose to keep patients safe or which have an impact on water hygiene.

Water Safety Plan:

16 You suggested the development of an asset register. Can you explain what this is? What would this look like? How would you expect this to be managed? Who would normally be involved with this? Is having an asset register, based on your experience, standard practice? How might this assist the water management/contamination?

A An asset register is a requirement within the HSE *Legionella* ACOP guidance to ensure that assets which could pose a risk of Legionnaires' disease if not managed or maintained appropriately, are identified and included in risk assessments and those which require maintenance, as well as ongoing surveillance and monitoring as required, for example, regulating valves, thermostatic mixing valves, calorifiers, RO units etc. This is usually the remit of the estates team. In high-risk patient areas the risk assessment a multidisciplinary group should carry out a risk assessment and also ensure that systems, water and wastewater components, fittings, equipment, placement of patients' personal effects and furniture etc which could pose risks of infection from other waterborne pathogens are also listed to ensure they are risk assessed, managed and maintained appropriately. This would normally include for example the IPC, ward manager, cleaning supervisor, matron etc. (see also BS 8580-2)

b. You stated that the water safety group (WSG) should determine the water quality required for the safety of each user group, and you mentioned WHO and 'French Guidelines'. Can you advise whether this is general guidance which any hospital would be expected to follow or guidance in response to something you had observed or were advised of at the QEUH/RHC?

A This is something should be considered at the design stage of each hospital taking account of the type of patients, their susceptibility to infection and treatments offered. Some patients, because of increased susceptibility to infections, need a defined water quality over and above that supplied by the water distribution system. For some neutropenic patients for example, only sterile water will be considered safe for both consumption and personal hygiene. WHO published some guidance in 2002 which indicated the water quality needed to protect immunocompromised patients based on their immune status, this is

referenced in the latest version of the WHO Guidelines for Drinking Water Quality 2022. The specialist needs of patients should be taken into account at the concept stage of the building and included in the design brief. The French guidelines include defined water qualities for different uses and patients and are referenced in Table 4.1 Nomenclature of waters used in health- care buildings in France (this is referenced within WHO Water Safety in Buildings 2011)[2]

Design Issues:

17 Single Barrier Approach:

i. Can you explain what a multi-barrier approach is? From your experience, is it unusual for a hospital not to have a multi-barrier approach? If so, why is that unusual?

A See above, the multi-barrier approach is advocated by the World Health Organisation (WHO) to minimise the risk of harm from exposure to water. For example, whilst temperature control may be the traditional primary control measure in a healthcare environment if there is failure in the attainment of target control temperatures, then patients and staff would be put at risk. Cold water risks are increased when water temperatures rise during a heatwave and likely to result in increasing incoming cold- water temperatures, other factors which could compromise temperature management could include calorifier breakdowns, power cuts etc. affecting the ability to control hot water for example. A second barrier such as chemical water treatment regime, if in place and appropriately managed would still continue to provide protection from growth of microorganisms within the water system for patients to ensure its safety.

ii. Can you expand on why you state that the temperature will not meet the target 100% of the time at every outlet? What are the implications of this?

A See also above; Effective temperature control depends on the outlets being frequently used (at least daily) to draw water at the target temperatures (cold < 20

°C and hot >55 °C) through to the periphery of the system up to the point of delivery to avoid temperatures reaching the range at which waterborne pathogens such as legionellae and others will grow. The way hospitals are now designed with a high number of single ensuite rooms mean that for very ill patients who are not able to use the ensuite, there is a risk of stagnation in the unused outlets and toilet which is a high-risk factor for waterborne pathogen growth and the potential for exposure to high levels when patients recover enough to use the ensuite. To mitigate this there should be a flushing regime to flush each outlet on a daily basis and flush the toilets. However, this is very rarely achieved for all outlets, very difficult to audit and costly in terms of staff time and wasted water. There is increasing evidence that where water and associated above ground wastewater systems are provided in patient rooms at high-risk of infection because of their immune status or breaches in the skins integrity due to indwelling venous catheters (e.g. central lines), there is an increased risk of waterborne infections particularly from Gram-negative bacteria, and for transfer of antimicrobial resistance genes within the associated drainage.

Designs should take account of the change in patient behaviours for example, for many procedures, patients no longer spend time in hospital before and after procedures, they are expected to shower at home and come into hospital on the day of their procedure and return home the same day not using the ensuite shower at all. The presence of little used outlets puts the entire system at risk and increases: -

- water management costs,
- the risk of infection leading to increased patient stays and antibiotic use
- an increased risk of antimicrobial resistance and
- an increased use of water and personnel to flush little used outlets.
- the impact on sustainability targets as water of drinking water quality is flushed to waste.

iii. You stated that it would have been prudent to have had point of use filters to protect the highest risk patients. Can you explain how point of use filters work? Why would they protect the highest risk patients? Do you consider it to be standard practice to have point of use filters in place? What, in your opinion, is the risk in not having point of use filters in place?

A Point of Use Filter (POUF), depending on the specification, minimise the risks from distributed water by filtering out microbial hazards immediately before water is dispensed at the outlet. As long as the appropriate filters (sterilising grade absolute filters) are fitted correctly and managed appropriately, they retain microbial hazards which can cause infection, including legionellae and other Gram-negative bacteria as well as NTMs, to deliver safe water. (see earlier comments re POUF above). There is good peer reviewed evidence of their effectiveness at reducing risks to patients from waterborne hazards, reducing costs associated with waterborne infections and lowering the risk of transmission of antimicrobial resistance.

b. Overprovision of water outlets:

i. You stated that, 'it was felt' that there was an overprovision of water outlets. How was this communicated to you? By whom was it communicated to you? Was this your observation? Were you advised of this during your visit? Did you agree with this?

A This is a common design problem in that the calculation for provision of water outlets guidance is out of date and nearly all hospitals have too many outlets. In recent years the risk from unused outlets, the increased use of hand gels, and the risks from waterborne pathogens in outlets and drains in causing waterborne infections, is better understood. This was discussed during my visit and yes I very much agree with this.

ii. Why would an overprovision of outlets contribute to low flow in the system?

A Where there are many outlets which aren't used, the spurs which feed the taps off the distribution pipework (usually a few feet in length) remain stagnant. Stagnant water is subject to temperature loss in hot water pipes and temperature gain in cold water pipes feeding these. Where water is not moving (because the outlets aren't used then the control measures, whether temperature or biocide do not reach the outlet continuously. Warm water temperatures and stagnation provide ideal conditions for waterborne pathogens to grow.

iii. From your experience, are ensuite bathrooms and showers common in new build hospitals? Did you have any concerns regarding this?

A Unfortunately, yes they are common, the current NHS policy focus seems to be more geared to giving patients a hotel type of experience rather than providing a safe, nurturing and sustainable environment to recover from illness. Whilst single ensuite rooms have some benefits in that patients get better sleep and there is a lower risk of patient-to-patient transmission of infection, (therefore it is necessary to have some isolation rooms). In my experience there is a growing body of infection prevention and control specialists in the built environment and estates engineers who consider the risk is much higher of patient harm from water and drains which aren't used sufficiently to ensure their safety in patient rooms.

For some patients as already explained, exposure to water and associated above

ground drainage poses too great a risk of direct harm and also increases the potential for an increase in the development of antibiotic resistance as many of these waterborne opportunistic pathogens are inherently resistant and facilitate the spread of antibiotic resistance between microbial species. There will always be some long-term patients who will need an ensuite shower, but the design of patient rooms should not be a one size fits all. The trues cost of the provision of all ensuite rooms should take into account:

- The initial cost of the fittings and installation
- The cost in terms of manpower of managing the unused outlets.
- The cost of water and sustainability implications of using more tap water than necessary for flushing
- also, the sustainability implications of heating and treating water to be flushed
- the cost of monitoring and testing to verify controls are effective, taking account of personnel and laboratory costs
- The increased length of patient stays, theatre time and antibiotics for resulting Gram-negative infections (there is much evidence in peer reviewed publications that providing filtered “sterilised” water or preventing exposure altogether reduces the overall number of gram -negative infections and reduces antibiotic use)
- The economic and social cost to those infected and their families
- The increased risk of antibiotic resistance
- The increased cost of wastewater management to treatment works.

iv. Recommendation 7 suggests that outlets are reviewed and removed if unnecessary. Are you aware if this happened or was considered by the QEUH? In your experience, for what reason would an outlet be deemed unnecessary?

A As far as I recall I did not know, until I read the documentation provided for this inquiry that an SBAR raised. It has been usual in designs (until recently) that as well as a wash hand basin for
patients in their ensuite there has also been a clinical wash hand basin in the patient room for handwashing. Handwashing provision for staff is not always necessary in patient rooms and can be safely provided outside the patient area / room with gel provision once inside. The provision of wash hand basins in

rooms should be subject to risk assessment based on the immune status of the patient and any co morbidities which may affect their risk of waterborne infection. Providing just one wash hand basin in the ensuite, and not in the patient room, can protect patients from splash and aerosol contamination

v. How would you expect such action be balanced against the risk of contamination from contractors?

A The way that we design and build hospitals has to change so that the focus is on patient safety first and foremost. Site management is important, a clerk of works or equivalent working for the intended owner and with the project water safety group should ensure that all materials, components and fittings arrive and are managed on site as specified and are suitably protected so they do not introduce nutrients and microorganisms into the system during construction, installation, filling, commissioning up to the point of handover and beyond. All water system and fittings as well as drainage (including toilets) should remain sealed until handover so they can't be used by contractors and contaminated. The filling of the system should be at a time agreed by the project water safety group as late as possible in the project to avoid stagnation in the period between filling and handover.

vi. Are flow sensors and flushing regimes commonly used from your experience? How effective are they? Given your knowledge of the water contamination at the QEUH/RHC, how effective do you think sensors and flushing regimes would have been at resolving the water contamination issues?

A The use of remote monitoring by automatic sensor devices including of flow, temperature and biocides is increasing and becoming more available and cost effective. Remote monitoring would not remove the risk from poor design installation and commissioning. As long as the system has been kept free from contamination during the build process to handover and remote monitoring is a very useful tool in keeping the system safe. However, there are some factors that need to be considered to ensure its effectiveness depends on for example:

- the type and positioning of sensor chosen,
- the quality and calibration (needs to be calibrated for the parameters to be measured and robust),

- the accessibility for calibration and maintenance,
- the strength and type of signal
- the frequency of sensing (too frequent (multiple time per minute for example) can generate so much data that deviations may be missed,
- the way the data is transmitted (how good the signal from the sensor to the data collection device),
- the way that data handling and trend analysis is carried out and
- how alerts to out of target parameters are transmitted and
- the chains of communication to manage any actions necessary.
- The integration of AI technology

In my opinion automated remote monitoring is the future but we are still on a learning curve. However, there are already remote sensors already in use, such as in self-flushing outlets which can be set to flush if an outlet has not been used for a period of time and that can collect data on the type of usage etc. I am aware of hospitals where these are already successfully used to help manage the risk in low use and high-risk areas. As with anything electrical and mechanical they need to be risk assessed, installed and maintained appropriately.

c. Sluice rooms:

i. Can you explain the risks associated with the positioning of the sluice rooms? How does the positioning of sluice rooms relate to water contamination? Did anyone else share your concerns regarding the design of Ward 2A?

A It is generally accepted that the risk of waterborne infections resulting from exposure to water and wastewater is increased when sinks are used for anything other than handwashing, e.g. disposing of water used for patient hygiene, drinks, antibiotic infusions etc. are disposed of down the sink. The risk of such instances is increased if the sluice room is positioned far from the patients especially those who are critically ill, as nursing staff will not want to leave their patients. In addition, there is an increased risk of spills resulting in slips and falls if water has to be carried some distance from the point of use.

Designing sluice rooms to be central to avoid these risks is a sensible approach. I cannot remember if anyone else shared these concerns before my visit but I would be surprised if it hadn't been raised previously.

ii. Recommendation 8 suggests that the Trust review their design guide with infection specialists for future designs. Are you aware if infection specialist had been involved from the point of designing the QEUH/RHC?

A No I am not aware.

iii. Would you have expected such experts to have been involved?

A Ideally Yes although there are currently very few IPC professionals with expertise in the built environment. There are also very few architects and design engineers who understand the risks associated with poor water system design.

iv. How effective was the design process in your view?

A I think the outcome for the patients and their families affected speaks for itself. The problem with design and build projects is that the contractors do not have sufficient knowledge to design out risks and there is usually no one on-site oversight to ensure the build is carried out as specified and the focus is on the absolute requirement to provide a safe outcome for all patients including those at the highest risk of harm.

v. Did you discuss collaboration with infection control at your meeting on 25th April 2018? If so, what was the discussion around this? Were any concerns shared? If so, what concerns were shared, and by whom?

A It is so long ago I can't remember exactly but I am fairly confident this would have been discussed especially when Dr Inkster and I visited the ward in question.

c. Flow straighteners/aerators:

i. Can you explain what a flow straightener/aerator is?

A A flow straightener is a device fitted into the spout of the tap to create a laminar flow (smooth the flow and decrease turbulence) to reduce the risk from splashing. An aerator typically introduces air into the flow and reduces the volume of water passing out of the outlet to reduce water use. There are different types and complexity of flow straighteners, the investigation into the Belfast outbreak showed that the more complex type are more likely to be colonised than the simpler types. These inserts typically look a sieve-like structure and are made of materials (some plastic or metal) and inserted into the outlet and provide an increased surface area for biofilm growth.

ii. Is it well known that these inserts cause waterborne HAIs? If so, how do flow straighteners and aerators cause waterborne HAIs? Do you have a view on why these would have been included in the design of the hospital? Are they common features in other hospitals?

A Following the Belfast outbreak in particular I would have expected that architects, design engineers, Estates and IPC teams understand the implications of fitting these especially in augmented care areas. The first mention I am aware of was of flow straighteners linked to waterborne infections in a neonatal unit was published in the New England Journal of Infection in 1966. Since then, the outbreak which occurred in Belfast in 2011/ 2012 made national news and resulted in an independent review (similar to a public inquiry) and in addition, there are many publications in peer-reviewed journals and guidance at the time from the Department of Health *"Pseudomonas aeruginosa – advice for augmented care units"* published in 2013.

My personal experience is that the design engineers and those responsible for procurement were not sufficiently aware of the risks to successfully design out risks from water systems in healthcare premises. Despite Department of Health guidance that aerators/flow straighteners should be avoided my experience is that they are still found in healthcare premises.

You mention an outbreak of Pseudomonas Aeruginosa linked to flow straighteners. Can you expand on this? Why do you consider that the outbreak was linked to the flow straighteners? Would those at GGC have been aware of

the deaths in Belfast? On what basis would you consider that they would have been so aware? Had they been aware, what do you consider they should have taken from the incident in Belfast**?**

8

A See above answer and the findings from the independent review and publications related to the Belfast outbreak. I would be surprised if those designing the hospital had not been aware of the Belfast outbreak. As identified earlier it made the news UK wide and resulted in new guidance from the Department of Health. The design brief for QEUH should have been specific and excluded these taps with inserts from the design. There should also have been a process within the WSP to ensure that the procurement of taps was such that they did not incorporate aerators/flow straighteners. I would have hoped that those designing and engineering the project, taking account of the intended user group, would have sufficient competence that to ensure they were designing safe spaces for the intended users and collaborated with IPC and the clinical teams to establish if there were any special requirements needed in the design. For example, ensured there was sufficient collaboration with IPC, clinical teams, estates, microbiologists etc. to ensure materials, components and fittings would not pose a risk to these patients and could be effectively disinfected for example by putting through a wash and disinfector or to be autoclaved.

iii. Recommendation 9 suggests that flow straighteners and aerators are removed in high-risk areas and replaced with outlets which can be more easily maintained. Why are flow straighteners and aerators difficult to maintain?

A See earlier answers, Because of their complexity and the likelihood of them collecting scale, particulates and biofilm. They have an increased surface area for colonisation with biofilms and are difficult to clean and disinfect. They increase the risk of infection, are an avoidable risk, and therefore under health and safety legislation (e.g. COSHH) they should be removed or replaced with something which minimises this risk.

iv. How easily can they be replaced?

A There are taps available which do not require inserts available

v. What effect in respect of infection risk would there be in replacing the flow straighteners and aerators?

A It's not possible just to replace the flow straighteners/ aerator in a tap that is designed to work with them in place, the tap needs to be designed to give laminar flow removing them with just increase the splashing risk. Taps without inserts reduces the risk of harm to patients.

vi. Would this be a reasonable step for the hospital to take considering factors such as the cost and disruption to patients?

A Patient safety has to come first, The risk of colonisation of outlets would be significantly reduced therefore also the high risk of waterborne infections for these patients. There is good peer reviewed evidence that if you remove the risk of waterborne infections there is not just a cost saving to the organisation, but reduced overall levels of Gram-negative infections, reduced antibiotic use and theatre time and reduced patient lengths of stay compared to those who do not get infected within healthcare premises.

e **Point of use filters:**

i. Can you explain what you mean when you refer to 'demountable outlets? Why are these more effective for highly vulnerable patients?

A These are outlets which can be removed for disinfection / sterilisation. The ability to remove, clean and disinfect/ sterilise the outlet (see above) by putting through a washer disinfect, or autoclaving is a more effective way to reduce microbial colonisation than trying to disinfect the tap in situ.

ii. Can you recall how often filters were being changed? How often would you expect the filters to be changed? What do you consider the risk to be if filters are not changed as you would expect?

A I can't remember if this was discussed, the timescale depends on the manufacturer, type of filter and the hardness and amount of particulates in the

water as to what the recommended time frame would be. Another factor when considering if they need to be replaced is if the water pressure drops through the filter due to clogging. If I recall correctly, they used PALL filters which typically had a 30-day lifespan.

iii. You state that contamination of the filter is extremely rare and most likely to be the result of external factors. Were the filters within the QUEH/RHC contaminated at the time of your visit and report?

A Not determined

iv. If so, what was the source of the contamination? How do filters typically become contaminated? What do they typically become contaminated with? How is such contamination a risk to vulnerable patients?

A See earlier answer about point of use filters.

v. Recommendation 12 suggests parents fill their baby baths from the shower to reduce the risk of filter removal: why would this reduce the risk of filter removal? How were parents filling baths and children being washed? Is this recommendation based on your observations and/or understanding of what was happening in ward 2A?

A If I recall correctly there was evidence of patients parents removing point of use filters from the wash hand basin to fill the baby bath because wouldn't fit under the tap with the filter in place. This was a practical solution and removal was less likely to happen if they used the shower instead.

f **Cleaning:**

i. Can you recall the details of any discussions on cleaning the point of use filters? If so, what was the nature and details of any such discussions?

A I don't recall the exact discussions, but I sent Dr Inkster a video that I was involved with making with Dr Elaine Cloutman Green in collaboration with the Royal Society for Public health and Great Ormond Street Hospital.

ii. How were point of use filters being cleaned at the time of your visit? How are point of use filters typically cleaned? Do you have an opinion on the methods

being used and the risk of contamination associated with these methods?

A I don't know how the point of use filters were being cleaned at the time of my visit. Different manufacturers have different opinions as to whether the filter should be cleaned or not as there is a risk of contamination of the outlet of the filter from poor technique particularly if those cleaning them do not understand or have been trained to clean these effectively and without the potential to contaminate the filter outlet during the process.

iii. What are the water regulations on backflow prevention and who should comply with these? Can you explain the importance of having 'an effective air gap'? What are the consequences of the sinks in patients' bathrooms not being compliant?

A In Scotland these are bylaws; "*Paragraph 15 (Byelaws in Scotland)*

(1) *Subject to sub-paragraphs (2) to (5), every water system must contain an adequate device or devices for preventing backflow of fluid from any appliance, fitting or process from occurring".*

(2) *The definition in Water Regs UK is that "An air gap' means a visible, unobstructed and complete physical air break between the lowest level of water discharge and the level of potentially contaminated fluid downstream (critical water level) within a cistern, vessel, fitting or appliance, hereinafter called a receptacle, for example if a tap was fitted so that the spout protruded below the water line there is a potential for water which had been in contact with the contents of the drain, to flow into the tap spout and contaminate the fitting and water within it. By ensuring that the tap cannot protrude below the water line means that there is a water free space (air gap) between the outlet and the water in the sink/ basin and so backflow cannot occur.*

iv. In terms of Recommendation 14, what measures were taken to remedy the sinks in the bathrooms? Were new sinks fitted or plugs removed? How effective do you consider any remedial work to have been in relation to infection control?

A I have no information to answer this

g

Patient and environmental isolates:

i. Can you recall details of the discussion around ruling out water as a potential source for cupriavidus? Who was involved in any such discussion? What position(s) were taken during the discussion?

A I think it was with Dr Inkster and we were both on the same page that it was likely to be associated with the water and / or drainage system.

ii. What was the basis of your opinion that water should not be ruled out as an environmental source despite different strains being identified met? What was the outcome of the discussion?

A It is not possible to exclude a match between the clinical isolates and environmental sources for several reasons,

- There is a huge sampling error when taking samples, for example the point at which patients would be at highest risk is when the outlet had s not been used for several hours. When taking a true pre flush sample i.e. when an outlet hasn't been used for several hours) the potential for positive results decreases significantly within seconds of the outlet being turned on. False negatives results are likely after only minutes of the tap being turned on and water flowing as the biofilm in the outlet is washed away.

  There were insufficient isolates tested at the same time from a single sampling event. To have a 95% statistical probability that there is no link between patient and environmental sources you would need to pick and type at least 30 isolates from the same sampling event and same culture plate.
  For the same reason it is possible that patients, particularly if immunocompromised may be infected with more than one strain.
  All potential sources of exposure and transmission were not as far as I am aware, sampled, for example all drains, overflows, toilets, cleaning equipment, outlets and drains in staff and parent areas, etc.
  In addition, recent work published in Nature confirms that patients may commonly be co-infected by multiple pathogen clones, so the isolate picked for typing may not be representative.

iii. You state that it was likely that water was the source and cannot be ruled out due to isolates not matching. Can you explain this further and provide reasoning for this conclusion?

A See above

iv. Are you aware if the steps you describe were taken to rule out environmental sources and confirm a patient strain in the system?

A No

h Water temperature:

i. Can you explain the importance of maintaining water temperature?

A Already answered above.

ii. What is the importance of maintaining data on water temperature? What kind of data would you expect to see being maintained?

A Already answered above.

iii. Over what time period should such data be maintained?

A *It is a legal requirement see HSE ACOP L8:- Record keeping.*

" person or persons appointed under paragraph 39 shall ensure that appropriate records are kept, including details of:

a. the person or persons responsible for conducting the risk assessment, managing, and implementing the written scheme.

b. the significant findings of the risk assessment.

c. the written scheme required under paragraph 53 and details of its implementation; and

d. the results of any monitoring, inspection, test or check carried out, and the dates. This should include details of the state of operation of the system, ie in use/not in use.

67 Records kept in accordance with paragraph 66 should be retained throughout the period for which they remain current and for at least two years after that period. Records kept in accordance with paragraph 66(d) should be retained for at least five years'"

iv. How should any such data be utilised?

A Already answered above

v. Did not having this data available cause you concern? If so, why?

A Yes, because of noncompliance with their legal duty, which in turn is a cause of concern regarding their competence. The lack of such data means it is difficult to do any root cause analysis when adverse results were identified.

Communication with GGC and Dr Teresa Inkster

Refer to email correspondence of 16 March 2018 between Ian Storrar, Philip Ashcroft and Susanne Lee: Fw cupriavidus pauculus URGENT.

18. Was this the first contact you had regarding the water contamination at the QEUH/RHC?

A Yes this is a repeat question see above.

19. What knowledge, if any, did you have of the issues with the water in advance of this?

A Non.

20. In this email you refer to Cupriavidus Pauculus. Can you explain what this pathogen is? Is this a common pathogen? Where is this pathogen normally detected? In your experience, what is the typical cause of its appearance?

A This is a repeat question.

21. Following this email, did anyone from GGC contact you to follow up on your advice? If so, from whom did you receive contact? How did they contact you? Can you please provide details of any such communication? Did you respond to any such communication? If so, when did you respond? How did you respond? What was the nature of your response?

A Non except I received a nice email from Ian Storrar thanking me, I did receive a forwarded email from the Director of Facilities, Allyson Hirst via Dr Inkster asking

for availability for a joint meeting with Tom Makin, however, I was told when I replied to Dr Inkster this was no longer needed. Dr Inkster told me later when I asked about why, that they did not allow her to invite me again as they didn't like what I had said.

22. When was your first contact with Dr Inkster? Can you provide the details of this contact from Dr Inkster? What information did she provide you with? What, if anything, did she request of you? How long did your contact with Dr Inkster continue for? When was your last contact with Dr Inkster?

A This has already been answered.

I am in contact with Dr Inkster regularly, I have asked Dr Inkster to present a webinar for the RSPH and as a recognized expert I have asked she be part of British standard committees I chair, writing new waters safety standards. She is also a respected member of a group I am the lead technical author of writing a Department of Health Technical bulletin to update HTM 0401 for the design of units for high-risk patients. Last contact probably wb 15.7 2024 to discuss the drafting of the technical bulletin.

23. Did you have any involvement with the water technical group? If so, can you please provide details of the nature of your involvement?

A Not since my visit

Other than your meeting of 25th April 2018, did you have contact with anyone else from the hospital or GGC either in person, by email, phone or otherwise? If so, can you please provide details of who you had contact with, how you were in contact with them, and the nature and details of those communications?

A This is a repeat question and not as far as I recall.

Refer to email – 23 March 2018: Teresa Inkster and Susanne Lee - Re: Glasgow water incident - request for assistance.

24. In this email, Dr Inkster advises that she, along with Dr Armstrong and Mary Anne Kane, would like to invite you to undertake a more formal role to assist going forward. What was your understanding of this invitation and what your role would be going forward?

A This is already answered.

25. Did you ever have any contact with either Jennifer Armstrong or Mary Anne Kane?

A Not to my knowledge If so, can you please provide details of the dates of any such contact, and the nature and details of any communications? Did you communicate with anyone else other than Dr Inkster in this regard? No not as far as I can remember

a) If so, can you please provide details as to who you were in contact with, when, in what manner, and the nature and details of any such contact?

A Not as far as I can remember, apart from at the meetings in Glasgow and the ward visit my contact was Dr Inkster.
Refer to Email – 24 March 2018: action points from teleconference.

26. Dr Inkster and Annette Rankin undertook to discuss your remit and email you. Do you remember receiving these emails? If so, what was your official remit? Were you satisfied with the terms of your remit? If you were not, on what basis were you not so satisfied, and what do you consider your remit ought to have encompassed?

A Because I was not asked to return as expected as far as I recall a remit was never agreed

Refer to IMT 23 March 2018 – Future Preventative Measures

27. The minutes of this IMT state that Dr Inkster formally invited you to explore the hypothesis and consider additional measures, especially for BMT patients. Did you have a hypothesis at this point regarding what might be causing the water contamination? If so, can you please provide details of what your hypothesis was, and how you reached it? Did this hypothesis change following your visit and/or as you were provided with further updates from Dr Inkster throughout your involvement with the incident? What is your current hypothesis on the cause of water contamination at the hospital? On what basis did you reach this hypothesis? Has this hypothesis been communicated to anyone at GGC? If so, when was it communicated, to whom was it communicated, and how was it communicated?

A I have already answered this in previous questions. My opinion is that the hospital was poorly designed and managed during the construction and following filling with water. The evidence is in the documentation and speaks for itself. as far as I remember some of this was discussed during the visit.

28. Did Dr Inkster seek your advice on the introduction of new taps and dosing the water supply to the hospital? If so, when did she seek your advice on this? What advice did you provide to her? When did you provide this advice? On what basis was any such advice provided?

A We talked about dosing alternatives during the meeting at the hospital and in following emails

Refer to IMT 12 June 2018

29. It was noted that there were cases of Enterobacter within the hospital and that Dr Inkster had been consulting with you regarding this. Do you recall these discussions? What information were you provided with by Dr Inkster relating to these cases? Were you provided with documents or was your knowledge restricted to verbal conversations and/or emails?

A As far as I recall via an email on the 10th June 2018 from Dr Inkster. Did you consider that you had been provided with all relevant information in relation to the cases of Enterobacter? As I understood it the Enterobacter was likely to be related to the ongoing issues. What advice did you give to Dr Inkster? My

response was in relation to the risk of splashing and increased risk where filters are fitted when the outlets have not been designed to take them as raised by Dr Inkster. Also, the difficulties in cleaning drains and referred her to George McCracken head of the estates risk team at the Belfast Trust whom I know had tried disinfecting drains with Actichlor.

30. How did you reach any conclusions that you did? Was your advice was taken forward and actioned? If so, how do you understand your advice was taken forward? Was there any follow-up from the initial discussions with Dr Inkster where you were advised of the outcomes, and the details of any outcomes?

A From experience, and Dr Inkster told me she was going to call George apart from that I was not aware of further actions.

Point of Use Filters

Refer to IMT 21 March 2018

31. With reference to page 5 of the Minutes from the IMT on 21 March 2018, it states that a decision was taken to use the water without first testing the microbiological efficacy of the filters and that this was something you agreed with. Do you recall the nature and details of any discussions regarding the microbiological efficacy of point of use filters which you may have had? If so, who did you have these discussions with? Was the decision to proceed to use the water something which you agreed with? If not, why not? What did you understand the reasoning behind this decision to be? Are there risks involved in proceeding to use the water without confirmation of the efficacy of the filters? If so, how would you expect these risks to be balanced?

A I only vaguely recall these discussions. The filters that were proposed were PALL filters. PALL filters have been used around the world, they have good validation data and there are many peer reviewed international independent evaluations in the literature of their efficacy in reducing the risk of waterborne infection in high-risk patient areas.

Concerns about mobile sinks and bottled water

Refer to email correspondence of 16 March 2018 between Ian Storrar, Philip Ashcroft and Susanne Lee: Fw cupriavidus pauculus URGENT.

32. In an email dated 16th March 2018 to Philip Ashcroft, you expressed concerns regarding the use of mobile sinks and bottled water. Can you expand on these concerns? What did you consider the risks to be in using mobile sinks and bottled water? Why were they risks? To whom were they risks?

A This was based on previous observations of how these mobile sinks have been stored between uses in other hospitals which put them at risk of colonisation, which was a cause of concern, particularly when intended for high risk patient areas. I have previously observed mobile sinks had been left for some time with residual water in them, This allows them to be colonised with biofilm microorganisms and therefore they pose a continued risk.

33. What is the significance of the distinction between bottled water and sterile water for immunocompromised patients?

A Bottled water is not sterile and can contain a range of naturally occurring waterborne pathogens including *Pseudomonas aeruginosa.* There have been outbreaks in hospital intensive care units from using *Pseudomonas aeruginosa* colonised bottled water.

34. Are you aware if mobile sinks were being thoroughly disinfected before use? How are mobile sinks disinfected?

A No I did not have any information on whether they were being disinfected before use. Ideally they would be drained after use and dried as far as possible , and then disinfected, pipework replaced and disinfected again before use

35. How often would you expect them to be disinfected?

A Depends on the usage. A risk assessment is needed good practice would be to drain, disinfect and dry thoroughly after use and in my opinion a minimum of at least weekly to prevent biofilm growth whilst in use. The sump should have disinfected water to control growth in the pipework (as for distributed water) Chlorine tablets or chlorine dioxide tablets would suffice.

36. What, if any, are the risks in not disinfecting mobile sinks at the intervals that you would expect?

A As above they become colonised potentially with waterborne pathogens particularly *Pseudomonas aeruginosa.* Biofilms once established cannot be removed effectively over the long term. Replacement of tubing etc. would be needed.

37. Can you explain what the 'Dutch Lead' is? What is the significance of it?

A Joost Hopman from the Netherlands was the first to carry out research and publish on the decreased risk to patients from waterborne infections when sinks were removed from ICUs is removing water completely from the highest risk places something which happens often? Why would you expect water to be removed completely from these areas?

Still not commonplace but it is becoming increasingly discussed to protect high risk patients. It depends on the susceptibility of the patients and based on clinical risk. The idea is to protect patients from being in the vicinity of sources of exposure to water and drains and any sprays or aerosols emanating from them.

38. Do you know if your concerns were considered, and any action subsequently taken by the hospital? If so, what actions do you understand to have been taken, and when?

A No Repeat question.

39. Following this email exchange, did you discuss the issues of mobile sinks and bottled water with anyone either directly or via email?

A Not as far as I can recall.

40. If so, who did you discuss the matter with, when, and what was the nature and details of any such communications?

Site Visit

41. In advance of your visit to the QEUH/RHC on 25th April 2018, what, if any, information were you provided with in advance of the meeting? Who provided you with this information? Were you able to consider any information provided to you in advance of the meeting? If so, what were your impressions of what you had been provided with? Why did you suggest a meeting was necessary? What was your understanding of the purpose of this meeting? Who was your main point of contact for the meeting?

A Repeat question.

42. In the morning, you met with Dr Inkster, Annette Rankin, Professor Brenda Gibson and Susie Dodd. What do you recall from this meeting? What was discussed? Were you provided with any documentation? Can you recall what views had been taken by those who you were meeting with on water contamination? At this meeting, and before your visit to the ward, did you form an initial view on the issue of water contamination? If so, what initial view had you formed, and on what basis was it so formed?

A Repeat question, the purpose of the visit was to see the ward for myself (that was the purpose) and to put the problems into context. I try to keep an open mind.

43. In your report, you advised of your concerns from observations which you made on your visit to Ward 2A. If you have not already done so, can you expand on those concerns and the basis on which you reached them?

A Already answered.

44. How long did you spend in Ward 2A? Did you view any other parts of the hospital? Were you given access to all areas which you requested? Did you feel you had enough time to complete your inspection? Was there an opportunity to speak to staff working on the ward? Did the staff have any concerns which they expressed to you? If so, what concerns were communicated to you?

A I don't recall exactly how much time I spent on the ward, there are always limitations in what is possible on such a visit especially where there are highly immunocompromised patients and children with parents, but I was able to see

sufficient for an initial visit. I did speak to staff, including Professor Gibson as we walked to the ward, she was clearly concerned about the patients. I recall being shown the agreement that if I remember correctly was for parents to read and sign to show they have an understanding of the need to keep patients safe.

45. Can you expand on your concerns regarding the design of Ward 2A?

A The layout was such that the sluice rooms were placed so that staff had to walk relatively long distances to dispose of water used for example, for personal hygiene in the sluices. This is difficult for staff who do not want to leave their patients and poses risks of slips and trips and an increased likelihood that wash hand basins will be used for disposal purposes. There had not been any consideration of the practicalities of using the ensuites for parent childcare for example it was very difficult to fill baby baths and so filters were removed, the sinks had also not been designed to take POUF.

46. In the afternoon, you met with Dr Inkster, Annette Rankin, Mary Anne Kane, Ian Powrie, Ian Storrar and Colin Purdon. What do you recall from this meeting? What was discussed? How were you received at this meeting? Can you recall what view, if any, those attending the meeting had on the issue of water contamination? What, if any, advice or opinions did you express during this meeting? How was this received by those at the meeting?

A I gave feedback on what I had seen as described above and described in my report. I cannot remember whether we discussed disinfection at this point or in the morning.

Water Outlets

Refer to IMT 26 October 2018:

47. Following your recommendation to reduce the number of water outlets, changes to hand facilities were discussed with a focus on the ante rooms in BMT, and the suggestion that trough sinks be removed. Were you aware of this proposal and were you asked for advice on it? If so, what advice did you give? Is this something which you would have recommended? If so, on what basis would you have recommended it? Did you view the BMT and the trough sinks on your site visit? If so, what were your observations? Did you have any concerns?

A I was not aware of the actions taken but I was aware of the increased risks from sinks and drains to high-risk patients including from splash contamination. Yes based on risk assessment as I had some concerns re splashing and resultant potential for cross contamination

Refer to SBAR: October 2018:

48. This SBAR was produced following your advice to reduce the number of water outlets. It states, '*the isolation rooms in ward 2A have recently been converted from positive pressure ventilation lobby rooms to positive pressure isolation rooms with an ante room'*. Can you explain what a positive pressure ventilation lobby room is? Can you explain what a positive pressure isolation room with an ante room is? What are the key differences between these rooms?

A Ventilation is outside my area of expertise so I was just repeating what I had been told.

49. Did the conversion of the rooms have any impact on water contamination? In your opinion, would such a change be made in response to issues with water contamination or other environmental factors?

A I didn't visit again so cannot comment.

50. The recommendations in the SBAR suggest that staff should be given an opportunity to demonstrate the need for handwashing in the ante room given there are prescribed circumstances where handwashing should take place rather than alcohol-based hand rub. What are your views on this recommendation? Do you agree that the circumstances described justify the need for the sinks to remain in the context of the bigger issue of water contamination?

A There has to be a risk assessment depending on the uses of water and the susceptibility and closeness of outlets and drains to the patient. A considered need for handwashing as opposed to just hand gel would be if there was a *C.difficile* problem for example, (I was not aware if this was the case) Consideration should also be considered in the risk assessment in areas where nappies are changed.

Drains

Refer to IMT 13 September 2018:

51. Reference is made at page 3 of the Minutes by Dr Inkster to a conversation she had with you where you asked whether a drain survey had been undertaken. Do you recall this conversation? If so, why did you ask about a drain survey and how does this relate to the wider issue of water contamination?

A Drains are a recognized risk factor for the growth of microorganisms, particularly unusual opportunistic pathogens. I was aware that there had been debris found in the water tanks and therefore likely that due diligence had not been followed re the fitting of the drains. If drains are occluded, then there can be backflow onto the surfaces of the wash-hand basins leaving contamination from the drains on surfaces to which patients may be exposed both directly from direct contact and indirectly from splashing.

52. You asked about scopes being put down the drain. Can you explain why you were asking about this? Is this something which you would recommend? Does this enhance the efficacy of the survey? If so, in what way?

A It is the most sensible way to investigate drains to look for blockages.

53. Do you know if a drain survey was carried out? If so, when was it carried out? By whom was it carried out? Were the results of this shared and discussed with you? If so, what were the results? How were the results taken forward? Are you aware of any actions taken as a result of the survey?

A I recall Dr Inkster telling me that there was black slime but apart from that I'm unable to answer the remaining questions.

54. Your comments on the drain survey were to be sent to others in the meeting and then actioned. Did you have contact with anyone else from the hospital or GGC in relation to your advice on a drain survey? If so, with whom did you have contact, in what manner, and what is the nature and details of any such communication?

A See above, nothing further as far as I recall.

Refer to email 13 September 2018:

55. In this email, you provided advice on the drains. What do you mean when you refer to, 'insufficient fall in the drains? What is the significance of this?

A There needs to be sufficient fall (slope downwards) in the drainpipes to give sufficient flow otherwise water, sediment, faeces, paper etc will accumulate.

56. In your view, and given the information you had available, what was the likelihood that there was:

a. Insufficient fall in the drains?

b. Insufficient capacity in the drains?

c. Builders' debris in the pipework?

On what basis did you reach the conclusions in respect of the above?

A I was only aware of the builder's rubble as stated above.

57. Can you explain why disposable wipes and nappy liners are a potential contributor to the problems with the drains? Is this a common problem in children's hospitals? How would disposable wipes and nappy liners contribute to problems with drains?

A It's a problem in most hospitals, wipes and paper towels are disposed of down the toilet and cause blockages.

58. How would this normally be managed?

A Signage, though this is ignored, provisions of sufficient waste bins, regular emptying, and plumbers physically unblocking drains.

59. Can you explain the risk of splash back from the sinks and why this would contaminate the filters and sinks?

A When taps are turned on the water hits the surface of the sink and also the drain if the spout is directly over the drain. This causes splashes which experimentation has showed can reach up to 2 m from the sink. These splashes can contain microorganisms from the drain, including antibiotic resistant strains which can contaminate surfaces, staff and patients themselves.

60. You agree that closing the unit is in the best interests of the patients. Can you expand on this and the reasoning behind this conclusion?

A The unit needed a great deal of work to make it safe, once a system is colonised by biofilm containing waterborne pathogens there is no effective way of long-term removal i.e. the water system and associated drainage would have posed an ongoing risk of harm to these patients and costs to the Board. Removing drains etc. increases the risk of cross contamination potentially leading to infection. The safest option for these patients was to move them to a safe space whilst this work to replace the plumbing was carried out.

Chemical Dosing

Refer to Water Technical Group: 27 April 2018

61. When discussing your report, your conclusion that the water system was likely contaminated before handover is mentioned. Can you explain this conclusion? What was the nature of any discussion about it?

A Repeat question.

62. When discussing chemical dosing, you advised that a higher dose of Sanosil would be more effective in clearing biofilm. However, you also advised that it may cause damage to the pipes longer term. Can you expand on this advice in more detail? How would it cause damage to the pipes? How would a higher dose of Sanosil be more effective at clearing biofilm?

As far as I remember we discussed options for dosing of chlorine dioxide and copper silver ionisation, copper silver was ruled out because of the materials in the system. I don't recall advising on the use of Sanosil as our experience (both my business partner and mine) is that Sanosil does not work effectively in colonised systems, and I always advise on caution about its use especially in heavily colonised systems as our combined experience has shown it is not effective throughout the system and that quite often the recommended doses and contact time by manufacturers are not followed.

I do not recall saying this about Sanosil as I don't advise it is used in highly colonised systems, I would certainly have said this about chlorine dioxide.

63. Are you aware of how GGC proceeded to dose the pipes?

A Sorry No.

64. Was this something which was discussed further with you? If so, with whom did you discuss it? What was the nature and details of any such discussions?

A Not that I recall directly, though I think i recall Dr Inkster telling me in a call that Sanosil was deemed incompatible with the types of taps that were in use.

65. How would the risk of damaging the pipes in the longer term be balanced with the use of a higher dose of Sanosil?

A See above, for oxidising biocides including chlorine dioxide it is recognised that its use even at recommended levels, decreases the lifecycle off the materials. this is accepted by mechanical engineers as a worthwhile pay off for keeping systems safe.

Action Plan from Susanne Lee Report

Refer to Action Plan – 17 August 2018

66. Have you seen this document previously?

A No.

67. The Action Plan was created by Dr Inkster and Ian Powrie based on the recommendations in your report dated 25th April 2018. Is the Action Plan an accurate reflection of your recommendations? If not, why not?

A Yes.

68. Was this document discussed with you or did you have any input into it?

A No.

69. Do you have any comments to make on this document?

A Only that there seems to be a long interval between the issuing of my report and action plan development.

70. Can you provide comments on the ‘Action’, ‘Timescale’ and ‘Status’ in relation to the following: see above I am not sure what is being asked for here above what has already been stated?

a) Recommendation 1:

b) Recommendation 2:

c) Recommendation 3:

d) Recommendation 4:

e) Recommendation 5:

f) Recommendation 6:

g) Recommendation 7:

h) Recommendation 8:

i) Recommendation 9:

j) Recommendation 10:

k) Recommendation 11:

l) Recommendation 12:

m) Recommendation 13:

n) Recommendation 14:

A no I was not party to any discussions following my report as far as I can remember.

BBC Documentary: Secrets of Scotland’s Super Hospital

71. You participated in the BBC Documentary Secrets of Scotland’s Super Hospital which aired in June 2020: when did the BBC approach you to participate in this? What documentation were you provided with prior to your interview? When were you interviewed for the documentary?

A I no longer have this documentation as it was given in confidence, I also had problems with my computer, I have since changed computers and could not access them which is why I had to contact Dr Inkster for a copy of my report . I did contact the police to ask for the list of what I gave to them when they visited me, which I have since forwarded.

a) Was it substantial (the list)?

A A Some of it was redacted the documents I concentrated on were the two DMA risk assessments, 2015 and 2018. My conclusion was they should never have admitted patients into the hospital until they fixed the water contamination problems they were having within the hospital.

72. In the documentary, you commented on the management of the water temperature and that basic control measures were not working at the time of the risk assessment. Can you expand on this?

A A HSE and NHS guidance on control measures is there to prevent microbial growth so if you keep water below 20 °C , (most bacteria will be in a dormant stage and not actually growing, so below 20 °C there is a very low risk of infection but once the temperatures are above 25 °C you get a very steep growth curve (exponential growth) i.e. the bacteria grow very quickly and their ability to cause infection increases . Though a maximum 25 °C is allowed in some European guidance as this is in the slow growth phase of legionella for example). To minimise risk as far as possible cold water temperatures should be kept below 20°C . Stagnation increases the ability of bacteria to stick to surfaces in biofilms, once growing in biofilms microorganisms are much more resistant to biocide treatment so a control measure is to keep the water moving to each outlet to ensure the control measures are achieved throughout the system. Hot water systems should be delivered at a minimum of 55 degrees as there are some bacteria such as Nontuberculous mycobacteria (NTM) which are very resistant to temperature control. There is evidence that the cannot be recovered in hot water systems at 55°C but at 50 °C they can still be recovered. The aim should be to keep water in the cold water tanks 2 °C less than 20 °C to allow for heat gain between the tank to the outlet.

The documentary highlights further concerns which you had, including the high risk of contamination from stagnating water and significant communication issues with those responsible for maintaining the water system. Can you comment further on these concerns?

As above re stagnation which increases the risk of colonisation and microbial growth. The DMA risk assessment 2015 raised the issue of poor communication and this having the potential to exacerbate the risk of microbial growth. *"lack of defined communication between involved parties may be a contributing factor to the out of specification bacterial and legionella results recently recorded bv NHS Estates".* In addition, there was a lack of communication highlighted between Estates and the contractor with the example of a calorifier being reinstated without evidence of appropriate safeguards to protect the system from contamination and the lack of communication meaning Estates had no knowledge at the time this was being carried out.

73. You describe 'fundamental failures' by not ensuring those involved in water safety were being trained to understand risk and what they should be doing to manage it. Can you expand on these failures please?

A See 72 which Refers to DMA Canyon Reports 2015 and 2018. The contractor reinstated a calorifier without any evidence of communication with estates and of taking measures to ensure the risk of cross contamination was managed. The pipework was left uncapped during construction allowing nutrient ingress, there was debris in the CWSTs, and a lack of understanding of the risks from flexible hoses are just a few examples highlighted in the DMA risk assessments

A big problem is a lack of understanding for example is if people don't know why the poor temperature controls are significant in managing the risk, and they don't understand the consequences to patients if the temperatures are incorrect, the importance doesn't register with them. We all see that if people don't understand, from the architects onwards, they don't know how to design out risk factors and what they need to do so good control of all water systems can be achieved, They need to understand why good water system design is so important.

74. At the time of your visit to the QEUH/RHC, were you aware of the report published by specialist water consultants DMA Canyon dated 29 April 2015? If so, had you considered it prior to your visit? Had you considered the report prior to the preparation of your report? If so, what were your impressions of the report by DMA Canyon? How did this report impact on the preparation of your report? Were you aware of any actions taken in respect of the recommendations made by DMA Canyon?

A see above, yes I was aware but the version I remember had redactions, so I don't think I saw the whole report until it was provided in the bundle.

I was really shocked that there was so much wrong at the time they were about to admit patients. They had high cold-water temperatures (at 30 degrees), that is frighteningly high as it is in the exponential growth stage for legionellae for example, . They hadn't got a disinfection system installed to mitigate the risk from poor temperature control. It's highly likely that a large hospital with a large water system won't achieve consistent temperatures, so there is a need for a multi barrier approach as advised by the World Health Organization guidelines. Particularly as the intended patient group: bone marrow transplant patients are one of the highest risk patients you can have – they should have the highest level or protection. If you follow the WHO 2003 guidelines (referred to in the current WHO guidelines for drinking water quality (2022[3]) , neutropenic patients should have sterile water and shouldn't be exposed to tap water, so to have water that wasn't controlled as far as reasonably possible is putting the patients at high risk of infection. There should have been a multidisciplinary risk assessment (environmental and clinical involvement) for the spaces these particularly vulnerable patients were in.

75. At the time of your visit to the QEUH/RHC, were you aware of the report published by specialist water consultants DMA Canyon for 2017, which is dated 31 January 2018? If so, had you considered it prior to your visit? Had you considered the report prior to the preparation of your report? If so, what were your impressions of the report by DMA Canyon? How did this report impact on the preparation of your report? Were you aware of any actions taken in respect of the recommendations made by DMA Canyon?

A see above and as far as I can remember I had only seen the full report when you supplied the bundle. I was impressed by these risk assessments; this is not something I say often). I was part of the committee which wrote the BS 8580-1 so am very critical. Apart from being a bit long winded and a bit repetitive this was one off the best risk assessments I had seen (and I have seen many). I took their risk assessments on board and included some recommendation based on their observations into my report.

76. In relation to the report by DMA Canyon dated 29 April 2015, you stated in the documentary that you would have expected it to go straight to board level to allow a decision to be made at corporate level as to whether the hospital was safe to open. Can you comment further on this?

A I was really shocked that there was so much wrong, they'd finished construction in 2015 and started occupation fairly soon afterwards, this risk assessment was done as a preoccupation assessment, there were so many things wrong, and they didn't address those before admitting patients. So, I would have expected the findings to be put on the risk registers and discussed at board level or senior management to discuss the implications of the risk assessment. I haven't seen anything to say this happened, that there were many things not addressed inby the time the 2017 assessment was completed us a cause for concern. . I haven't seen any evidence that senior management action actually happened.

77. Is there anything further you would like to comment on in relation to the report by DMA Canyon dated 29 April 2015?

A I am rarely impressed by risk assessments, but I actually feel they did a good job and made some good recommendations, they seem to be very thorough, and I was shocked that the remedial actions from 2015 had not been carried out.

78. In the documentary, you described yourself being 'horrified' that so many defects identified in 2015 had not been rectified in 2017. Can you explain what defects you are referring to and the concerns these raise? Are you aware of why any such defects had not been remedied as you would have expected?

A Temperatures seem to have got better, but they are still talking about cold water temperatures being a problem, expansion vessels still not as in the recommended guidance, lots of flexible hoses, the double check valve on the CWST still in the 2017 version, as well as dead legs etc. etc. There was a Department of Health letter which went out in 2013 (?), which advised against use of these hoses as they had been found to be heavily colonised, including with legionellae. That information was well known, these hoses should not be used in healthcare premises. The risks hadn't been mitigated and the longer that you have the potential for increasing microbial growth, the risk is going to rise. In 2017 risk assessment they still had the same debris in cold water tank that they identified as present in 2015 one, not carrying out something as basic as cleaning out a cold-water tank is not acceptable.

79. Were patients being put at risk by the failure to remedy these defects? If so, why do you consider that to be so?

A If you hand over the design and build to a contractor who doesn't have the necessary skills and knowledge to understand the risk from poor design, construction, installation, commissioning, and operation, particularly for a hospital with high risk patients, then there are going to be problems. You've absolutely got to take account of the intended patient group when you're designing a hospital. There wasn't as far as I know, any risk assessment on the patients and what they needed to keep safe. It is almost as if it was designed for a general hospital and not considering the vulnerable patient groups which is shocking.

80. Is there anything further you would like to comment on in relation to the report by DMA Canyon dated 31 January 2018?

A not that I can think of at present

81. Have you been approached by anyone else other than the BBC in relation to the issue of water contamination at the QEUH/RHC?

A Other than Doctor Inkster not that I recall.

Any other relevant information

82. Is there anything else which you believe is relevant and would like to bring to the Inquiry's attention?

A An additional comment on Dr Inkster - I have huge respect for her, particularly in raising her very valid concerns despite the consequences. I have invited her to present at seminars, conferences and international postgraduate training courses I've organized and because of her unique expertise I've invited her to be on British Standard Groups writing risk assessment standards for *Pseudononas aeruginosa* and other waterborne pathogens and sampling for *Pseudomonas aeruginosa*, as well as contributing in an expert group writing guidance for the design of hospital units intended for patients at high risk of infection. I think she's been treated appallingly.

I would also like to point the Inquiry in the direction of the following documents for their reference.

- Review of Issues Relating to Hospital Water Systems' Risk Assessment A43941023
- Health & Safety Executive in their Approved Code of Practice and guidance ACOP L8 "Legionnaires' disease. The control of legionella bacteria in water systems".

Declaration

I believe that the facts stated in this witness statement are true. I understand that proceedings for contempt of court may be brought against anyone who makes, or causes to be made, a false statement in a document verified by a statement of truth without an honest belief in its truth.

The witness was provided the following Scottish Hospital Inquiry documents for reference when they completed their questionnaire statement.

Appendix A

A43255563 – Bundle 1 - Incident Management Team Meeting Minutes (IMT Minutes)
A43299519 – Bundle 4 - NHS Greater Glasgow and Clyde: BAR Documentation
A43955371 – Bundle 8 - Supplementary Documents
A43293438 – Bundle 6 - Miscellaneous Documents
A47175206 – Bundle 9 - QEUH Cryptococcus Sub-Group Minutes
A47395429 – Bundle 10 - Water Technical Group / Water Review Group Minutes
A47390519 – Bundle 11 - Water Safety Group
A47069198 – Bundle 12 - Estates Communications

The witness provided the following documents to the Scottish Hospital Inquiry for reference when they completed their questionnaire statement.

Appendix B

A49639088 – Dr Susanne Barbara Surman-Lee CV 2024

Dr Susanne Surman-Lee
[redacted]
Telephone: [redacted] Mobile
Email: [redacted]

PROFILE OVERVIEW

- Dr Susanne Surman-Lee, Hon. FRSPH, FRSB, CBIOL., FIHEEM., FWMSoc, FPWTAG, is a Consultant Clinical Scientist (Public Health Microbiologist) registered with the UK Health Professions Council (Reg. No. CS02982)), a Chartered Biologist and Director of Legionellae Ltd which provide legal and independent public health consultancy and advisory services.
- Susanne has over 40 years of experience in Clinical and Public Health Microbiology and has a strong scientific and research background with a PhD on *Legionella* growth within biofilms and protozoa and over 30 years of experience; advising, troubleshooting, providing training, auditing and investigating cases and incidents in over 50 healthcare premises nationally and internationally. She has also worked as a temporary advisor to WHO at a workshop in the Middle East on Water Hygiene in Healthcare, as well as at a web based international WHO meeting on water quality. She is an author / editor of the WHO Legionella and the Prevention of Legionellosis (2007) and Water Safety in Buildings (2011). She is passionate about ensuring that patient safety is put first and foremost in with the aim that all newly built healthcare premises should be safe for all users and all uses of water to which patients, staff and visitors might be exposed.
- For over 20 years, she has supported the development of legislation, guidance and standards, working with government departments, professional societies and standards bodies nationally and internationally including as a member of the working groups developing the Department of Health's' HTM 04:01, the UK Health and Safety Executives' Approved Code of Practice and associated guidance for managing risks associated with *Legionella* in water systems HSG 274 and also the Pool Water Treatment Advisory Groups guidance on pool water quality, leading the chapter on hydrotherapy pools. Her work with the British Standards Institution is supporting the UK's work towards the achievement of the UN Sustainable Development Goals SDG6 on the provision of safe water and sanitation for all, proposing the relevant standards and chairing the committee which developed BS 8680-2020 on the development of water safety plans, BS 8580-2 risk assessment for *Pseudomonas aeruginosa* and other waterborne pathogens and is leading the development of a new standard on sampling for *Pseudomonas aeruginosa.* She is also currently chairing a group for the Department of Health, writing a technical bulletin to update current guidance on preventing the risk of NTM infections in newly built hospital units intended to house patients at the highest risk of waterborne infections.
- Susanne's recent and current activities include being an invited speaker at the Lord Mayor of London's Coffee Colloquy on working towards the UN SDG6 goals, working with other professionals to produce a practical book for healthcare professionals on water hygiene (Walker et al., 2023) and working with the NHS England New Hospital program as a subject matter expert on water hygiene, wastewater systems and safety standards. In October 2023, was a co-organizer, chair and lecturer of a very successful ESCMID postgraduate course on water hygiene for healthcare professionals, which took place in Belfast.

ADDITIONAL ACTIVITIES AND AFFILIATIONS INLCUDE:-

CURRENT

- Chair of a Department of Health technical bulletin expert group to enhance HTM 04:01

guidance for NHSE on designing safe spaces for patients at high risk of NTM and other waterborne pathogens since 2023

- -National Health Service England (NHSE) New Hospital Programme - invited member of the Water and Wastewater Safety Group, Sampling Group, Safety Standards Group, Safety Standards Steering Panel Member and Safety Criteria Panel
- **L**ecturer; Great Ormand Street Environmental Network training course on Waterborne transmission, monitoring and control since 2022.'
- Invited speaker Infection Prevention Society Environment, Cleaning and Decontamination Conference
- Member off the Scientific committee for the ESCMID Study Group for Legionella Infections conference Dresden 2024
- Honorary Fellow of the Royal Society for Public Health and Programme Director of their water webinar series,
- Chair of the RSPH Water Special Interest Steering Group
- Fellow of the Water Management Society and member of their technical committee
- Trusted grant and abstract reviewer for the European Society for Clinical Microbiology and Infectious Diseases (ESCMID).
- A Fellow and member of Council of the Pool Water Treatment Advisory Group
- A Freeman of the City of London and Liveryman of the Worshipful Company of Plumbers (WCOP),
- A member of the WCOP Educational and Technical Committee.
- Working with the Belfast Health and Social Care Trust since 2013, as their independent water hygiene advisor, designing and leading research projects into microbial colonisation of hospital water systems and a member of the Trust water safety and usage group. Providing advice and training to infection prevention and control teams, aquatic physiotherapists, contractors, plumbers and patient support staff. I am also a member of the pool water safety group.
- Providing expert water hygiene advisory services to Dolphin Square, the largest privately rented residential complex in the UK, providing water hygiene and safe water design training and chairing the Dolphin Square Water Safety Group since 2019
- Chair of the European Society for Clinical Microbiology and Infectious Diseases Legionella Study Group revising the European working European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease since 2022
-

2023-

- Invited speaker, water hygiene seminar , Organized by Oslo University Hospital
- International postgraduate training on water hygiene in healthcare Course, programme development lead , chair and lecturer, collaborative ESCMID Study Groups
- Coauthor of Water Safety in Healthcare published by Elsevier.
- invited to be a member of the American Society of Plumbing Engineers, ASPE 82 -Drains and Wastewater
- Elected as a Fellow of the Pool Water Treatment Advisory Group.

MEMBERSHIPS OF LEARNED AND PROFESSIONAL SOCIETIES INCLUDE

- Member of the International Water Association, the Healthcare Infection Society, the Infection Prevention Society, the Central Sterilizing Club and the Association for Professionals in Infection Control and Epidemiology (APIC). A member of ESCMID Study Groups, including for Legionella infections (ESGLI), nosocomial infections (ESGNI), and infections caused by food and water (EFSWIG). Also as an affiliate member of the Chartered Institute for Building Service Engineers and the Chartered Society of Physiotherapy

HISTORY

- From leaving the Health Protection Agency in 2009 to the present, Dr Susanne Surman-Lee has been a trusted source of professional independent public health microbiology advice and consultancy nationally and internationally for the prevention and control of infections caused by water in built and recreational environments, including for incident and outbreak investigation support. She provides independent professional public health microbiology and advice and, consultancy services and bespoke training to NHS, other healthcare providers and others on water system safety and infection prevention and control (IPC) in the built environment as well as on good water system design to CEOs, IPC teams, patient support, plumbers, contractors and design teams, public health and estates engineers, water treatment providers and providers of water hygiene equipment. She is frequently asked to present at national and international meetings.
- **From 1998-to 2009,** Health Protection Agency (HPA) Unit Head then promoted to Director of the London Regional Food Water and Environmental Microbiology Services Laboratory and Lead London, Home Counties and Eastern Regional HPA Food and Water Microbiologist responsible for providing routine food and water microbiology testing services support and training services for all the environmental health and port health authorities and health protection Units, in London and the Home Counties as well as commercial clients. In addition supporting national food and water outbreak investigation teams including in the detection and prevention of food and waterborne illness, leading research on microbial hazards from food and water with local authorities and the Port Health Authorities, including the impact of rainfall on the River Thames. Susanne was a member of the National Outbreak Investigation Team and also represented the HPA on national and international food and water standards bodies. Susanne was also the Founder of the London Wide Water Forum, which included water utilities, regulatory and public health bodies to rationalise the approach to the investigation of outbreaks of waterborne disease within London. Susanne also developed and taught for several years an MSC module on waterborne pathogens and infections caused by water for the London and Queen Mary Medical School.
- **1994 -1998** Public Health Laboratory Service Grade B Clinical Scientist and Deputy Head of the PHLS Water and Environmental Research Laboratory, providing routine public health water microbiology services, water quality research projects, external quality assurance provision for *Legionella* testing laboratories, and outbreak investigation support for regulatory and public health bodies and support for the University of Nottingham Medical school student teaching.
- **1994** Grade A Trainee Clinical Scientist Preston Public Health Laboratory carrying out research and routine public health microbiology and day-to-day management of a collaborative research project investigating the survival of species of *Salmonella* and *Campylobacter* on designated and non-designated bathing beaches.
- !**990-1994** researching for a PhD in the growth of Legionella in Biofilms and protozoa in collaboration with PHLS Centre for Applied Microbiology and Research Porton Down, and part-time radiation protection officer for the University of Central Lancashire
- **1988-1990** Grade A clinical research Scientist, clinical microbiology Hope Hospital Salford on various clinical microbiology projects, including biofilm growth in urinary catheters, validation of microbiology testing and identification kits and mentoring and supervising medical colleagues undertaking masters' projects.
- **1985-88** Further education BSc Joint Honours in Biochemistry and Physiology
- 1980-1985 career break
- **From 1970- 1980** , I worked as a biomedical scientist in NHS and Public Health Laboratories; Manchester Royal Infirmary and St Mary's Manchester, Joint appointment Preston Royal infirmary and Preston Public health laboratory, providing routine clinical and public health microbiology, including Brucella typing, and supporting research projects.

TECHNICAL STANDARDS & GUIDANCE ACTIVITIES

Susanne has been involved in the development of national and international guidance and publications and reports on water quality and hygiene for over 20 years including: ---

- Chair ESCMID *Legionella* study group which produced guidelines for managing water system in buildings during the time of COVID for hospitals, nursing homes, dentists, and other buildings published 2020.
- Chair and Editor, European working European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease, published on the ECDC website 2017
- Member of the working group UK Department of Health Guidance HTM 04---01 parts A---C 2016
- Member of the working groups updating the HSE ACoP and Guidance HSG 274 2013-14
- Member of the working group updating guidance for spa pools HSG 282 2016
- Lead author PWTAG Swimming Pool Water chapter 21 on Hydrotherapy pools
- Author and editor of the World Health Organizations' Water Safety in Buildings 2011
- Author and editor of the World Health Organizations' *Legionella* and the prevention of legionellosis –2007
- Contributor, WHO Guidelines for drinking water quality

PUBLICATIONS

- Dr Michael Weinbren, George McCracken, **Dr Susanne Surman-Lee**, Dr Teresa Inkster, (April 2024) Honing design to improve from one build to the next part 2, Health Estates Journal.
- Dr Michael Weinbren, George McCracken, Dr **Susanne Surman-Lee** Dr Teresa Inkster, (March 2024), Honing design to improve from one build to the next part 1 Health Estates Journal.
- James T. Walker, **Susanne Surman-Lee,** Paul J. McDermott, Michael Weinbren (2023) Safe Water in Healthcare: A Practical and Clinical Guide. Elsevier
- **S. Surman-Lee** and G. McCracken., **(**Jan 2021) Don't assume that others understand your system. Health Estates Journal
- **Surman-Lee.,S**. Health Estates Journal June 17 2020 Don't take your eye off water safety during the outbreak
- Leiblein TW, Tucker M, Ashall M, **Lee SB**, Gollnisch C., Hofer S., Legionella and risk management in hospitals—A bibliographic research methodology for people responsible for built environment and facility management. International Journal of Hygiene and Environmental Health, Volume 219, Issue 8, November 2016, Pages 890-897
- Leiblein, T., Tucker, M., Ashall, M., **Lee, S.B**., Gollnisch, C. and S. Hofer. „Duty holders for Legionella prevention in healthcare organisations: The implications for Facility Management". Poster first published at ESGLI Conference, Third Annual Scientific Conference, London, 16.- - - 17.09.2015. Poster Session 4 "Microbial Ecology, Prevention and Control Strategies", Poster No. 4/P45. Printed in Waterline --- Journal of the Water Management Society (ISSN: 09547711), Winter 2016--- 15, p. 36
- Sartory DP; Pauly D; Garrec N; Bonadonna L; Semproni M; Schell C; Reimann A; Firth SJ; Thom C; Hartemann P; Exner M; Baldauf H; **Lee S**; Lee JV; (2014), Evaluation of an MPN test for the rapid enumeration of *Pseudomonas aeruginosa* in hospital waters, Journal of Water and Health. vol. 13, issue 2, p 427, ISSN 14778920. ISBN 14778920
- John Alvey • David Bebbington • Philip Chown • Giles Green, David Little • George Piper • **Susanne Surman- Lee** (Revised January 2014) Managing the Risk of Legionnaires' disease in Vehicle Wash Systems W046 Guidance produced by Water Management Society Working Party
- **S Lee** and JV Lee (2013); Outbreak Investigations and Identification of Legionella in Contaminated Water Chapter in Methods in molecular biology (Clifton, N.J.) 954:87--- 118 ·· (2013)
- Rasetti-Escargueil and **Susanne Surman-Lee** (editors) (2012), Clostridium Botulinum: A Spore Forming Organism & a Challenge to Food Safety Christine Publisher: Nova Science Publishers Inc. ISBN:9781614705758
- J.V. Lee, S. Lai, M. Exner, J. Lenz, V. Gaia, S. Casati, P. Hartemann, C. Lück, B. Pangon, M.L. Ricci, Scaturro, S. Fontana, M. Sabria, I. Sánchez, and **S Surman-Lee**. (2011) An international trial of quantitative PCR for monitoring for Legionella in artificial water systems, Journal of Applied Microbiology, Volume 110, Issue 4, pages 1032–1044,
- ECDC Training Materials (2010)) Health Protection Agency (UK) and the University of Chester (UK) with the direct involvement of Louise Brown, Janice Gidman, Emma Gil Gunn-Jones, Ian Hall (on behalf of the ECDC Legionnaires Disease Outbreak Toolbox Development Group), Tim Harrison, Rob Johnston, Carol Joseph, Sandra Lai, John Lee, Falguni Naik, Nick Phin, Michelle Rivett, and **Susanne Surman-Lee. Available at https://eva.ecdc.europa.eu/course/view.php?id=177**

- Hiran Dhanji, Niamh M. Murphy, Michel Doumith, Sema Durmus**, Susanne Surman Lee**, Russell Hope, Neil Woodford, David M. Livermore, Cephalosporin resistance mechanisms in *Escherichia coli* isolated from raw chicken imported into the UK, *Journal of Antimicrobial Chemotherapy*, Volume 65, Issue 12, December 2010, Pages 2534– 2537, https://doi.org/10.1093/jac/dkq376
- Health Protection Agency Guidelines for Assessing the Microbiological Safety of Ready to Eat Foods, London Health Protection Agency November 2009
- I. Giraudon, S. Cathcart, S. Blomqvist, A. Littleton, **S. Surman-Lee,** A. Mifsud, S. Anaraki, G. Fraser (2009). Large outbreak of salmonella phage type 1 infection with high infection rate and severe illness associated with fast food premises. Public Health, 123,444-447
- Little, C. L., Jemmott, W., **Surman-Lee, S.**, Hucklesby L., & de Pinna, E. (2009). Assessment of the Microbiological Safety of Edible Roasted Nut Kernels on Retail Sale in England, with a Focus on Salmonella. Journal of Food Protection, 72(4), 853–855.
- Elviss NC, Little CL, Hucklesby L, Sagoo S, **Surman-Lee S**, de Pinna E, Threlfall EJ; Food, Water and Environmental Surveillance Network. (2009) Microbiological study of fresh herbs from retail premises uncovers an international outbreak of salmonellosis. Int J Food Microbiol. Aug 31;134(1-2):83-8.
- Whittaker PJ, Sopwith W, Quigley C, Gillespie I, Willshaw GA, Lycett C, **Surman-Lee S,** Baxter D, Adak GK, Syed Q. (2009) A national outbreak of verotoxin-producing Escherichia coli O157 associated with consumption of lemon- and-coriander chicken wraps from a supermarket chain. Epidemiol Infect. Mar;137(3):375-82.
- Grenfell P, Little CL, **Surman-- - Lee S**, Greenwood M, Averns J, Westacott S, Lane C, et al., (2008) The microbiological quality of potable water on board ships docking in the UK and the Channel Islands: an association of Port Health Authorities and Health Protection Agency Study. Journal of Water and Health [2008), 6(2):215- - - 24]
- K. Lock, C. MillettR. Heathcock), C. A. Joseph, T. G. Harrison, J. V. Lee, G. Rao, **S. Surman-Lee** and On Behalf of The Outbreak Control Team (2007) Public health and economic costs of investigating a suspected outbreak of Legionnaires' disease. Epidemiology and Infection 2008, 136(10):1306- 14]
- The importance of environmental monitoring during outbreak investigations (pdf, 10655Kb), **Susanne Surman- Lee**. Workshop 2007, EURL-Salmonella for Salmonella | EURL salmonella. https://www.eurlsalmonella.eu/Workshops/Archive_Workshops/Workshop_2007
- A Salmonella Typhimurium outbreak from ...Little C, Walsh S, Hucklesby L, **Surman-Lee S**, Pathak K, Hall Y, de Pinna E, Threlfall E J, Maund A, Chan C H, S Walsh. (2006) Salmonella contamination in non-UK produced shell eggs on retail sale in some regions of England. Euro Surveill.;11(47):
- K Beyrer; S Lai; JM Dreesman; JV Lee; Carol A Joseph; T Harrison; **Susanne Surman-- Lee**; C Lück; Bonita Brodhun; U Buchholz; A Windorfer, (2007): Legionnaires' disease outbreak associated with a cruise liner, August 2003: epidemiological and microbiological findings; Epidemiology and infection 2007;135(5):802- 10.
- Bentham R, **Surman- Lee S**, Lee JV, Briand E, Van de Kooj D. (2007) Potable water distribution systems Chapter 3 in Legionella and the Prevention of Legionellosis. In: Legionella and the Prevention of Legionellosis. Bartram, J., Chartier, Y., Lee, J.V., Pond, K. and **Surman- Lee, S**. (eds) World Health Organization. Geneva, Switzerland. Chapter 3. pp 59---73 ISBN 92 4 156297 8.
- **Surman- Lee, S**., Fields, B.S., Hornei, B., Ewig, S., Exner, M., Tartakovsky, I., Lajoie, L., Dangendorf, F., Bentham, R. H., Cabanes, P.A., Fourriere, P., Trouvet,

T. and Wallet, F. (2007) Ecology and Environmental sources of Legionella. In: Legionella and the Prevention of Legionellosis. Bartram, J., Chartier, Y., Lee, J.V., Pond, K., and **Surman- Lee, S.** (eds) World Health Organization. Geneva, Switzerland. Chapter 2. pp 49--- 57 ISBN 92 4 156297 8.

- **Surman-Lee, Susanne** and Bentham, Richard. 2006. Environmental Sampling Data to Determine Risk: a United Kingdom Perspective, p 543-548. In Cianciotto, Nicholas P. and Kwaik, Yousef Abu and Edelstein, Paul H. and Fields, Barry S. and Geary, David F. and Harrison, Timothy G. and Joseph, Carol and Ratcliff, Rodney M. and Stout, Janet E. and Swanson, Michele S.(ed), *Legionella*.
- Bartram, J., Bentham R.H., Briand, E., Callan, P., Crespi, S., Lee., J.V. and **Surman--- Lee S.** (2007) Approaches to Risk Management. In: Legionella and the Prevention of Legionellosis. Bartram, J., Chartier, Y., Lee, J.V., Pond, K., and Surman---Lee, S. (eds) World Health Organization. Geneva, Switzerland. Chapter 3. pp 59---73 ISBN 92 4 156297 8.
- **Surman--- Lee, S**, could you cause legionnaire's disease? Recreation July/August 2006.
- Rooney R, Lee JV, Crespi S, Panie G, Chevet PF, Trouvet T & **Surman-Lee S.** Legionnaires' disease associated with hotels and ships. Chapter 6. in Legionella and the Prevention of Legionellosis. WHO (2007) ISBN 92 4 156297 8
- **Surman- Lee S,** Drasar V & Lee JV. Natural spas, hot tubs and swimming pools. Chapter 7 in Legionella and the Prevention of Legionellosis. WHO (2007) ISBN 92 4 156297 8
- **Surman-Lee, S**. and Bentham, R. Environmental Sampling Data to Determine Risk – a UK Perspective. In: Proceedings of the 6th International Legionella Conference, Cianciotto, N., Swanson, M., Abu Kwaik, Y., Fields, B.S., and Geary, D. (eds) Hyatt Regency, Chicago, Illinois. USA, October 16---20, 2005. American Society for Microbiology.
- Pankhurst, C.L., Coulter, W., Philpott-Howard, J.N., **Surman-Lee, S**., Warburton, F. and Challacombe, S., 2005. Evaluation of the potential risk of occupational asthma in dentists exposed to contaminated dental unit waterlines. Primary Dental Care, (2), pp.53-60.C
- L Watson; Robert J Owen; B Said; S Lai; JV Lee; **Susanne Surman-Lee**; Gordon Nichols 2004: Detection of Helicobacter pylori by PCR but not culture in water and biofilm samples from drinking water distribution systems in England. Journal of Applied Microbiology 2004;97(4):690- 8.
- Vulindlu M, Charlett A, **Surman S, Lee** JV. 2004 Comparison of agar-based methods for the isolation and enumeration of heterotrophic bacteria with the new multidose IDEXX SimPlate method. Water Sci Technol. 2004;50(1):277- - - 80.
- Owen, R.J., Chisholm, S.A., Brick, G., Lee, J.V., **Surman-Lee, S.**, Lai, S., Said, B. and Nichols, G., 2006. Culture of Helicobacter pylori from domestic water samples–the impact of strain variation on growth on solid and in liquid media. Water science and technology, 54(3), pp.147-152.
- Joseph C, Lock K, Heathcock R, Millett C, **Surman S**, Lee JV, Harrison T & Maguire H. 2005 Legionnaires' disease in southeast London. Euro surveillance Weekly 10 (36): 08/09/
- Belucha Sirerol, Sandra Lai, Stephanie Chisholm, Bengü Said, Gordon Nichols, **Susanne Surman- Lee,** Robert Owen, John V Lee. Health Significance of Pathogens Associated with Drinking Water Biofilms: Final Report, September 2005 Website Publication Date April 01, 2008 ISBN 978 0 7559 1655 9 (Web only publication)
    - Rooney R, Lee JV, Crespi S, Panie G, Chevet PF, Trouvet T & Surman- **Lee S.** 2007 Hotels and ships. Chapter 7 in Legionella and the Prevention of Legionellosis. WHO ISBN 92 4 156297 8,

pp 103--118

- Watson CL, Owen RJ, Lai S, Lee JV, **Surman S,** Nichols G, Said B. 2004 Detection of Helicobacter pylori by culture and PCR in water and biofilm samples from drinking water distribution systems in England. Journal of Applied Microbiology; 97:690---8.
- Lee J. V.& **Surman S B**. 2002 Eleven years' experience of novel strategies for legionella control in a large teaching hospital. In Legionella Eds: Marre R, Abu Kwaik Y, Bartlett C et al. ASM Press, Washington DC pp 398 --- 401.
- Lee J V, Surman **S B,** Hall M & Cuthbert L. 2002 Development of an international EQA scheme for the isolation of Legionella species from environmental specimens. In Legionella Eds: Marre R, Abu Kwaik Y, Bartlett C et al. ASM Press, Washington DC pp 271---274.
- Lee JV et al. 2005 The determination of Legionella bacteria in waters and other environmental samples (2005) Part 1 --- rationale of surveying and sampling. Standing Committee of Analysts, Environment Agency http://www.environmentagency.gov.uk/commondata/acrobat/book_200_1028650.pdf
- Bartram J, Chartier Y, Lee JV, Pond K and **Surman- Lee S** (Editors) 2007 Legionella and the Prevention of Legionellosis. WHO ISBN 92 4 156297 8
- Calvert J, Copping S, Crabb S, Firth P, Gosling H, Johnson M, Lee JV, Murfin J, Newbold J, Nichols G, Price H, Senior S, Stam P, Steer M**, Surman- Lee S**, Tomlinson M, Tuckwell S & White P. 2006 Management of Spa Pools: Controlling the Risk of Infection. London: Health Protection Agency. 2006 ISBN 0 901144 80 0
- Development of an International External Quality Assurance Scheme for Isolation of Legionella Species from Environmental Specimens. 2001 John V. Lee, **Susanne Surman**, Maureen Hall, Lorraine Cuthbert., Editor(s): Reinhard Marre, Yousef Abu Kwaik, Christopher Bartlett, Nicholas P. Cianciotto, Barry S. Fields, Matthias Frosch, Jörg Hacker, Paul Christian Lück https://doi.org/10.1128/9781555817985.ch53
- Jana Jass, **Susanne Surman**, James Walker (Eds), Medical Biofilms: Detection, Prevention and Control, Book., John Wiley & Sons,(2003)
- **Surman, S**., Morton, G., Keevil, B. and Fitzgeorge, R., 2001. Legionella pneumophila proliferation is not dependent on intracellular replication. Legionella, pp.86-89.J. Walker, S. Surman and J. Jass, (Eds)., Industrial Biofouling: Detection, Prevention And Control., John Wiley & Sons Ltd (2000)

RESEARCH REPORTS

Dr Lee has been involved in the research and production of many scientific reports. A selection of these is listed below:

- Lightfoot, D.P. Sartory, G Sprigings, S. Cole, **S. Surman**, J. Lee, P. Gale, H. Tillet 2000 Comparison of microbiological methods of analysis: organisations and supervision of performance tests. A research report to the Drinking Water Inspectorate, DWI contract 70/2/128
- Lee J. V., **Surman S B** & Bouwer A 2001 Comparison of GVPC with GVPN Phase II: inoculation with real samples Report prepared for Oxoid Ltd.
- Whale A., Said B., Owen B., Watson C., Drobniewski F., Nichols G., Lee J. V., Weldon L., Edwards R., Lai S., **Surman S.** 2003. Further studies on the Incidence of Mycobacterium avium Complex (MAC) in drinking water supplies
- The detection of *Helicobacter pylori* in water and biofilm samples). A research report from the Health Protection Agency to the Drinking Water Inspectorate DWI/70/2/146 Final report November 2003
- Brick G., Chisholm S., Owen R., Nichols G., Lee J.V., Lai S., **Surman S**., Said B.

2004. Further studies on the incidence of Helicobacter organisms in water supplies. A Research Report from the Health Protection Agency to the Drinking Water Inspectorate for Contract Variation DWI/70/2/146 F i nal Report – December 2004 84pp

- Sirerol B., Lai S., Chisholm S., Said B., Nichols G., **Surman--- Lee S**., Owen R., Lee J. V. 2005 Health Significance of Pathogens Associated with Drinking Water Biofilms. Report to the Scottish Executive. 94pp
- Lane C., **Surman--- Lee S.**, Sellwood J., and Lee J. V. 2007. The Thames Recreational Users Study. Report for the City of London Port Health and Environmental Services Committee 25th September 2007. 24pp